frontiers in Human Dynamics

TYPE Original Research
PUBLISHED 22 June 2026
DOI 10.3389/fhumd.2026.1847136

OPEN ACCESS

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RECEIVED 03 April 2026
REVISED 02 June 2026
ACCEPTED 03 June 2026
PUBLISHED 22 June 2026

CITATION
Kaya MH, Bulut MA, Aşık G and Adiguzel T (2026) An E-professional training in self-regulated cognitive strategies for K-12.
Front. Hum. Dyn. 8:1847136.
doi: 10.3389/fhumd.2026.1847136

An E-professional training in self-regulated cognitive strategies for K-12

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This study investigates the design, implementation, and impact of an e-professional development program focused on self-regulated learning (SRL) cognitive strategies for K-12 teachers. Framed by an integrative theoretical perspective on SRL, the study examines how teachers can embed rehearsal, organization, elaboration, and critical thinking into regular teaching content across grade levels, subjects, and learning contexts. It also explores the characteristics of learning environments that support SRL strategy instruction and the role of digital technologies in facilitating this process. A mixed-methods design was employed. The study drew on 24 lesson plans developed by teachers who participated in a seven-week cognitive strategies module within a broader 16-week SRL training program. Quantitative data were obtained through an expert-developed rubric assessing the integration, implementation, and technology integration of SRL cognitive strategies, while qualitative data were analyzed through thematic analysis of the lesson plans. The findings indicate that the training had a positive impact on teachers' instructional planning and classroom-oriented strategy use. Teachers successfully incorporated SRL cognitive strategies across preschool, primary, middle, and high school contexts, with particularly strong evidence of elaboration and critical thinking activities. Quantitative results showed higher scores for implementation than for overall integration, suggesting that teachers were more successful in applying strategies in specific instructional activities than in embedding them systematically throughout whole lesson plans. The study also shows that learner-centered, reflective, and collaborative environments are conducive to SRL strategy instruction. In addition, digital tools supported the use of all four cognitive strategies by enabling interaction, feedback, visualization, collaboration, and authentic task design. Overall, the study demonstrates that structured, theory-informed professional development can help teachers integrate SRL cognitive strategies into everyday instruction and foster more learner-centered, technology-enhanced educational practices. These findings offer practical implications for teacher education, curriculum design, and school-wide efforts to promote independent, strategic, and reflective learning across contexts.

KEYWORDS
cognitive strategies, digital learning technologies, K-12 education, self-regulated learning, teacher professional development

Introduction

Teachers do not have any trouble identifying self-regulated students in their classes (Zimmerman and Martinez-Pons, 1988). They stand out as confident, diligent and resourceful learners. These students are not simply reactive to instructional outcomes, but, when necessary, they take proactive actions to overcome obstacles like puzzling course materials, inappropriate learning environments and confusing teachers (Zimmerman, 1990). Possessing both the will (i.e., motivational components) and the skill (i.e., cognitive components) (Pintrich and De Groot, 1990), they efficiently manage their own learning by setting goals, monitoring themselves, using various strategies, and self-evaluating their achievement (Boekaerts et al., 2000). These students are distinguished as being (meta)cognitively, motivationally, and behaviorally active learners (Zimmerman, 1986).

Although it is quite easy to notice such students, this is not the case when it comes to unveiling the factors that make them self-regulated learners (Credé and Phillips, 2011). SRL is most commonly characterized by three cyclical phases: forethought, performance, and self-reflection (Hashey et al., 2023). The forethought phase includes task analysis and self-motivation beliefs, while the performance phase involves self-control and self-observation. The self-reflection phase focuses on self-judgment and self-reaction (Torre and Daley, 2023). Despite extensive research on self-regulated learning (SRL), its foundations are still not fully understood. The intertwined relation between context, learner, performance, and characteristics makes the inner mechanisms of SRL perplexing (Postholm, 2011). SRL is not a monolithic construct that students either use or do not use (Kaplan, 2008); nor is it a personal trait or a fixed set of skills (Zimmerman, 2002). It becomes more confusing when disentangling the constructs since many of them overlap conceptually such as (meta)cognition, (meta)motivation and volition (Boekaerts, 1996). Researchers have used the terms in different ways, so it is not unusual to notice that one researcher's metacognitive strategy is another researcher's cognitive strategy (Zeidner, 2019). Hence, the most plausible way to define SRL is to identify its key components, which most researchers agree are the cognitive, metacognitive, behavioral, and motivational domains, without getting lost in blurred boundaries. Cognitive strategies are the mental processes that students use so as to acquire understanding, knowledge, and skills (Pintrich, 2000). Metacognition refers to the ability of planning, self-monitoring and self-evaluating the learning process. While the domain of motivation involves attitudes, self-efficacy, competence, and the beliefs that have an impact on the development and the use of cognitive and metacognitive skills (Zimmerman, 2000), the behavioral domain consists of the skills and strategies necessary to create an optimal learning environment that fosters learning (Hashey et al., 2023). To make sense of these overlapping dimensions, the present study draws on several seminal models of SRL.

