

A Self-regulated Learning Approach to Promoting Learners' Participation and Performance in Writing Education

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Abstract: Augmented reality (AR) is seen as a useful tool for improving student learning in writing education, but the limitations of its application and its effectiveness in combination with self-regulated learning (SRL) remain questionable. This study explores the impact of the AR-SRL teaching approach on primary school students' Chinese writing performance and learning engagement. 115 students were divided into three groups: the traditional SRL approach (C-SRL), the AR-based SRL approach (AR-SRL), and the AR technology under the traditional approach (AR). Results showed that the AR-SRL group outperformed others in writing, cognition, emotion, behavior, and social engagement, with stronger autonomy and engagement, particularly among those with high self-regulation. In contrast, the AR group without SRL support showed more random behavior and lower task efficiency, while the C-SRL group had less interaction and engagement. These findings emphasize the role of SRL in technology-enhanced learning and the limitations of relying solely on technology, indicating a need for further investigation into the integration of AR and SRL in education.

Keywords: Augmented reality, Self-regulated learning, Learning engagement, Behavior sequence analysis, Writing education

1. Introduction

This study addresses challenges in primary school Chinese writing, such as limited expression, insufficient feedback, and low motivation, which result from traditional teaching methods that emphasize knowledge transmission over writing interest and self-regulation. While self-regulated learning (SRL) strategies can improve writing skills (Shen & Bai, 2024), primary students often lack guidance in applying them effectively. Augmented reality (AR) shows promise for enhancing engagement and writing performance but may also introduce cognitive load and distractions. This study proposes a model integrating AR and SRL to examine the effects on writing outcomes, engagement, and behavior through three teaching approaches: C-SRL, AR and AR-SRL. The following research questions:

RQ1: How do different learning approaches affect students' writing outcomes?

RQ2: How do different learning approaches influence students' learning engagement?

RQ3: How does self-regulation level impact students' learning engagement across different approaches?

RQ4: How do learning behavior patterns vary across different learning approaches and self-regulation levels?

2. The self-regulated learning based AR approach for Chinese article writing

This study, conducted in a fourth-grade writing course on "My Adventure", aims to enhance students' perception of hard-to-observe scenes and improve realism. Using the "Wild Animal AR" system, students interact with 3D scenes featuring voice explanations, questions, and virtual touch. The AR-SRL approach, based on Zimmerman's model, structures writing into three stages (Figure 1 on left). The "I Am a Writing Doctor" learning sheet acts as an external memory aid to support self-regulation in writing.

3. Methods

3.1. Experimental design and procedure

The study used a mixed-method quasi-experimental design, combining quantitative (ANOVA) and qualitative (behavioral sequence analysis) methods. The four-week experiment (Figure 1 on right) involved three groups: (a) C-SRL group: Traditional video-based learning with simple task-oriented sheets and general teacher feedback. (b) AR group: Immersive AR-based learning with traditional task sheets and immediate teacher feedback. (c) AR-SRL group: Writing tasks within AR, supported by self-regulated learning sheets guiding goal setting, self-diagnosis, peer evaluation, and self-assessment, with teacher support. Students' writing levels were comparable before the experiment.

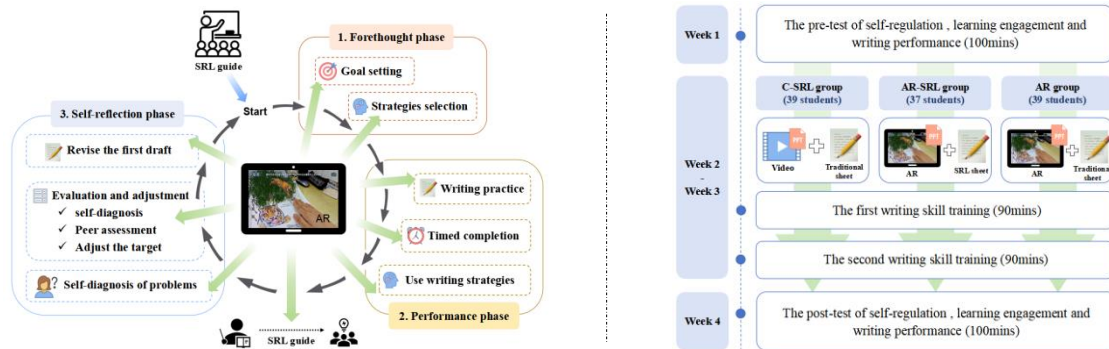


Fig.1 Structure of the AR-SRL approach (left) and experiment procedure (right)

