Investigating Pedagogical Agents’ Scaffolding of Self-regulated Learning in Relation to Learners’ Subgoals

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**Abstract.** Self-regulated learning (SRL) is required during learning with intelligent tutoring systems (ITSs) as learners need to monitor and regulate cognitive, affective, metacognitive, and motivational processes. Efficient SRL enables learners to distinguish between instructional material relevant towards their goals from extraneous and potentially irrelevant information. However, not all learners can make this distinction. As such, ITSs incorporate pedagogical agents (PAs) to scaffold SRL through cognitive and metacognitive prompts which engage learners in deploying SRL and then provide feedback on accurate strategy use within context (i.e., time-on-task and in relation to subgoals set prior to learning). This study examines how PAs scaffold SRL during learning with MetaTutor, an ITS on the human circulatory system. Undergraduate learners’ (N=60) log-file data captured (1) when strategies were used, (2) who initiated the strategy (i.e., learner, PA), and (3) when instructional materials were (ir)relevant to the previously set learner subgoals. Results found learners engaged in significantly more strategies when the page was fully relevant to at least one subgoal. Further, results showed learners self-self-initiated strategies more regardless of content relevance but PAs prompted more strategies when content was relevant versus irrelevant to a subgoal. Finally, SRL strategy frequency on relevant content decreased as time-on-task increased where self-initiated strategy use decreased at a significantly greater rate than prompted strategies. Findings show how production rules guiding PA instructional behaviors can better scaffold SRL – through contextualizing SRL strategies to the instructional content and in relation to the relevance of the content to learners’ subgoals.

**Keywords:** Intelligent Tutoring Systems, Self-regulated Learning, Pedagogical Agents, Subgoals.

1. Introduction

Self-regulated learning (SRL) refers to one’s ability to monitor and change their own cognitive, affective, metacognitive, and motivational processes during learning (Azevedo & Winne, 2022; Winne, 2018). Theories of SRL situate learners as active participants where learners set goals, develop plans to reach their goals, enact strategies during learning, and evaluate deployed strategies as effective in attaining progress towards goals (Winne, 2018). When deploying SRL strategies, tactics used to engage in SRL such as evaluating content as relevant to a goal or summarizing information, learners can constantly evaluate their progress towards goals and subgoals. However, most learners struggle with efficiently and effectively using SRL strategies to attain their goals (Josephsen, 2017). Because of this, there is a need for SRL to be scaffolded, especially as learners manage multiple goals while learning about complex STEM topics.

Intelligent tutoring systems (ITSs) serve as platforms for knowledge acquisition by presenting instructional content (e.g., text, diagrams), often with embedded scaffolding. For example, ITSs typically incorporate pedagogical agents (PAs) which are lifelike artificial characters that can prompt learners to engage in an SRL strategy and provide feedback on learners’ accuracy in deploying that strategy (Johnson & Lester, 2016; Schroeder et al., 2017; Sikstrom et al., 2022). The goal of this study is to investigate how learners are scaffolded by PAs’ external regulation of their SRL as they learn with intelligent tutoring systems (ITSs). Specifically, this study examines how both PAs prompt and learners self-initiate SRL strategies when instructional information is encountered and how this may change when the content is either relevant or irrelevant to achieving learners’ subgoals.

1. Theoretical Framework

In this study, we examined PAs' scaffolding during learning with an ITS using Kramarski & Heaysman’s (2021) model of SRL and self-regulated teaching (SRT). The SRL-SRT model dictates the relationships between three different types of self-regulation including teachers as learners deploying SRL, teachers regulating their own SRT practices (teacher-focused SRT), and teachers guiding learners’ SRL (learner-focused SRT). To be effective facilitators of learners’ SRL, teachers must be proficient in SRL themselves as learners as well as use SRT during their teaching practices. However, this model assumes that teachers carry the full knowledge and understanding of how to deploy SRL during learning and teaching as well as facilitate learners’ self-regulation. Within this study, we extend the SRL-SRT model to consider PAs as teachers. We consider PAs, supported by production rules set by SRL experts, to have the full knowledge of SRL strategies including when to deploy these strategies. As such, this study focuses on how PAs demonstrate SRT practices and scaffold learners’ SRL to attain their subgoals during learning with an ITS.