The current study is grounded in an integrative theoretical framework synthesized from seminal SRL models (Table 1), particularly those developed by Zimmerman, Pintrich, Winne and Hadwin, and Boekaerts. Zimmerman (2000) makes a noted distinction between SRL strategies and SRL processes in his three-phase cyclic model involving forethought (task analysis & self-motivation beliefs), performance (self-control & self-observation), and self-reflection (self-judgment & self-reaction) phases. Aligned with social-cognitive theory, Zimmerman's model underscores the tangled interaction among the dimensions of behavior, motivation, and (meta)cognition in this dynamic process. Pintrich's model (2004) contributes to this perspective by taking into account learners' motivational beliefs and the environmental factors that affect planning, monitoring, and reflection. Additionally, Winne and Hadwin's (2008) COPES model has an explicit metacognitive focus, emphasizing task definition, goal setting, strategic flexibility, and cognitive tactics driven by self-monitoring. Boekaerts' dual-processing model (2011) supports the proposition that students simultaneously strive to achieve both mastery and coping goals, with emotional regulation as part of the broader self-regulation process. Combined, these perspectives offer a comprehensive basis for considering the interplay of cognitive, metacognitive, motivational and affective strategies in SRL activities. Not only does this synthesis further the understanding of theoretical concepts, but it also serves as a guide to the design of teacher education programs. In explicitly bridging theory with teacher practice, the current work makes a distinct contribution to existing SRL literature, providing important clues on how teachers can best support their students' SRL across different education contexts, subjects, and grade levels. The study's distinctive contribution is its focus on teacher-generated post-training lesson plans within an e-professional development program, linking SRL theory, cognitive-strategy instruction, and digital mediation across K-12 contexts while treating the evidence as exploratory rather than causal (Dolmans, 2019).

TABLE 1 Seminal SRL models.

Models	Pre (Planning & Preparation)	While (Performance)	Post (Reflection)
Zimmerman (2000)	Forethought (Task analysis, goal-setting, strategic planning)	Performance (Self-control, monitoring)	Self-reflection (Self-judgment, self-reaction)
Pintrich (2004)	Forethought, planning and activation (Phase 1)	Monitoring (Phase 2) Control of the self, task, context (Phase 3)	Reaction and reflection (Phase 4)
Winne and Hadwin (2008)	Definition of the task (Phase 1) Goals and plans (Phase 2)	Studying tactics and strategies (Phase 3)	Adaptations (Phase 4)
Boekaerts (2011)	Identification, interpretation, primary and secondary appraisal, goal setting	Goal striving	Performance feedback

Because teachers are central to translating SRL theory into classroom practice (Dignath-van Ewijk et al., 2013), professional development is essential for helping them understand and apply these principles effectively (Pressley and Harris, 2006). Effective SRL interventions often focus on specific areas such as cognition and metacognition (Hattie et al., 1996), which are crucial for developing teachers' SRL skills (Ortube et al., 2024). As noted by Randi (2004), a specially designed professional development program involving explicit instruction can help teachers broaden their understanding of SRL (self-regulated learning), which in turn influences their roles, behaviors, beliefs, values, and practices (Adıgüzel et al., 2023; Lombaerts et al., 2009). In order to do so, they need to reconstruct their philosophy of instruction, broaden and/or alter their current teaching skills (Shulman and Shulman, 2004). In addition to direct instruction, dialogue with peers is of paramount importance as collaborative reflection helps teachers gain advanced knowledge and insights (Bartimote-Aufflick et al., 2010). Once teachers develop insights in their own use of SRL, this will help them model the target strategies for their learners (Paris and Winograd, 2001). In the process of becoming a self-regulated learner, students need several supports (Pintrich, 1995). These include teachers modeling target self-regulatory strategies and fostering students' awareness of their own behaviors, cognitions, and motivations (Radovan, 2019). Students also require positive motivational beliefs, opportunities to practice the strategies regularly, and constructive feedback on their use of these strategies (Zimmerman and Moylan, 2009).

Among the dimensions of SRL that teachers can support, the present study focuses specifically on cognitive strategies. The ability to self-regulate is generally associated with improved performance on cognitive tasks (Jonker et al., 2010). Although no consensus exists on a definitive set of cognitive strategies (Yip, 2007), rehearsal, organization, elaboration, and critical thinking are considered fundamental (Bartels et al., 2010). Rehearsal involves repetition to aid memorization (Manganelli et al., 2019), while organization highlights essential information through underlining, diagrams, note-taking, and summarizing (Richardson et al., 2012; Weinstein and Palmer, 2002). Elaboration, involving interpreting, exemplifying, inferencing, and analogizing (Tay, 2013), integrates new knowledge with existing data, promoting higher-order thinking (Bartels et al., 2010; Pintrich and De Groot, 1990). Critical thinking allows learners to evaluate content critically and form opinions (Facione, 2011; Richardson et al., 2012; Vermunt, 1998). Unlike rehearsal and organization, considered surface-level (Rozendaal et al., 2003), elaboration fosters deep processing and long-term retention (Richardson et al., 2012; Soenens et al., 2012).

Cognitive strategies can be identified and enhanced through explicit instruction (Weinstein and Mayer, 1986). Rosenshine and Meister (1992) propose a six-step teaching guideline: introducing the strategy via modeling, adjusting task difficulty during guided practice, practicing in various contexts, providing feedback, gradually increasing student responsibility, and facilitating independent practice. Awareness of cognitive strategies fosters learner autonomy and confidence (Sizoo et al., 2003), while successful students typically utilize diverse strategies (McCann and Turner, 2004) and can effectively evaluate their application in learning (Pokay and Blumenfeld, 1990).