3.2. Measurements

This study assessed students' writing ability, self-regulated learning (SRL), and engagement using multiple methods: (a) Writing Evaluation Criteria (Huang et al., 2020), focusing on Accuracy, Organization, Expression, and Creativity, totaling 100 points. (b) SRL Ability Questionnaire (Barnard et al., 2009), with 21 items across six dimensions, classifying students into high (high-SRL) and low (low-SRL) groups. (c) Learning Engagement Questionnaire (Wang et al., 2016), with four dimensions (cognition, behavior, emotion, social). (d) Learning Behavior Coding, analyzed via 90-minute video recordings, coded every 15 seconds using Li et al. (Li et al., 2023) scheme.

4. Results

In question 1, the homogeneity test of variance revealed that all dimensions except organization failed to meet homogeneity, so the Welch test and Games method were used. Results showed significant differences in writing performance, with the AR-SRL group outperforming the C-SRL group in total score, accuracy, organization, expression, and creativity, and surpassing the AR group in accuracy, organization, and expression. In question 2, one-way ANOVA assessed the impact of learning approaches on engagement. Pre-test results showed no significant differences, ensuring comparability. The post-test results indicated that both AR-SRL and AR groups outperformed C-SRL in all engagement dimensions, with the AR-SRL group showing greater improvement in cognitive and social engagement, and the AR group excelling in emotional engagement. In question 3, the study analyzed engagement differences between high- and low-SRL students across three learning approaches. In the C-SRL group, high-SRL students excelled in cognitive and emotional engagement but not behavioral engagement. In the AR-SRL group, post-test results showed higher cognitive, emotional, and social engagement for high-SRL students. In the AR group, pre-test differences were seen in emotional engagement, and post-test differences in cognitive engagement, with high-SRL students performing better.

In question 4, C-SRL students mainly listened (SL, 40.37%), completed tasks (SC, 34.79%), and observed materials (SO, 10.75%). AR-SRL students prioritized task completion (SC, 43.19%), listening (SL, 28.80%), and peer discussion (SDP, 10.22%). AR students focused on listening (SL, 36.34%), task completion (SC, 35.67%), and interacting with learning tools (SO, 14.10%). These results suggest AR-SRL students engage more in tasks and discussions, C-SRL students focus on listening and tasks, and AR students interact more with tools. Figure 2 (left) visualizes the behavioral paths of the three groups. In the AR-SRL group, students often transitioned from listening to answering or sharing (SL → SR; SR → SA) and formed circular behaviors through discussion or observation (SO → SDP; SDP → SO). C-SRL students focused on task lists or teacher explanations (SC → SC; SL → SL), while AR

students alternated between observation and discussion (SO $\rightarrow$ SDP; SDP $\rightarrow$ SO) with fewer behavioral transitions, often repeating peer list viewing or question-raising (SLP $\rightarrow$ SLP; SR $\rightarrow$ SR).

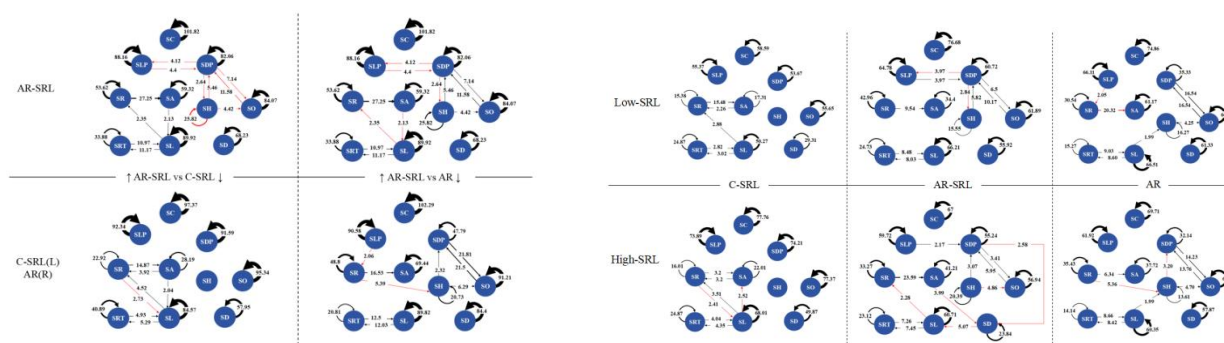


Fig.2 Learning behavior patterns of the three groups (left) and behavior patterns at two SRL levels in each group (right).