1. Pedagogical Agents as Scaffolders of SRL

Findings from several studies have supported the effectiveness of PAs on learning outcomes, and specifically as scaffolders of SRL. For example, a study by Dever et al. (2022) found that learners who received prompts from PAs to engage in SRL strategies not only demonstrated greater learning outcomes but also better overall functional deployment of SRL strategies. This study also found that learners will self-initiate more SRL strategies when they receive external scaffolding by a pedagogical agent which demonstrates that PAs not only supplement learners’ SRL strategy use but also encourage learners to deploy their own strategies. Harley et al. (2017) found that when learners collaboratively set subgoals with PAs prior to their learning session, learning outcomes increased compared to subgoals set without learner-PA collaborations. Similarly, results from a study by Lallé et al. (2017) showed that when learners demonstrated performance goal orientation, learning gains increased when the duration and rate of eye-gaze fixations on PAs increased. Finally, Wiedbusch et al. (2021) used principal component analysis to find that PAs supported the use of SRL strategies as the PAs themselves followed Winne’s (2018) information process theory of SRL. However, there exists a large body of literature that counters findings from the aforementioned studies, citing that PAs do not significantly enhance learning outcomes (Schroeder et al., 2013, 2015). Because of these mixed findings, this study aims to understand how PAs are currently used in ITSs and identify areas for improving how PAs can support SRL over time throughout a learning task.

While multiple studies have evaluated the effectiveness of PAs as external facilitators of learners’ SRL (Azevedo et al., 2022; Sikström et al., 2022; Taub et al., 2015), limited studies have examined the importance of PAs in scaffolding SRL strategies in relation to set subgoals. Subgoals have been shown to be essential for guiding learning as well as an integral part of SRL. A study by Urgo and Arguello (2023) showed that, overall, setting subgoals was important for planning and monitoring processes but that the initiator of the subgoals were important to consider for learning outcomes. Specifically, when learners set their own subgoals, learning outcomes increased. As such, it is important to consider how learners deploy SRL strategies with external regulation from a PA in relation to learner-set subgoals during learning with an ITS.

1. Current Study

The overall goal of the current study was to examine how PAs can scaffold learners’ SRL by externally-regulating learners’ strategy use contextualized to the subgoals set by learners at the beginning of their task. This study will extend current literature to identify PAs as virtual teachers of SRL and further the development of PA adaptability through understanding how current PA instructional behaviors scaffold learner SRL deployment. This study aims to achieve these goals by addressing four research questions:

*Research Question 1*: *Are there differences in the frequency of SRL strategy use when instructional content is relevant versus irrelevant to a learner’s subgoal?* We hypothesize that, with PA prompt and feedback scaffolds, there will be a greater frequency of SRL strategy use when the instructional content is relevant to learners’ subgoals rather than irrelevant. This is supported by prior literature that state that PAs are effective in scaffolding SRL (Azevedo et al., 2022; Dever et al., 2022; Harley et al., 2017; Lallé et al., 2017; Sikström et al., 2022; Taub et al., 2015; Wiedbusch et al., 2021).

*Research Question 2: Does the frequency of SRL strategy-use on relevant and irrelevant content pages significantly differ between initiators?* Based on prior research (Dever et al., 2022), we hypothesize that learners will self-initiate SRL strategies more than PAs. Second, we hypothesize that there will be a difference in the frequency of SRL strategy use on relevant versus irrelevant content but do not hypothesize a direction due to lack of prior literature.

*Research Question 3*: *What is the likelihood that instructional content will be relevant to learners’ subgoals based on when SRL strategies are initiated over learners’ time on task and the initiator of the SRL strategy?* Based on literature which supports PAs as effective scaffolders of SRL (Azevedo et al., 2022; Dever et al., 2022; Harley et al., 2017; Lallé et al., 2017; Wiedbusch et al., 2021), we hypothesize that the likelihood instructional content are relevant to learners’ subgoals will be higher if PAs are the initiators of SRL strategies and if SRL strategies are initiated consistently across learners’ time on task, indicating a constant deployment of SRL essential for learning (Winne, 2018).

*Research Question 4: What is the likelihood that instructional content will be relevant to learners’ subgoals based on when SRL strategies are initiated over learners’ time on a content page and the initiator of the SRL strategy?* Prior literature supporting the effectiveness of PAs in scaffolding SRL (Azevedo et al., 2022; Dever et al., 2022; Harley et al., 2017; Lallé et al., 2017; Wiedbusch et al., 2021) leads to the hypothesis that the likelihood instructional materials are relevant to learners’ subgoals will be higher if PAs are the initiators of SRL strategies and if learners spend more time on the content page.