Despite the documented value of explicit strategy instruction, important gaps remain in how SRL cognitive strategies are embedded across K–12 contexts. First, although the cognitive use of SRL strategies is known to be advantageous, the integration of these strategies into regular instruction across grade levels, topics, and subjects remains limited; therefore, research on a comprehensive, embedded training approach is needed (Adıgüzel et al., 2023). Furthermore, extant literature highlights the importance of supportive and autonomy-supportive learning environments for successful SRL development; however, the features of such optimal learning contexts still need to be more clearly defined (Opdenakker, 2022). Additionally, while critical thinking has been widely agreed upon as one of the higher order cognitive strategies in SRL, the explicit teaching and practice of critical thinking within SRL on all levels are underemphasized, which reveals a gap that needs to be further examined (Guo et al., 2023). Finally, while digital technologies have huge potential for supporting SRL (Kizilcec et al., 2017), there is very little evidence of how this potential is put into practice, of how SRL cognitive strategies are intentionally supported by digital tools in routine teaching and learning and teachers' professional development in this area, emerging as a gap that needs further empirical investigation (Elmabaredy and Gencel, 2024). Consequently, structured and theory-informed professional development programs are crucial but currently underrepresented in research, especially those covering diverse educational contexts, subjects, and grade levels comprehensively.

Addressing these gaps, the present study examines a 7-week cognitive-strategy component within a broader 16-week e-professional training program for K-12 teachers, grounding the design in major SRL frameworks. Rather than testing causal effects, the study analyzes post-training lesson plans to explore how SRL cognitive strategies were represented in instructional design, which learning-environment features were planned, how higher-order strategies were addressed across grade levels and subjects, and how digital tools were incorporated. By treating lesson plans as design artifacts rather than as direct evidence of classroom implementation or student learning, the study offers exploratory evidence about teachers' planned integration of SRL cognitive strategies. By answering the following questions, this current study aims to examine how a specially designed teacher training program may support teachers as they plan to assist their learners in gaining SRL cognitive strategies:

1. How can 'SRL cognitive strategies training' be inserted into regular teaching content?
2. What are the characteristics of learning environments suitable for the training of SRL cognitive strategies?
3. How can higher order SRL strategies be implemented across all grade levels, subjects or topics?
4. What is the role of digital learning technologies in SRL cognitive strategies training?

Methodology

The present study employed an exploratory mixed-methods approach that integrated rubric-based quantitative scoring with

qualitative thematic analysis of the same post-training lesson plan corpus. The primary goal was to examine the design and evaluation of a professional development program focused on the cognitive-strategy dimension of SRL for K-12 teachers, with particular attention to how teachers planned to integrate these strategies into regular instruction. Quantitative scoring summarized the extent to which lesson plans represented SRL cognitive-strategy integration, implementation, and technology integration, while qualitative analysis explained how these strategies were planned across activities, grade levels, subjects, digital tools, and learning environments. The two strands were connected during interpretation by comparing rubric patterns with qualitative themes; therefore, the findings are presented as complementary evidence about planned instructional design rather than as causal evidence of program effectiveness.

The professional development program consisted of training on four key SRL strategies: cognitive strategies, role-modeling, self-questioning, and monitoring. For the purposes of this study, the focus was solely on the cognitive strategy component, ensuring that other SRL strategies did not influence the findings. Participant teachers received training on cognitive SRL strategies and were tasked with enriching their lesson plans using these strategies (Appendix A). Their lesson plans were subsequently evaluated using a rubric developed by the researchers, providing quantitative data (Appendix B). In addition, qualitative data were collected by analyzing the lesson plans through thematic analysis to assess how the cognitive strategies were integrated.

The researchers, who were faculty members from different universities, held the trainer role in this self-regulated learning cognitive strategy training program. They have experience of around 10–15 years in SRL, teacher training, cognitive presence, digital learning and K-12 studies. They have produced international scholarly work in these fields; and designed and delivered many teacher-training programs for a wide variety of educational and sectoral institutions. Each trainer held a responsibility ranging from the needs analysis, material and content development, training delivery and assessment stages to the publication stage of the present SRL training. Because the researchers also designed, delivered, and evaluated the training, their dual role may have created risks of confirmation bias and overly positive interpretation. To mitigate this risk, two raters used explicit rubric descriptors, reliability was calculated, peer-debriefing sessions were held, and the research team engaged in reflexive discussions about assumptions during analysis.

Self-regulated learning training program

The 16-week self-regulated learning training plan was designed, implemented and evaluated by the researchers as a continuing and practice-oriented professional development program. The whole program was composed of four topics on how to use cognitive, role modeling, self-questioning and monitoring strategies as SRL dimensions. In the current research, only the first theme, which was cognitive strategy training, was delivered and examined. While the full four-topic SRL program lasted 16 weeks, the cognitive strategy training component was designed to run over a 7-week period. The Kemp instructional design model and community of learning framework (Lave, 1991; Palincsar et al., 1998) were deployed in designing and delivering the program (Butler et al., 2004) as shown in Table 2.

The training began by helping teachers understand SRL through reflection on their instructional experiences, classroom observations, and real-life teaching contexts. This stage enabled trainers to effectively conduct needs and learner analyses. Next, trainers introduced foundational concepts, competencies, and instructional strategies for promoting cognitive skills in students. Teachers participated in interactive sessions focused on applied, data-informed techniques aimed at fostering independent learning skills, critical thinking, and effective management of problem-based and reflective learning processes.

Teachers developed lesson plans incorporating cognitive SRL strategies and prepared reflection reports on their implementation. Trainers provided feedback on these lesson plans before classroom implementation. Online platforms, including Google Classroom and Google Site, facilitated distribution of lesson plans and feedback, promoting an online community of practice where teachers could access peers' plans and related trainer feedback (Broadbent and Poon, 2015).

TABLE 2 SRL professional development program.

