

Complementary Perspectives for the Evaluation of Student-Teachers' Pedagogical SRL in Metacognitive Hypermedia Environment

Tova Michalsky, Bracha Kramaraki
School of Education, Bar-Ilan University, Ramat-Gan 52900,
Israel

Email: michalt@mail.biu.ac.il, kramab@mail.biu.ac.il

Abstract. The present study combined an electronic diary approach with self-report measures in order to investigate the process of student-teachers' pedagogical SRL in two hypermedia environments: hypermedia with metacognitive instruction (HYP+Meta) and hypermedia without metacognitive instruction (HYP). The electronic diary approach was based on self-reflections prompted with the IMPROVE metacognitive questioning method [1]. These questions were embedded within a hypermedia environment, during students' pedagogical assignments to design learning activities. Ninety five student-teachers training to be science teachers participated in the study during one academic semester. SRL measures were assessed in two complementary perspectives: a self-report questionnaire (MSLQ: cognition, metacognition and motivation) and a time-series analysis of self-reflections written during designing lesson units (planning, monitoring, debugging and evaluation). Results showed that being exposed to HYP+Meta environment may enhance student-teachers in their ability to reflect and regulate their learning process on all SRL measures. This in turn may develop their pedagogical ability to design complex learning activities. Further analysis indicated high correlations *within* SRL measures (self-report and self-reflections) and *between* SRL and complex designing tasks.

Keywords. Self-Regulated Learning; Student-Teacher Education; Perspectives of SRL Evaluation; IMPROVE Training; Hypermedia

Introduction

1. Self-regulated learning: Perspectives for evaluation

In recent years, the role of self-regulated learning (SRL) in education has elicited much interest. Research has focused on students' SRL skills as a means for attaining successful learning. Students are self-regulated to the degree that they are metacognitively, motivationally, and behaviorally active participants in their own learning process (e.g., [2]). Self-regulated learning can be evaluated from complementary perspectives, either as an offline or an online process. SRL as an offline process can be perceived as aptitude measures, which are defined as a relative enduring attribute of a person that predicts future behavior. Such measures include self-report questionnaires

that were successful in demonstrating significant predictions of students' academic outcomes. SRL as an online process can be perceived as an event measure which is defined as a temporal entity with a discernable beginning and an end. Because event measures can assess sequential dependency of responses, they are well suited for making causal inferences about online changes in SRL in real time and within authentic contexts. Such measures include computer traces, think-aloud protocols, direct observation, microanalyses, and diaries of studying [3]. One of the emergent questions regarding the ways of evaluating the SRL process concerns how closely online measures of SRL would compare to self-report measures in assessing changes in self-regulation during learning [2,3].

In our study we implemented both complementary measures, offline (self-report questionnaire) and online, (self-reflections diary), to assess the SRL of student-teachers. The use of the self-reflection diary was selected for a number of reasons [3]. First, diaries allow us to observe learning over time. Second, they allow us to reflect on all the components of the self-regulation cycle, among them goal setting, strategies, monitoring, and self-evaluation. Finally, the diary may focus students' attention on the relationships between the different components, especially the relationship between implementing specific strategies and attaining goals. Therefore, the synergetic cooperation of all the SRL components might be supported by the diary.

2. Student-teachers preparation for SRL in a metacognitive hypermedia environment

The importance of SRL has raised challenges for teachers' professional education. Educators and researchers believe that the ability to develop self-regulating skills in students is associated with teachers' own self-regulation, both in learning and in teaching. It is argued that the more teachers understand about their **own SRL**, the better they can **perceive** the value of SRL and **teach SRL** to their students. Consequently, researchers propose that student-teachers should be trained in high-SRL learning environments that encourage knowledge construction through SRL (e.g., [4, 5]).

Our study focuses on a hypermedia environment. This environment offers information through a variety of hypertexts, graphics, animations, and audio or video, through which the student navigates intuitively. In hypermedia, students are given access to a range of nonlinear information. Such nonlinear organization not only provides new possibilities for teaching about the structure of domain knowledge, it also provides an opportunity for self-regulated learning. Hypermedia requires that students regulate their own study - namely, to decide what to learn, how to learn, whether they understand the material, when to change learning plans and strategies, and when to increase their efforts [6].

However, findings indicate that students have difficulty regulating their learning process in a hypermedia environment [6,7]. In light of these difficulties, researchers suggest that teachers need to develop a new body of

pedagogical knowledge that constitutes ways of supporting SRL in the domain of teaching with hypermedia (e.g., [8]).

