Infusing Self-Regulated Learning in Computational Thinking through Professional Learning for Science Teachers

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ABSTRACT

The purpose of this study was to examine the effectiveness of a longitudinal professional development (PD) program designed to teach science teachers how to foster student self-regulation in computational thinking (CT) related to data practices. In this study, 20 secondary-school science teachers participated in a year-long PD program. The PD program included a one-week intensive summer seminar and continued PD sessions throughout the school year. Teachers' knowledge and application of SRL were assessed before and after the summer institute through their responses to open-ended questions. Teachers' self-efficacy in infusing SRL into lesson plans was measured at three time points using a quantitative rating scale: before and after the summer institute, and six months after the summer institute. Results showed teachers' knowledge and application of SRL improved following the summer institute. On the other hand, teacher efficacy in infusing SRL into lesson plans also significantly increased after the summer institute but decreased six months later. Implications and limitations were discussed.

INTRODUCTION

Self-Regulated Learning in Science Education

- SRL refers to the degree to which "students are metacognitively, motivationally, and behaviorally active participants in their own learning process"(Zimmerman & Schunk 2001, p.5).
- Research has shown that SRL skills are positively associated with higher academic achievement (Zimmernan & Kitsantas, 2005; Zimmerman & Schunk, 1989).
- Research on professional learning focused on SRL has shown that, many teachers are not familiar with the specific concepts of SRL or how to successfully implement them in a classroom setting (Finsterwald et al., 2013; Kremer-Hayon & Tillema, 1999; Lau, 2012; Pauli et al., 2007).

Computational Thinking

- CT refers to a set of mental processes involved in formulating problems with solutions represented as computational steps and algorithms (Aho, 2012; Wing, 2011).
- CT has been found as an important across disciplines at the K-16 level (Wing, 2008) and has been listed as a required skill for high school students by the Next Generation Science Standards (National Science Teaching Association, 2013).

Self-Regulated Learning in Computational Thinking

- While CT generally involves solving complex problems by creating and utilizing algorithmic processes (Aho, 2012; Denning, 2017; Grover & Pea, 2015; Wing, 2006), Peters-Burton et al. (2018) argue that, like SRL, CT can also be conceptualized as an iterative goal-directed process applicable across many academic domains.
- Research findings demonstrate the importance of incorporating SRL in science education, particularly in CT (DiBenedetto & Zimmerman, 2013; Schraw et al., 2006).

Thus, this study aimed to examine the effectiveness of a longitudinal PD program designed to teach science teachers to incorporate SRL in CT related to data practices.

Research Question

- To what extent does the proposed PD program influence science teachers' knowledge and application of SRL and self-efficacy beliefs in infusing SRL in CT data practices?

METHODS

Participants

- Participants included 20 secondary science teachers in the Mid-Atlantic region.
- The four subjects of focus included were biology, physics, earth science, and chemistry.

Professional Development Program

- Summer Institute (two-weeks long, of which one week was devoted to SRL)
  - A researcher gave teachers presentations and lectures on SRL processes and key terms.
  - Teachers reflected and discussed on what they need to know concerning SRL.
  - Teachers worked together to create a worksheet that students could use.
  - Teachers designed lesson plans infusing SRL in CT.
- Continued PD Sessions (one school year)
  - Science content teams collaborated to design lesson plans with SRL incorporated.
  - Teachers and researchers met monthly to share ideas about implementation of SRL.

METHODS

Data Collection Instruments

- Demographic Information: age, gender, ethnicity, education, teaching experience, etc.
- Teacher Efficacy in Infusing SRL into Lesson Plans (α=.97)
  - This scale included 10 items based on different aspects of SRL (Zimmerman, 2013)
  - It was assessed using a scale of 0 (certain cannot do at all) to 100 (highly certain can do)
  - An example item was "To what extent can you develop lesson plans that enable students to successfully consider their goals when beginning a new assignment?"
  - Teachers' efficacy was reported as a range of their confidence depending on their experience teaching a range of students (most at-risk students and most gifted students)
- Teachers' Knowledge of SRL (one open-ended question)
  - "How would you define and describe SRL? Provide as many details as you can using the space below."
- Teachers' Application of SRL (one open-ended task)
  - Teachers read a vignette of a struggling science student who was lacking SRL strategies
  - Teachers answered this question: "Create a list describing specific things you could do to help the student improve his self-regulated learning."

Procedures

Teachers' SRL knowledge and application were collected before (T1) and after the summer institute (T2). Teachers' efficacy in infusing SRL into lesson plans was assessed before (T1) and after the summer institute (T2) and six months after the summer institute (T3).

Data Analysis

Two trained coders coded teacher responses to the SRL knowledge and application questions using a rubric developed based on key component of SRL (Zimmerman, 2000).

- The rubric included both frequency count and quality of SRL strategies (Zhang et al., 2020).
  - The quality of SRL knowledge was evaluated by three dimensions: breadth, depth, and iterative cycle, while that of SRL application was evaluated by breadth, strategy explanation, and action plan.
  - Each dimension was rated from 1-3, and these scores of three dimensions were summed up. Responses were assigned to one of four categories based on scores (1-4).
- A repeated measures ANOVA was conducted to examine differences in teacher efficacy at three time points. Paired t tests were conducted to examine differences in the frequency count of teachers' SRL knowledge and application before and after the summer institute; a Wilcoxon Signed-Ranks test was conducted to test the quality of teacher knowledge and application, and crosstabs were provided to show changes.