Phase	Topics	Tasks	Delivery mode and duration
Introduction	What is SRL?	Suggested readings for teachers	Asynchronous and Synchronous – 1 week
	Teacher as a self-directed learner	Teacher self-evaluation and reflection reports on SRL experiences + Readings	Asynchronous – 1 week
	Teacher as a self-directed teacher	Lesson plans: analysis and reflection	Asynchronous – 1 week
Theme-focused phase[a]	Theoretical and practical introduction	Interactive materials for teachers + Preparing a lesson plan	Synchronous and Asynchronous – 1 week
		Trainer feedback + Implementation on lesson plans	Asynchronous – 1 week
		Reflection on lesson plans	Synchronous and Asynchronous – 1 week
Closing	Wrap-up workshops	Re-implementation + Best Practice Presentations	Synchronous – 1 week

[a]This phase includes all four themes successively, namely cognitive regulation, role-modelling, self-questioning and monitoring.

Training sessions, aligned with the principles of SRL development (Butler et al., 2004), consisted of two synchronous Zoom meetings and two asynchronous sessions via Nearpod. Nearpod allowed trainers to present interactive video content and collect teacher responses through multiple-choice and open-ended questions, enabling ongoing formative assessment of teachers' progress.

In the final stage, teachers and trainers engaged in a collaborative, full-day online event. During this session, participants shared best practices, discussed lesson plans, and engaged in think-aloud activities. Teachers collaborated within subject-specific groups, enriching professional dialogue, collective learning, and reflective practices as a community of learners.

The setting and primary data sources

The foundation school where the study was conducted has a history of more than 100 years in Turkiye. The school offers education from preschool through high school and university with the same foundation's name, serving approximately 5,000 students across multiple campuses in K-12 only, with a philosophy focused on personalized learning, holistic development, and inclusivity, and programs including the International Baccalaureate (IB) Primary Years and Diploma Programs, STEAM education, and foreign language courses in English, German, French, and Spanish.

The training was mandatory school-wide, and the study was conducted with a selected 80 teachers in the 2023–2024 academic year, with the senior management's initiative. There were 20 teachers from each of the four campuses and grade levels. The ages of the teachers ranged from 29 to 45, and they taught at pre-school, elementary, middle, and high schools. Their teaching experience varied between 4 and 20 years, and none had previously received training in cognitive SRL strategies. In terms of education, 50% held a bachelor's degree ($n = 40$), 32.5% a master's degree ($n = 26$), and 12.5% a doctoral degree ($n = 10$). Most teachers were female (75.76%, $n = 61$), with males comprising 24.24% ($n = 19$). Teaching experience ranged from 4 to over 20 years, with the majority having 11–15 years (43.75%, $n = 35$). A total of 24 lesson plans were collected across preschool ($n = 2$), primary ($n = 6$), middle ($n = 8$), and high school ($n = 8$) levels. During lesson-plan production, the 80 teachers worked in collaborative subject- and grade-level groups; therefore, the lesson plan, rather than the individual teacher, served as the unit of analysis.

The broader four-topic SRL training program, (a) cognitive, (b) role modeling, (c) self-questioning, and (d) monitoring, lasted for 16 weeks and yielded collaborative lesson-plan artifacts from the 80 participating teachers: 24 lesson plans on cognitive regulation, 16 on role modeling, 34 on self-questioning, and 26 on monitoring. Because the present study focused only on cognitive SRL strategies, the 24 cognitive-regulation lesson plans formed the analytic corpus. These lesson plans were group products generated during the training rather than 24 separate indicators of individual teacher performance.

The purposeful sampling criteria were operationalized as follows: each included lesson plan had to focus on cognitive SRL strategies rather than the other three SRL topics, contain explicit planned activities related to at least one cognitive strategy, provide enough information to score implementation and technology integration, and represent one of the K-12 grade bands included in the training. The resulting 24 lesson plans therefore represent the cognitive-strategy artifacts generated within the selected school context and should not be interpreted as a statistically representative sample of all participating teachers.

The consent for the cognitive strategy training was taken in an agreement signed by the private school, while parents agreed to take every proper action to improve teachers' capacity in a yearly contract. The online platforms created for the teacher training activities were also open to parents' access in case they wanted to observe the training events, aiming at enriching their children's learning journey.

Data collection and analysis

Primary data were derived from the 24 cognitive-strategy lesson plans and analyzed through a convergent mixed-methods procedure. The quantitative strand used an expert-developed rubric to score three dimensions: integration of SRL cognitive strategies (rehearsal, organization, elaboration, and critical thinking), implementation of these strategies, and technology integration for SRL cognitive strategies. The rubric was developed from the SRL and cognitive-strategy literature and refined through expert consultation with researchers experienced in SRL, teacher education, and educational technology; reviewers checked the alignment, clarity, and sufficiency of the criteria before final scoring. Appendix B presents the descriptors: integration ranges from one cognitive strategy (score 1) to all four strategies (score 4), implementation ranges from introducing a strategy to supporting independent practice, and technology integration ranges from teacher-led introduction to authentic extension activities. The qualitative strand used thematic analysis with inductive coding to explain how strategies were represented in the lesson plans, while deductive coding was used to connect the qualitative evidence to the rubric criteria (Braun and Clarke, 2006; Woiceshyn and Daellenbach, 2018). Two raters scored the lesson plans independently, and reliability testing yielded a strong intraclass correlation coefficient (ICC = 0.93).

For the deductive analysis, the researchers actively searched each lesson plan for evidence corresponding to the three rubric dimensions and assigned scores from 1 to 4. In the quantitative analysis, descriptive statistics were prioritized because the data consisted of a small corpus of post-training lesson plans, not pre-post teacher scores. Normality was explored through Kolmogorov–Smirnov tests and skewness-kurtosis values (Table 3); although Kolmogorov–Smirnov values were significant ($p < 0.05$), skewness and kurtosis values fell within the −2 to +2 range, indicating an acceptable approximation to normality (Field, 2013). Levene's test suggested homogeneous variance ($p = 0.98$), but these assumption checks are reported only to support the exploratory comparison among rubric dimensions.