1. Methodology
   1. Participants

120 undergraduate students were recruited to participate in a two-day study, split between one of two conditions: (1) the Control condition (*N* = 60) in which participants did not receive PA prompts and feedback but could self-initiate an SRL strategy by selecting one from the SRL palette (see MetaTutor Section); and (2) the Prompt and Feedback condition (*N* = 60) where the participants both received prompts from PAs to engage in SRL strategies and self-initiated SRL strategies as they learned with MetaTutor. For the purposes of this current study, we only used data from the 60 participants in the Prompt and Feedback condition (60% female; RangeAGE = 18 – 28; *M*AGE = 20.2; *SD*AGE = 2.19) to identify how PAs instructional behaviors directly relate to how learners deploy SRL strategies and the likelihood that the instructional materials will be relevant to the learners’ subgoals. After completing their task in MetaTutor, participants were compensated ($10/hr., up to $40) for their time.

* 1. MetaTutor: An ITS about the Human Circulatory System

### Interface. To examine how PAs scaffold learners’ self-regulation during learning, this study used MetaTutor as the ITS for this experimental study (see Azevedo et al, 2022 for details). MetaTutor, a hypermedia-based ITS, was designed to teach participants about the circulatory system. To do so, MetaTutor used 47 content pages of instructional text and diagrams with four embedded PAs to prompt participants to engage in SRL strategies. MetaTutor was designed to support SRL strategy use through several features including: (1) a table of contents to afford participants the opportunity to select the most appropriate pages relevant to their learning goals and subgoals; (2) a progress bar and a timer to allow participants to monitor progress toward learning goals; (3) text and diagrams to afford participants the opportunity to acquire knowledge and coordinate information; (4) an SRL palette to offer participants the opportunity to identify and select SRL strategies while exploring instructional content; and (5) one of four PAs to interact with participants depending on the triggered production rules, each supporting a specific component of SRL.

### Pedagogical Agents. PAs within MetaTutor were designed to verbally prompt participants to engage in SRL strategies based off production rules and provide feedback on learners’ success in using the strategy. Specifically, a strategy was prompted based on time thresholds and behavioral conditions. Each PA was developed to represent four different SRL functions – guide participants through the system, engage in planning, monitor their progress, and use learning strategies. Gavin the Guide helps students to navigate through the system by highlighting tools and orienting the students about the task. Pam the Planner supports participants in setting appropriate sub-goals (PLAN), activating their prior knowledge (PKA), and coordinating sub-goals. Mary the Monitor helps participants monitor their progress toward their subgoals (MPTGs), deploy content evaluations (CEs), engage in judgments of learning (JOLs), and report feelings of knowing (FOKs). Sam the Strategizer helps participants summarizing (SUMM) and taking notes (TN), and making inferences (INF; see Azevedo & Dever, 2022 for details). Log-file data were collected for each participant to identify how participants interacted with the MetaTutor environment. These data captured which SRL strategy was used, the time at which the strategy was initiated, and who the initiator of the strategy was – either prompted by the PAs or self-initiated by the participant.

* 1. Experimental Procedure

Two sessions of the experiment were conducted. During Session 1, participants gave consent, answered demographic inquiries as well as self-report questionnaires measuring motivation and emotions, and completed a 30-item multiple-choice pretest on the knowledge base covered by MetaTutor (e.g., human circulatory system knowledge items). During Session 2, participants were calibrated to an eye tracker, an electrodermal activity bracelet, and facial recognition software as well as taught how to think-aloud using a think-aloud training protocol. At the start of the MetaTutor learning task, participants were required to establish two subgoals. Participants were instructed to complete the subgoals by utilizing tools within the environment, including texts and diagrams on content pages, and by deploying SRL strategies Students in both conditions were prompted to complete an Emotions Value (EV) questionnaire roughly every 14 minutes throughout the instructional period. After completing their learning task during Session 2, participants completed a 30-item multiple-choice post-test and self-report questionnaires that assessed motivation and emotion regulation. Participants were then compensated $10 per hour (up to $40) and thanked for their participation.