Figure 2 (right) shows that in the AR-SRL group, high-SRL students were less disorganized and listened more compared to low-SRL students. In contrast, the high-SRL students in C-SRL were more disorganized, listening less while observing picture books. The AR group resembled C-SRL, with high-SRL students showing more disorder but engaging more in peer discussions. High-SRL students in the AR-SRL group exhibited less disorder and followed a distinct behavior pattern: moving from answering questions and peer discussion, to classroom disorder, then back to listening and answering questions again. This pattern was absent in C-SRL and AR groups.

5. Discussion and conclusion

RQ1 examined the impact of AR-SRL on writing performance. The results showed the AR-SRL group outperformed the C-SRL group in overall writing, accuracy, organization, expression, and creativity, and exceeded the AR group in expression and creativity. This supports Li et al. (Li et al., 2023), who found that AR enhances learning through multimedia and interaction. Combining AR's immersive experience with SRL's structured approach boosts engagement and writing skills. However, AR alone may be ineffective without clear learning goals and strategies. RQ2 explored the impact of different groups on students' learning engagement. The results showed that the AR-SRL group had significantly higher cognitive, behavioral, emotional, and social engagement than the C-SRL group, particularly in cognitive and social engagement. Studies suggest that greater autonomy in writing enhances motivation and engagement, especially for lower-performing students (Li et al., 2023). The AR-SRL approach boosts engagement by combining AR's interactive experience with SRL strategies, providing multiple feedback channels. While the AR group showed higher emotional engagement than the C-SRL group, the AR-SRL group showed minimal differences in emotional engagement, possibly due to the cognitive load of SRL. RQ3 examined learning engagement differences among students with varying levels of SRL. Results showed that high SRL students in the AR-SRL group outperformed low SRL students in cognitive, emotional, and social engagement, as high SRL students were better able to utilize the resources and strategies of the AR-SRL approach. Low SRL students may face cognitive load and reduced emotional engagement in AR environments. The addition of AR enhanced cognitive engagement for high SRL students and emotional engagement for low SRL students. Furthermore, low SRL students in the AR group showed greater improvement in emotional engagement, suggesting AR is more effective in mobilizing emotions for lower-regulated learners. RQ4 analyzed classroom behavior differences under different teaching approaches. Results showed that AR-SRL students exhibited more active behaviors, including frequent self-monitoring, reflection, communication, and task-focused actions, reflecting their high engagement. This suggests that integrating SRL strategies in AR environments promotes self-directed learning. In contrast, AR students without SRL showed random, passive behaviors, highlighting the importance of instructional design. Traditional SRL group behaviors were fragmented with low interaction. The AR-SRL group showed significantly higher self-monitoring (42.9%) and social communication (23.9%) compared to the C-SRL (23.2%, 24%) and AR groups (34.2%, 22%), demonstrating its ability to enhance autonomous learning. High SRL students in the AR-SRL group exhibited better performance with less disorder and more

participation, while C-SRL students displayed more disorder despite being attentive. The AR-SRL approach motivated high SRL students and enhanced task focus. In the AR group, high SRL students engaged more in peer discussions but showed disordered behavior due to the disorganized AR teaching mode. Both the AR-SRL and AR groups displayed behavior patterns suggesting that AR technology fosters interaction and social engagement, supporting the AR-SRL approach's effectiveness in enhancing engagement and optimizing behavior.

This study examines the impact of combining augmented reality (AR) with self-regulated learning (SRL) strategies on primary school students' engagement in Chinese writing. The results show that the AR-SRL approach significantly enhances cognitive, emotional, behavioral, and social engagement. AR motivates students through an immersive environment, while SRL strategies help manage learning, especially for those with strong self-regulation skills. However, students with weak self-regulation may struggle without structured guidance, such as clear objectives and real-time feedback. Over time, the AR-SRL approach can foster sustained motivation, improve independent learning, and strengthen writing skills. By encouraging active learning and self-regulation, this approach helps students develop lifelong learning habits, boosting their adaptability and long-term academic success. The study provides a foundation for using AR and SRL in writing education and suggests further research to adapt this model for other subjects.

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