Because the same 24 lesson plans received scores on all three rubric dimensions, the one-way ANOVA was used only as an exploratory comparison of dimension-level score distributions rather than as a confirmatory test of independent groups or program effectiveness. The dependence among scores means that a repeated-measures ANOVA or non-parametric Friedman

test would be preferable in future studies with full paired data; therefore, the ANOVA and Tukey comparison are interpreted conservatively and are not used to claim causal impact. In all analyses, statistical significance was reported at $p < 0.05$.

No pre-training baseline, comparison group, classroom observation, longitudinal follow-up, or student outcome data were collected. Accordingly, the quantitative scores were interpreted together with qualitative themes to provide a contextualized picture of how SRL cognitive strategies were represented in post-training lesson plans, but they cannot demonstrate teacher improvement, actual classroom enactment, or student learning gains. This triangulation strengthens interpretive depth while keeping the conclusions within the limits of the design.

The study also employed an inductive coding approach, allowing themes to emerge directly from the data without predetermined categories (Saldana and Omasta, 2017). This method aligned with the principles of thematic analysis (Braun and Clarke, 2006) and enabled a grounded interpretation of the lesson plans. The analysis followed a three-phase process: open coding to identify initial concepts, axial coding to explore relationships among codes, and selective coding to refine core themes based on the research questions. Analysis occurred concurrently with data collection, supporting an iterative and responsive process (Morrison et al., 2002).

To ensure trustworthiness, multiple strategies were used. Peer debriefing was conducted post-analysis to assess the credibility of the findings and reduce potential bias (Creswell, 2002). Independent and collaborative coding by multiple researchers enhanced dependability and minimized individual subjectivity. Furthermore, the research team engaged in reflexive practices, critically examining their own assumptions and positionalities throughout the analytic process. This reflexivity contributed to the confirmability and authenticity of the results. To further address researcher positionality, the team explicitly considered how its involvement in designing and delivering the training could shape coding decisions, interpretation of lesson quality, and presentation of findings. Reflexive discussions and peer debriefing were used to challenge overly affirmative interpretations and to distinguish evidence of planned integration from evidence of actual classroom implementation.

Findings & discussion

This section presents the qualitative findings and quantitative results along with the discussions considering the research questions in light of the related literature and the conclusions drawn. This comprehensive analysis aims to provide a detailed understanding of the research findings, offering valuable insights that contribute to the broader academic discourse on SRL cognitive strategies.

The quantitative findings are presented in Table 4 through mean and standard-deviation statistics for the lesson plans based on integration, implementation, and technology integration of SRL cognitive strategies. The implementation dimension had the highest mean score ($M = 3.38$, $SD = 0.65$), followed by technology integration ($M = 3.21$, $SD = 0.72$) and integration ($M = 2.88$, $SD = 0.80$). Grade-level patterns were descriptive only because the number of lesson plans within each level was small; for example, preschool plans showed a higher integration mean ($M = 3.50$), whereas primary-school plans showed a lower integration mean ($M = 2.33$). Overall, the scores suggest that the analyzed lesson plans often included specific SRL-related activities, but they do not provide evidence of pre-training improvement or observed classroom implementation.

The exploratory one-way ANOVA indicated a difference among the three rubric-dimension scores [$F(2, 69) = 2.96$, $p = 0.05$], as shown in Table 5. When the groups were compared using Tukey's test, the only observed difference was between integration ($M = 2.88$, $SD = 0.80$) and implementation ($M = 3.38$, $SD = 0.65$) of SRL cognitive strategies ($p = 0.05$). This pattern suggests that the lesson plans more strongly represented implementation of specific

TABLE 3 Normality statistics.

Kolmogorov–Smirnov	Statistic	*df*	*p*	Skewness	Kurtosis
Integration of SRL CS	.27	24	.00	−.32	−.10
Implementation of SRL CS	.29	24	.00	−.54	−.52
Technology Integration for SRL CS	.24	24	.01	−.34	−.91
Total	.19	24	.02	.18	−1.29

CS, cognitive strategies.

TABLE 4 Descriptive statistics of the teachers' promotion of SRL cognitive strategies.

SRL cognitive strategy	*N*	Min	Max	M	SD	Pre-Sch M	Primary M	Middle M	High M
Integration of SRL CS	24	2	4	2.88	.80	3.50	2.33	3.25	2.75
Implementation of SRL CS	24	2	4	3.38	.65	4.00	2.83	3.63	3.38
Technology Integration for SRL CS	24	2	4	3.21	.72	3.50	2.83	3.25	3.38
Total	24	2.33	4	3.15	.54	3.66	2.66	3.37	3.17

CS, cognitive strategies, $N = 24$.

TABLE 5 Exploratory One-way ANOVA results for rubric dimensions.

Research model	Sum of Squares	df	Mean Square	*F*	*P*
Between groups	3.11	2	1.56	2.96	0.05
Within Groups	36.21	69	0.53		
Total	39.32	71			

activities than systematic integration across the whole lesson design; however, the result is treated as exploratory because the same lesson plans contributed scores to all dimensions.

Our analysis of teachers' lesson plans suggests that teachers may be more adept at incorporating these strategies into the practical aspects of their teaching rather than integrating them conceptually into their overall lesson plans. On the other hand, the lower mean scores in the integration of SRL strategies suggest a potential gap in translating these practices into a more comprehensive, overarching instructional design. It raises questions about the conceptual assimilation of SRL into the broader pedagogical philosophy and planning. Teachers, while proficient in executing specific strategies within the classroom setting (as reflected in the implementation scores), might encounter challenges when it comes to seamlessly embedding these strategies into the broader framework of their overall lesson planning (as indicated by the lower integration scores).