* 1. Coding and Scoring

### SRL Strategies. SRL strategies were identified using log files. Participants could either self-initiate SRL strategies using the MetaTutor interface and specifically the SRL palette or accept a prompt by a PA to engage in a strategy. Within this study, we included the SRL strategies of content evaluations, prior knowledge activation, summarizing, note taking, feelings of knowledge (FOKs), judgements of learning (JOLs), monitoring progress towards goals, and planning. Inferences were not included within the dataset as very few participants used the strategy.

### Page Relevance. The relevance of an instructional material page in MetaTutor was pre-determined by the system by several subject matter experts where, depending on the two subgoals participants chose, the content page would be labeled as relevant, irrelevant, or partially relevant for each subgoal. Pages that are fully relevant consist of five labels: (1) 0, 1; (2) 1, 1; (3) 1,0; (4) 0.5, 1; and (5) 1, 0.5. Pages that were not fully relevant consist of four labels: (1) 0, 0; (2) 0, 0.5; (3) 0.5, 0; and (4) 0.5, 0.5. For example, when a participant selected a content page the relevance could be labeled: “0 , 0.5”. This would indicate that the page was not relevant to the participant’s first subgoal but was partially relevant to the second subgoal. Two classification groups were created – pages that are fully relevant versus pages that are not fully relevant (hereby after referred to as irrelevant). In defining these groups, we are able to identify if and when an SRL strategy was initiated on a page that was fully relevant to at least one subgoal.

### Relative Task Time. This metric scaled all participants’ time on task from 0 to 1. In doing so, we are able to compare across participants and control for how long they took to complete the task when identifying at what point in time an SRL strategy was initiated. To calculate relative task time, the time at which an SRL strategy was initiated was divided by the participants’ total time on task. For example, if a participant initiated a content evaluation at minute 30 and they spent 50 minutes on task, then the participant initiated the strategy at 0.60, or 60% into their task.

1. Results
   1. Research Question 1: Are there differences in the frequency of SRL strategy use when instructional content is relevant versus irrelevant to a learner’s subgoal?

A paired *t*-test examined how learners differed in their frequency of SRL strategies when the instructional material was fully relevant versus not fully relevant to a learner’s subgoal. Results showed that learners engaged in significantly more strategies when the page was relevant to at least one subgoal (*M* = 32.7, *SD =* 14.8) than when the page was irrelevant (*M* = 14.8, *SD* = 9.31; *t*(59) = 7.74, *p* < .01).

* 1. Research Question 2: Does the frequency of SRL strategy-use on relevant and irrelevant content pages significantly differ between initiators?

A MANOVA was conducted to identify if the frequency of SRL strategy use on relevant and irrelevant pages was significantly different depending on the initiator of the strategy. Results indicated an overall statistically significant multivariate difference (Pillais’s Trace = 0.20; *F*(2,117) = 14.6, *p* < .01).

Post-hoc one-way ANOVAs found a significant difference between initiators for frequency of SRL strategies on both relevant (*F*(1,118) = 7.16, *p* < .01) and irrelevant (*F*(1,118) = 26.4, *p* < .01) content pages where learners self-initiated a greater number of SRL strategies on both fully relevant (*M* = 19.0, *SD* = 13.8) and irrelevant (*M* = 10.35, *SD* = 8.39)instructional content pages than PA prompted strategies (*M*RELEVANT = 13.92, *SD*RELEVANT= 5.3; *M*IRRELEVANT = 4.47, *SD*IRRELEVANT = 2.9). Simply, the frequency of SRL strategy use was greater when the instructional content was fully relevant to the learner’s subgoals and learners self-initiated a significantly greater number of strategies than PA prompts.

* 1. Research Question 3: What is the likelihood that instructional content will be relevant to learners’ subgoals based on when SRL strategies are initiated over learners’ time on task and the initiator of the SRL strategy?

We examined the probability that a content page was relevant to at least one subgoal when either a learner or PA deployed an SRL strategy taking into account time on task and initiator using a mixed effects growth logistic regression model. This model included relative time on task, initiator (i.e., learner versus PA), and the interaction between the two factors as independent variables with the dependent variable as the relevance of instructional materials to the learners’ subgoals (i.e., 1 = fully relevant, 0 = not fully relevant). Across all data, the model had 2848 observations nested within the 60 participants. Model results showed a significant intercept (B = 1.46, SE = 0.16; *p* < .01), main effect of time on task (B = -1.61, SE = 0.21; *p* < .01), and an interaction effect between time on task and initiator (B = 1.15, SE = 0.33; *p* < .01) with a nonsignificant main effect of only initiator (*p* > .05; see Table 1).