Teacher SRL Knowledge before and after the Summer Institute

		Post				Total (%)
		1 (%)	2 (%)	3 (%)	4 (%)	
Pre	1(No basis)	**0**	3 (18)	0	1 (6)	4 (24)
	2 (Beginning)	2 (12)	**0**	4(24)	5 (30)	11 (65)
	3 (Developing)	0	0	**2(12)**	0	2 (12)
Total		2 (12)	3 (18)	6 (36)	6(35)	17 (100)

Teacher SRL Application Before and After the Summer Institute

		Post				Total (%)
		1 (%)	2 (%)	3 (%)	4 (%)	
Pre	2 (Beginning)	**0**	**1 (6)**	3 (18)	2 (12)	6(35)
	3 (Developing)	0	0	**1(6)**	5(30)	6(35)
	4 (Proficient)	0	0	0	**5(30)**	5 (30)
Total		0	1 (6)	4 (24)	12 (70)	17 (100)

Note. Final codes: 1= no basis; 2= beginning; 3=developing; and 4=proficient. *N*=17. Bolded cases indicate teachers whose SRL level of knowledge did not change. Cases to the right moved up in level of knowledge and cases moved down in level of knowledge following participation in the PD.

RESULTS

The repeated measures ANOVA test showed that teacher efficacy for infusing SRL into lesson plans in T2 was significantly higher than was measured at T1.

- Teacher efficacy in infusing SRL into lesson plans for their most at-risk students significantly changed across these three time points, F (2, 14)= 14.39 (p<.001). Specifically, a significant difference was found between T1 (M=44.56; SD=12.54) and T2 (M=68.66; SD=13.31); p<.01. No significant difference was found between T2 and T3 (M=56.83; SD=21.10) or T1 and T3 (p>.05).
- Teacher efficacy in infusing SRL into lesson plans for their most gifted students also significantly changed across three time points; F (2, 14)= 10.47 (p<.01). Specifically, teacher efficacy at Time1 (M=77.97; SD=11.07) and Time 3 (M=84.09; SD=8.72) were significantly lower than teacher efficacy at Time 2 (M=90.47; SD=5.37) (p<.05). However, no significant difference was found between Time 1 and Time 3 (p=.16).

Teacher SRL knowledge and application also improved after the summer institute.

- The number of SRL strategies teachers described in their knowledge response significantly increased from T1 (M=1.53; SD=1.90) to T2 (M=4.42; SD=2.74); t(18)=3.93, p<.01.
- In the responses to SRL application question, teachers also included significantly more strategies at T2 (M=6.41; SD=2.40) than T1 (M=3.65; SD=2.06); t(16)=6.38, p<.01.

Wilcoxon Signed-Ranks test showed that the quality of teacher response in SRL knowledge and application significantly increased after the summer institute; $Z1$= 2.92, p<.01; $Z2$=2.97, p<.01.

Descriptive Statistics

Variable	Different Time Points	Mean	Standard Deviation	F/T value
SE	SE1Lower	44.56	12.54	14.39**
	SE2Lower	68.66	13.31	
	SE3Lower	56.83	21.10	
	SE1Upper	77.97	11.07	10.47**
	SE2Upper	90.47	5.37	
	SE3Upper	84.09	8.72	
SRL Knowledge	SRLKnowledge1	1.53	1.90	3.93**
	SRLKnowledge2	4.42	2.74	
SRL Application	SRLApplication1	3.65	2.06	3.68**
	SRLApplicaiton2	6.41	2.40	

Note. SE1Lower=teacher efficacy in infusing SRL into Lesson Plans toward the most at-risk students at Time 1; SE1Upper=teacher efficacy in infusing SRL into Lesson Plans toward the most gifted students at Time 1; SE2Lower=teacher efficacy in infusing SRL into Lesson Plans toward the most at-risk students at Time 2; SE2Upper=teacher efficacy in infusing SRL into Lesson Plans toward the most gifted students at Time 2; SE3Lower=teacher efficacy in infusing SRL into Lesson Plans toward the most at-risk students at Time 3; SE3Upper=teacher efficacy in infusing SRL into Lesson Plans toward the most gifted students at Time 3; SRLKnowledge1=the frequency count of strategies mentioned in teacher SRL knowledge response at Time 1; SRLKnowledge2=the frequency count of strategies mentioned in teacher SRL knowledge response at Time 2; SRLApplication1=the frequency count of strategies mentioned in teacher SRL application response at Time 1; SRLApplication1=the frequency count of strategies mentioned in teacher SRL application response at Time 2. **p<.001.

DISCUSSION

- Findings showed that teachers' self-efficacy in infusing SRL in lesson plans and teachers' SRL knowledge and application increased after the summer institute.
- Moreover, through the PD, teachers not only gained basic knowledge of SRL and its components, they also showed evidence of the ability to apply SRL at a deeper level, which was indicated by the quality category of SRL knowledge and application.
- These increases supported the importance of SRL PD in the classroom that was found by previous studies (Michalsky & Schechter, 2013; Xu & Ko, 2019).
- It should be noted that teacher efficacy in infusing SRL in lesson plans measured at T3 was lower than that measured at T2, and the decrease was statistically significant in teacher efficacy toward the most gifted students.
- However, there were also several limitations in this study:
  - Even though the PD was considered longitudinal, teachers' SRL knowledge and application were only assessed before and after the summer institute.
  - Other data sources, like interviews on teachers' implementation of SRL, could be included to validate these increases in future studies.

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