In initiating the discussion on SRL cognitive strategies based on the qualitative data, it is imperative to state the themes emerged from the content analysis of the lesson plans as shown in Table 6.

TABLE 6 Content analysis of lesson plans.

Theme	Category	Code	Frequency (out of 24)
Integrating SRL cognitive strategies training into regular teaching content regardless of grade levels, subjects or topics via various methods and techniques	Cross-Grade & Subject Integration	Cross-Grade Implementation	24
		Cross-Subject Implementation	24
	Varied Instructional Techniques	Use of Graphic Organizers	10
		Note-Taking & Highlighting	7
Creating an optimal learning environment to teach SRL cognitive strategies	Collaborative Learning Environment	Group Work & Collaboration	5
		Peer Discussion & Questioning	8
	Reflective & Supportive Environment	Self-Evaluation & Reflection	12
		Use of Rubrics/ Guidance	5
Focusing more on critical thinking strategies across all grade levels	Inquiry & Analysis	Questioning & Problem-Posing	15
		Analysis & Inference	18
	Evaluation & Reflection	Reflecting on Learning Outcomes	15
		Justification & Reasoning	20
Facilitating SRL cognitive strategies training through digital learning technologies	Digital Tools for SRL	Collaborative Digital Platforms	20
		Digital Flashcards & Quizzes	16
	Multimedia & Visual Aids	Animated Media Content	21
		Visual Media & Images	22

Integrating SRL cognitive strategies training into regular teaching content

Analysis of the teachers' lesson plans indicated that SRL cognitive strategies were planned across the sampled grade levels and subject areas. Rehearsal and organization appeared through repetition, memorization, color-coding, note taking, mapping, and categorizing, whereas elaboration and critical thinking appeared through comparison, inference, justification, reflection, and product creation. These patterns suggest broad planned coverage of the four cognitive strategies, but they should be interpreted as evidence of lesson-plan design rather than evidence of the quality or consistency of classroom enactment.

Because rehearsal and organization are commonly treated as surface-level strategies, their planned use appeared to support memory and structure, while elaboration and critical thinking appeared to support deeper processing and interpretation. This distinction helps explain how teachers designed SRL opportunities within regular content without implying that students' actual strategy use or learning outcomes were measured.

At the kindergarten level, the lesson plans included planned opportunities for all four SRL cognitive strategies. Rehearsal was represented through recalling national revolutions (L1), organization through mapping traffic signs (L2), elaboration through connecting visuals to historical events and interpreting images (L1, L2), and critical thinking through questions about revolutions, self-expression, and hypothetical scenarios (L2). These examples suggest that teachers can design age-appropriate SRL strategy activities for early learners, although the study did not observe whether kindergarten students enacted the strategies during instruction.

At the primary level, the lesson plans represented SRL cognitive strategies across language, social science, and foreign-language subjects (González et al., 2018). Organization was planned through underlining keywords (L8), grouping words (L7), and color-coding routines (L4), while elaboration and critical thinking were planned through inference, comparison, tourist-visit planning, recipe creation, and story evaluation (L3, L7, L8) (Phan, 2010). These plans suggest that higher-order strategy opportunities can be designed for primary learners, but they do not establish effectiveness at this grade level (Paul and Elder, 2006).

At the middle-school level, the lesson plans combined rehearsal and organization with planned elaboration and critical-thinking tasks in history, science, mathematics, and social science. Examples included mnemonics (L13), repeated measurement units (L12), sequencing words (L9), mapping tea production (L11), linking visuals (L9), solving algebraic problems (L10), comparing foreign policies (L15), and evaluating measurement methods or paper-use solutions (L11, L12). The evidence therefore points to planned strategic variety rather than observed mastery of SRL strategies.

At the high-school level, the lesson plans emphasized critical thinking alongside elaboration and organization in advanced subjects such as geography, chemistry, physics, biology, and foreign language (Zhang and Zou, 2022). Planned tasks included highlighting, listing, sequencing, linking terms to visuals, interpreting population pyramids, exploring citizenship, connecting poems to real life, justifying claims, and engaging in self-reflection (L17-L24). These examples support the feasibility of designing age-appropriate critical-thinking tasks at the high-school level, while claims about real-world problem solving or student outcomes require further evidence.

Creating an optimal learning environment to teach SRL cognitive strategies

Learning environments play a crucial role in shaping learning opportunities and learner development (Zulfiqar et al., 2018), and teachers have a central role in designing effective instructional settings (Lim and Barnes, 2002). Teaching SRL cognitive strategies requires teachers to adopt roles that support autonomy, reflection, modeling, feedback, and gradual release of responsibility (Lombaerts et al., 2009). Analysis of the lesson plans indicated that teachers planned several features associated with SRL-supportive environments, including student-centered tasks, collaboration, reflection, teacher modeling, feedback, and independent practice (Pires et al., 2020).

Unlike traditional teacher-centered classrooms, SRL-oriented environments require planned opportunities for student autonomy and participation (Stefanou et al., 2013). In the analyzed lesson plans, students were expected to take active roles through tasks such as creating imaginary dialogues (L21), proposing paper-saving solutions (L11), and participating in peer collaboration (Walker, 2003). These planned tasks are consistent with cooperative strategy-training environments (Baeten et al., 2010), but classroom observation would be needed to verify how these interactions occurred in practice.