**Table 1.** Model statistics for predicting the relevance of content pages for initiator and time on task.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Variable | B | SE | *p*-value | Odds Ratio (eb) |
| Intercept | 1.46 | 0.16 | *p* < .01\* | 4.32 |
| Time on Task | -1.61 | 0.21 | *p* < .01\* | 0.20 |
| Initiator | -0.04 | 0.18 | *p >* .05 | 0.96 |
| Time on Task\*Initiator | 1.15 | 0.33 | *p* < .01\* | 3.14 |

Results from this model show that content is 4.32 times more likely to be relevant to learners’ subgoals if learners immediately self-initiate an SRL strategy when the task began. However, as time increases, content pages are 0.20 times less likely to be relevant towards learners’ subgoals. Further, as time on task progresses, content is 3.14 times more likely to be relevant towards a learner’s subgoals if PAs prompt the strategy versus if the learner self-initiates the SRL strategy (see Figure 1). However, the likelihood of a strategy being deployed on a relevant content page decreased at a lower rate when the initiator was a PA, thereby demonstrating the effectiveness of PAs in prompting SRL strategies at appropriate times.

Chart, line chart

Description automatically generated

**Fig. 1.** Graph depicting the probability content pages will be relevant to a subgoal depending on when an SRL strategy was initiated over learners’ time on task and the initiator of the strategy.

* 1. Research Question 4: What is the likelihood that instructional content will be relevant to learners’ subgoals based on when SRL strategies are initiated over learners’ time on a content page and the initiator of the SRL strategy?

We ran another mixed effects growth logistic regression model to examine the probability that a learner versus a PA will deploy an SRL strategy on relevant versus irrelevant instructional materials as time progresses on an instructional material page. This model included time on instructional content page (seconds), initiator (i.e., learner versus PA), and the interaction between the two factors as independent variables with the dependent variable as the relevance of instructional materials to the learners’ subgoals (i.e., 1 = fully relevant, 0 = not fully relevant).

**Table 2.** Model statistics for predicting the relevance of content pages for initiator and time on content.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Variable | B | SE | *p*-value | Odds Ratio (eb) |
| Intercept | 0.28 | 0.12 | *p* < .05\* | 1.33 |
| Time on Content Page | 0.001 | 0.00 | *p* < .01\* | 1.00 |
| Initiator | 0.78 | 0.13 | *p <* .01\* | 2.18 |
| Time on Task\*Initiator | 0.001 | 0.00 | *p >* .05 | 1.00 |

Overall, there were significant main effects of time on content page (B = 0.001, SE = 0.0; *p* < .01) and initiator (B = 0.78, SE = 0.13; *p* < .01) but no significant interaction effect (see Table 2). A content page is 1.33 times more likely to be relevant to a learner’s subgoals if the PA prompts the SRL strategy at the very beginning of time on a content page. Further, as the time at which an SRL strategy is initiated on a content page increases, the content page is 1.0 times more likely to be relevant to learners’ subgoals. Model results also show that when PAs prompt SRL strategy use, the page is 2.18 times more likely to be relevant to learners’ subgoals. No significant interaction effect between the time on a content page and initiator was found. In sum, the likelihood that a page is relevant increases as time on the content page increases and when PAs prompt the SRL strategy (see Figure 2).

Graphical user interface

Description automatically generated with medium confidence

**Fig. 2.** Graph depicting the probability content pages will be relevant to a subgoal depending on when an SRL strategy was initiated over learners’ time on page and the initiator of the strategy.

1. Discussion

The goal of this study was to examine how PAs scaffolded learners’ SRL strategy use in relevance to learners’ set subgoals. To do so, this study investigated SRL strategy use when the strategies were both self-initiated by the learner and when a PA prompted the use of the strategy as learners encountered content pages about the human circulatory in MetaTutor. The *first research question* examined differences in the frequency of deployed SRL strategies when the content page was relevant to learners’ subgoals versus irrelevant. Results showed that learners’ frequency of SRL strategies were greater when the strategy was deployed on a relevant content page rather than an irrelevant page. This is consistent with our hypotheses and literature (Azevedo et al., 2022; Dever et al., 2022; Harley et al., 2017; Lallé et al., 2017; Taub et al., 2015; Wiedbusch et al., 2021) where PAs successfully scaffolded learners to engage in SRL when information was important for the completion of learners’ subgoals. Specifically, PAs demonstrated that they are effective scaffolders of SRL strategies by externally regulating learners’ deployment of SRL strategies.