Reviewing current metacognitive training research reveals that there are some general principles for effective metacognitive instruction (e.g., [9,10]). First of all, metacognitive instruction should be integrated in the domain-specific instruction. Second, the application and usefulness of instructed metacognitive strategies have to be explained, otherwise students will not use them spontaneously. Finally, metacognitive instruction should include questions of *what*, *when*, *why* and *how* students select a specific self-regulatory strategy, approach or response within the learning process, and how to monitor and adjust their learning accordingly in order to achieve understanding (e.g., [9]).

Mevarech and Kramarski's method [1], known as IMPROVE, encourages students to become involved in regulatory learning by using self-questioning methods. The metacognitive questioning encourages students to be actively engaged in self-regulation of their learning through the use of four kinds of questions: comprehension, connection, strategy, and reflection. Comprehension questions are designed to help students understand the information of the task or problem-solving (e.g., "What is the problem/task?", "What is the meaning of?"). Connection questions are aimed at prompting students to understand deeper-level relational structures of the task by articulating thoughts and explicit explanations (e.g., "What is the difference/similarity?", "How do you justify your conclusion?"). Strategy questions encourage students to plan and to select the appropriate strategy (e.g., "What is the strategy", "Why is this the appropriate strategy?"). Reflection questions play an important role in helping students monitor and evaluate their problem-solving processes. Reflection questions encourage students to consider various perspectives and values regarding their selected solutions (e.g., "Does the solution make sense?"; "Can the solution be presented in another way?").

In general, research has investigated the effects of IMPROVE metacognitive method on school students' mathematical reasoning [9,10,11]. Little research was done on using such method to help student-teachers develop their SRL in Hypermedia pedagogical context (e.g., [8]).

3. The current study's objectives

The purpose of this study was threefold. We compared the differential effects of hypermedia embedded within the IMPROVE method (HYP+Meta) versus HYP on the student-teachers' SRL. We examined the effects from complementary perspectives, both offline (self-report questionnaire) and online (self-reflections diary). We also compared the differential effects of HYP+Meta versus HYP on the student-teachers' pedagogical knowledge regarding designing learning activities skills. In addition, we examined the relationship between self regulation (offline and online) and pedagogical knowledge (designing skills) in each professional training program (HYP+Meta and HYP).

4. Method

4.1 Participants

Ninety five student-teachers training to be science teachers for high schools participated in the study. The participants were enrolled in a mandatory second-year course, Designing Learning Activities With a Hypermedia Environment, where they designed teaching curricula during one 14-lesson semester. All of the student-teachers who were enrolled in this course were randomly assigned to one of two research groups (HYP+Meta, n = 47, and HYP, n = 48).

4.2 HYP+Meta versus HYP

The computer based learning lessons were conducted in the computer lab. During their practice exercises, the student-teachers were asked to solve the given pedagogical tasks by referring to hypermedia resources (e.g., hypertexts, video clips or multimedia), and discussing the solution in a group forum,. For example, one task asked the student-teachers to: (a) Explain what student-centered learning is and provide an example; (b) Construct a rubric with four criteria to assess student-centered learning; (c) Design two different types of computerized student-centered learning tasks, compare them and assess them using the four criteria they had constructed; and (d) Present and discuss the conclusions with the class. The instructor was available to answer questions.

4.3 HYP+Meta

Student-teachers in this group were exposed to SRL support based on the IMPROVE model [1,9]. The metacognitive questions were designed as electronic pages and were displayed onscreen as automatic pop-ups at certain times during the practice of pedagogical skills. The student-teachers were encouraged to use them explicitly in solving their tasks, when providing explanations, and in conducting discussions. Each student-teacher was asked to solve the pedagogical task and to reflect on the solution process (see description in Measures section). The solutions and self-reflections were saved in a personal electronic diary and sent to the instructor.

4.4 Assessment measures

Three measures were administered in the study: SRL, both offline (self-report questionnaire) and online (self-reflections diary) and pedagogical designing tasks.

4.41 SRL, offline and online measures

Self-report questionnaire

The 50-item Motivated Strategies for Learning Questionnaire (MSLQ; [12]) assessed student-teachers' self-reported *cognition* (strategies: rehearsal, elaboration, and organizational), *metacognition* (planning, monitoring, and evaluation), and *motivation* in pedagogical learning (intrinsic value of learning and persistence in the face of difficulties). Participants rated each item on a 7-point Likert scale, ranging from 1 (not at all true for me) to 7 (very true for me). Higher scores indicated a higher level of SRL.

Self-reflections diary

The diary included all written responses to pedagogical tasks and self-reflections on the process [13]. The self-reflections ask about *planning* (e.g., "Describe the goal of the task and explain how you set them prior to learning. Elaborate on use of technology."), *monitoring* (e.g., "When, and how, did you assess your activity during the learning process? Please provide examples."), *debugging* (e.g., "Did you encounter difficulties or errors while performing the learning task? Please provide examples.") and *evaluation* (e.g., "How and in what ways you improved your functioning during the learning process? Please provide examples.").