The lesson plans also included planned mechanisms for self-awareness, modeling, and gradual release of responsibility. Examples included students critiquing their own stories with a rubric (L7), teachers modeling mnemonic creation before student practice (L13), and students writing poems based on genre features (L24). These activities reflect principles of strategy instruction and learner agency, while remaining evidence of instructional design rather than observed learner behavior.

Feedback mechanisms were planned through checklists and reflective questions designed to guide learning and address gaps (Han, 2014; Pintrich, 1995). Lessons such as L14, L20, L3, and L24 emphasized reflection on both process and product, supporting the feedback loop proposed by Rosenshine and Meister (1992). Overall, the findings suggest that SRL strategies were planned as part of regular content teaching rather than as separate add-ons, but the degree of actual classroom integration remains a matter for future observation-based research.

Focusing more on critical thinking strategies across all grade levels

The findings do not indicate that grade level is irrelevant to the acquisition of critical-thinking skills; rather, they suggest that teachers in this study were able to design age-appropriate critical-thinking opportunities across the sampled grade levels. This interpretation is more cautious than claiming that the training proved effectiveness across levels, because the evidence consists of post-training lesson plans rather than observed student performance. In this sense, the study complements previous work on metacognition and critical thinking (Ku and Ho, 2010; Park and Yun, 2017) by showing how teachers planned critical-thinking tasks within SRL-oriented lesson designs.

Examples of planned critical-thinking activities appeared across all grade bands. Kindergarten plans included questioning the need for revolutions (L1) and considering alternative possibilities (L2); primary plans included evaluating products and plans, creating environmental-awareness materials, critiquing stories with rubrics, and creating a recipe based on Zimbabwean cuisine (L3–L8); middle-school plans included justifying difficult vocabulary, reflecting on algebraic problem-solving steps, proposing paper-saving ideas, evaluating measurement strategies, and finding alternative solutions (L9–L15); and high-school plans included evaluating digital tools, connecting lesson information to learning outcomes, and assessing a learning task with a rubric (L17–L21). These examples show planned breadth across grade levels while avoiding the claim that students mastered critical thinking equally across levels.

These findings suggest that critical-thinking tasks can be planned for diverse K-12 contexts when teachers receive structured professional support, but they do not prove that learners gained or excelled in critical thinking processes. A plausible explanation for the breadth of the planned tasks is the school context, where teachers had access to continuous and complementary professional development in active learning, SRL, and digital learning strategies. Future studies should examine whether similar plans are enacted in classrooms and whether they influence student learning over time. Supplementary Material displays the matrix of levels, subjects and topics examined in this research.

Facilitating SRL cognitive strategies training through digital learning technologies

This study offers exploratory insights into how digital learning tools were incorporated into teachers' planned SRL cognitive-strategy activities as displayed in Table 7. In the current education landscape, technology can enrich learning opportunities by providing access to resources, prompts, interaction, collaboration, and feedback (Means et al., 2013). In the analyzed lesson plans and training process, education technology was represented across

TABLE 7 Technologies employed for particular SRL cognitive strategies.

Digital learning tools	Rehearsal	Organization	Elaboration	Critical thinking
Technology	YouTube Video	Mindmeister	Padlet	Google Classroom
	EdPuzzle	Nearpod	Phet Simulation	Breakout Rooms
	Padlet	Coggle	Chatterpix	Canva
	Mentimeter	Padlet	Nearpod	Google Forms
	Flipgrid		Pictramap	Quizlet
	SebitVCloud		Phet	Wizer.me
	Wordwall		Jamboard	Google Docs

rehearsal, organization, elaboration, and critical-thinking activities, but the study does not measure the independent impact of these tools on student SRL development (Liu et al., 2013).

In the professional development process, Google Classroom and Google Site functioned as organizational infrastructures for sharing lesson plans, trainer feedback, and peer examples, thereby supporting teachers' monitoring and revision of instructional designs. Zoom supported synchronous explanation, modeling, think-aloud discussion, and collaborative reflection, while Nearpod supported interactive video, polls, open-ended prompts, and formative checks that helped teachers and students engage with rehearsal, organization, and critical-thinking tasks. In the lesson plans, Padlet was especially useful for brainstorming, recall, exit tickets, and visual organization, and Google Docs supported collaborative elaboration through shared writing, peer feedback, and revision.

At the strategy level, tools such as YouTube, EdPuzzle, Wordwall, Quizlet, Mentimeter, and Nearpod were most useful for rehearsal because they supported repetition, retrieval practice, interactive questioning, and immediate response collection. Mindmeister, Coggle, Padlet, and similar mapping tools supported organization by helping learners arrange concepts, sequences, and relationships visually. Google Docs, Padlet, PhET simulations, Pictramap, and Chatterpix supported elaboration by encouraging learners to connect new information with prior knowledge, visuals, examples, simulations, or personal interpretations. Nearpod open-ended tasks, breakout rooms, Google Forms, Canva, Jamboard, and Google Docs supported critical thinking by enabling justification, comparison, peer discussion, evaluation of products, and creation of authentic materials.

Thus, the most useful tools varied by SRL process: retrieval and quiz tools supported rehearsal, mapping tools supported organization, collaborative writing and simulation tools supported elaboration, and discussion, evaluation, and creation tools supported critical thinking. The findings therefore move beyond listing technologies by showing how tool affordances were matched to specific planned cognitive-strategy functions.