The *second research question* examined differences in SRL strategy frequency when strategies were deployed on relevant and irrelevant content pages between initiators. In other words, we wanted to know if the frequency of learners’ self-initiated or PAs’ prompted SRL strategies changed depending on the relevance of content to a learner’s subgoals. Hypotheses were confirmed and results from first research question were corroborated where, in general, SRL strategies were deployed more on relevant content. Additionally, learners self-initiated a greater number of SRL strategies than PAs on both relevant and irrelevant content pages. These results demonstrate that although learners were able to discern between relevant and irrelevant content pages, they still deployed SRL inefficiently. This showed that while PAs were effective at scaffolding SRL strategy deployment, they did not actively discourage inefficient SRL behaviors. Implications of these findings further the development of PAs as more active teachers of learners’ SRL where inefficient SRL strategy use should be discouraged depending on contextualization of the content to learners’ subgoals rather than general encouragement to use a variety of SRL strategies.

The third and fourth research questions attempted to predict the likelihood content was relevant to the subgoal based on learner and PA behaviors over time. The *third research question* specifically examined the likelihood a content page was relevant based on the who initiated the SRL strategy and when throughout the full task strategies were used. Partially consistent with our hypothesis, content pages were more likely to be relevant when PAs prompted SRL strategies as time on task progressed rather than when learners self-initiated the strategy. However, the likelihood of relevance decreased as time on task progressed. Findings show that even though PAs provided external regulation of learners’ SRL strategies, learners were not able to discern when instructional content was relevant to at least one of their subgoals and as such, tended to not self-initiate SRL strategies on relevant content pages. This finding is essential for the development of future PAs where time on task is a significant factor of learners’ ability to (metacognitively) identify relevant from irrelevant content related to subgoals but current PAs do not fully support this decline of SRL efficiency and accuracy.

Finally, the *fourth research question* attempted to predict the likelihood content would be relevant to the subgoal depending on learner and PA SRL deployment as time on the content page increased. Findings from the research question were not fully aligned with our hypotheses where the likelihood of relevance was not affected by the initiator of the strategy over time. However, likelihood of content relevance increased as time spent deploying SRL strategies on the content page increased. Further, content pages were more likely to be relevant when the PA prompted the SRL strategy when time on page starts. These findings support PAs as effective initiators of SRL strategies, which is aligned with current literature on the effectiveness of PAs as scaffolders of SRL (Azevedo et al., 2022; Dever et al., 2022; Harley et al., 2017; Lallé et al., 2017; Sikström et al., 2022; Taub et al., 2015; Wiedbusch et al., 2021).

1. Conclusion and Future Directions

Findings from this research study support PAs as effective scaffolders of SRL in relation to learners’ subgoals. However, these results cultivate several avenues of discussion for understanding how PAs can be better designed as teachers of SRL for learners within ITSs using Kramarski & Heaysman’s (2021) SRT-SRL model. The SRT-SRL model can advance the field of AIED (see du Boulay & Luckin, 2016) by determining PAs’ instructional behaviors in reaching optimal levels and balance between self-regulated teaching and SRL. For example, is a greater frequency of SRL strategy use always an indicator of effective self-regulation? While some findings from this research study may support this line of thinking (e.g., Research Question 1), when including time as a variable, the greater frequency of SRL strategies indicate an inefficient use of SRL. In other words, could a greater number of SRL strategies be indicative of inefficient SRL as time progresses in ITSs or contextualized to specific content? This research study has further implications for the design of PAs within ITSs. Specifically, PAs have been used to externally regulate SRL strategies through prompts to engage in SRL and feedback on the accuracy of learners’ SRL strategy use. However, can we develop PAs that not only externally regulate SRL deployment but actively intervenes when learners show suboptimal or inefficient SRL strategy use (i.e., increased number of SRL strategies within a certain period of time)?

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