Conclusion

The findings suggest that the e-professional training was associated with lesson plans that contained planned opportunities for SRL cognitive-strategy integration, implementation, and technology-supported learning. The strongest pattern was not a demonstrated causal effect, but an exploratory indication that teachers' post-training lesson plans frequently included rehearsal, organization, elaboration, and critical-thinking activities across different subjects and grade bands. The study contributes to SRL literature by connecting an integrative theoretical framework with an e-professional development model and by analyzing teacher-generated lesson plans as artifacts of planned SRL instruction. It also highlights practical ways in which digital tools can support specific cognitive-strategy functions, particularly retrieval practice, visual organization, collaborative elaboration, feedback, and evaluation. At the same time, the results should be interpreted as evidence of planned instructional design, not as proof of classroom transformation, teacher improvement, or student learning gains.

As in other studies, this research has limitations that restrict the strength and generalizability of the conclusions. The study was conducted in a single private/foundation school context, despite the inclusion of four campuses, many in-service teachers, and varied subjects. Only 24 cognitive-strategy lesson plans were analyzed, and these were collaborative lesson-plan artifacts rather than individual teacher-level measures. The design did not include pre-test/post-test data, a comparison group, classroom observations, longitudinal follow-up, or student outcome evidence; therefore, the findings cannot establish causal effectiveness, actual implementation quality, long-term teaching change, or effects on learners' products. Future studies could include classroom observation, student data, larger and more diverse school contexts, cross-cultural comparisons, and longitudinal follow-up to examine how planned SRL strategies are enacted and sustained. Further research could also explore parental involvement and the tertiary level (Heikkila et al., 2011), while distinguishing clearly between planned instruction, implemented instruction, and student learning outcomes.

Data availability statement

The original contributions presented in the study are included in the article/Supplementary Material, further inquiries can be directed to the corresponding author.

Ethics statement

The studies involving humans were approved by FMV Işık okulları (Feyziye Mektepleri Vakfı). The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

MK: Writing – original draft, Writing – review & editing. MB: Writing – original draft, Writing – review & editing. GA: Writing – original draft, Writing – review & editing. TA: Writing – original draft, Writing – review & editing.

Funding

The author(s) declared that financial support was not received for this work and/or its publication.

Conflict of interest

The author(s) declared that this work was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Generative AI statement

The author(s) declared that generative AI was used in the creation of this manuscript. The authors declare that Gen AI was used in the creation of this manuscript. This manuscript utilized ChatGPT to enhance language clarity.

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Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fhumd.2026.1847136/full#supplementary-material

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10.3389/fhumd.2026.1847136

Appendix A Sample Lesson Plan.

Level: High School	Subject: Geography	Class Size: 18

Lesson Objective: By the end of the lesson, students will be able to identify and analyze the five basic types of population pyramids, infer demographic trends, and justify the characteristic shapes of these pyramids using self-regulated cognitive strategies.

Stage & stage aims	Procedures	Interaction Patterns	SRL strategies & specific activities	Timing
Warm-Up (Recall key concepts)	Students individually recall and post the five basic population pyramid types on Padlet. Class reviews and collectively repeats these concepts.	Individual → Whole-class	Rehearsal: Repeating the five basic types of population pyramids on Padlet	5 min
Interactive Presentation (Highlight and structure information)	Students use Nearpod to visually highlight densely populated areas on a world map. They participate in interactive polls to identify pyramid types; teacher annotates characteristics.	Individual → Whole-class	Organization: Highlighting dense population areas and identifying characteristics of pyramids through Nearpod activities	10 min
Group Activity (Connect new examples to prior knowledge)	Students analyze specific population pyramids collaboratively in Google Docs, explicitly discussing and recording connections between new examples and prior knowledge.	Small-group Collaboration	Elaboration: Making explicit connections between newly introduced population pyramids and previously learned demographic concepts in Google Docs	15 min
Critical Thinking Discussion (Analyze and justify)	Students individually submit open-ended responses via Nearpod, making inferences about the implications of population pyramids and justifying their pyramid shapes. Class discusses selected responses.	Individual → Whole-class	Critical Thinking: Making inferences about demographic trends and justifying the shape of population pyramids in Nearpod discussions	10 min
Conclusion & Assessment (Recap and Reflect)	Class collectively repeats pyramid types; students individually write brief reflections about demographic implications on Padlet as exit tickets. Teacher reviews and provides immediate feedback.	Individual → Whole-class	Rehearsal & Critical Thinking: Repetition of key pyramid types; Reflection and evaluation of demographic implications via Padlet	5 min

Appendix B Rubric for SRL Cognitive Strategies.

	1	2	3	4
Integration of SRL Cognitive Strategies The teacher uses…	One cognitive strategy (e.g., rehearsal) in the lesson plan.	Two cognitive strategies (e.g., rehearsal and organization) in the lesson plan.	Three cognitive strategies (e.g., rehearsal, organization, and elaboration) in the lesson plan.	Four cognitive strategies (e.g., rehearsal, organization, elaboration, and critical thinking) in the lesson plan.
Implementation of SRL Cognitive Strategies	Introducing new cognitive strategy	Introducing new cognitive strategy + Adjusting difficulty and providing various contexts for practice	Introducing new cognitive strategy + Adjusting difficulty and providing various contexts for practice + Giving teacher/peer/group-feedback opportunity	Introducing new cognitive strategy + Adjusting difficulty and providing various contexts for practice + Giving teacher/peer/group-feedback opportunity + Increasing student responsibility and independent practice
Technology Integration for SRL Cognitive Strategies	Introduction Level Teacher uses learning technology tool to introduce content	Engagement Level Students use learning technology tool to engage in content in low-order skills (answering, clicking, yes/no, commenting)	Enhancement Level Students use learning technology tool to enhance content in high-order skills (collaborating, reviewing, creating, evaluating)	Extension Level Students use learning technology tool to extend content to real life contexts (creating authentic materials, news stories, projects, applications, outside-the-class activities)