Reflections were analyzed three times during the semester: at the beginning (second week), middle (after six weeks) and end of the study (two weeks before the end). For each category of the reflections scoring ranged on a three-point scale from low (1- e.g., planning: the goal setting is unclear and unformulated) to high (3-e.g., the goal setting is formulated and backed by clear justification). Two experts in pedagogy graded the student-teachers' reflections. The inter-judge reliability for Cohen Kappa was 0.87.

4.42 Pedagogical designing tasks

Each participant was asked to design a written learning unit embedded in technology environment (3-lessons) about the effects of smoking on people's health. Judges, experts in designing learning activities, scored the participants' designing skills using an index [8,14]. The index focused on four categories: (a) Identifying learning objectives (e.g., "Presents clear learning objectives, including technological skills"); (b) Selecting content (e.g., "Identifies topics to be taught with technology"); (c) Planning didactic material (e.g., "Selects technologies such as hypermedia that put the learner at the center of the learning process"); and (d) Designing learning environment (e.g., "Uses online communication, adaptive feedback").

Each category was assessed by four rubrics. Each rubric was graded on a scale of 0 (not used) to 1 (used), with total scores ranging from 0-16. The inter-judge reliability for Cohen Kappa was 0.87.

Detailed description of the treatment, scores and scoring and examples of self-reflections and pedagogical design tasks can be found in the website <http://hl2.biu.ac.il/>

5. Results

5.1 SRL perspectives

Offline (self-report questionnaire)

A MANOVA for the pretest results indicated that, before the course began, no significant differences emerged between the two learning groups on any of the perceived SRL components ($p > 0.41$). Analysis of variance (ANOVA) with repeated measures (2 times x 2 groups) on each of the three components of the SRL variable revealed significant effects for time, and interaction ($p < 0.001$) between the learning groups and the time of measurement for each of the three SRL components (see Table 1): cognition, metacognition and motivation (all $F(1,91)$ with values between 7.65 and 47.68; $p < 0.001$).

Table 1. Means and standard deviations for self-report SRL measures by time and learning group

	HYP + Meta, $n = 47$		HYP, $n = 48$	
	Pre	Post	Pre	Post
Cognition	4.1 (1.3)	5.6 (1.5)	4 (1.3)	4.4 (1.3)
Metacognition	3.6 (1.3)	4.9 (1.5)	3.5 (1.3)	4.2 (1.3)
Motivation	4.5 (1.4)	5.9 (1.9)	4.4 (1.3)	5.0 (1.8)

A post-hoc analysis according to Cohen's d effect-size (d was calculated as the ratio between the differences of the pre-test and the post-test, and the average standard deviation of the pre-test) at the end of the course indicated that the HYP+Meta student-teachers more often reported that they were good strategy users. They perceived themselves as planning, setting goals, organizing, self-monitoring, and self-evaluating at various points during the process of skill acquisition. In terms of motivational processes, these learners reported high intrinsic interest and persistence in learning

(HYP+Meta: $d = 1.07, 0.93, 0.85$; HYP: $d = 0.40, 0.36, 0.48$, for cognition, metacognition and motivation, respectively).

Online (self-reflections diary)

We performed a time-serial analysis by conducting repeated measures of variance on each reflection category by time (3 measures) and learning group (HYP+Meta and HYP).

Table 2. Mean scores (M) and standard deviations (SD) on reflection categories by time and learning group

Reflections	Time 1		Time 2		Time 3	
	HYP + Meta $n = 47$	HYP $n = 48$	HYP + Meta $n = 47$	HYP $n = 48$	HYP + Meta $n = 47$	HYP $n = 48$
Planning	1.92 (0.52)	1.18 (0.54)	2.27 (0.58)	1.36 (0.59)	2.52 (0.57)	1.64 (0.54)
Monitoring	1.67 (0.54)	1.25 (0.52)	2.12 (0.62)	1.66 (0.52)	2.51 (0.61)	1.94 (0.56)
Debugging	1.95 (0.63)	1.22 (0.58)	2.27 (0.59)	1.58 (0.65)	2.54 (0.59)	1.73 (0.56)
Evaluation	2.04 (0.46)	1.29 (0.56)	2.31 (0.42)	1.56 (0.48)	2.63 (0.46)	1.87 (0.43)

Results (Table 2) revealed significant main effects for both time and learning group and a significant interaction between time and learning group regarding each criteria of the reflections categories (all $F(1,91)$ with values between 27.15 and 63.26; $p < 0.001$). During the study, both hypermedia groups (HYP+Meta and HYP) improved their reflections on each of the four categories (planning, monitoring, debugging and evaluation). However, the HYP+Meta students outperformed their HYP counterparts on each reflection criteria along the three measurements. These differences were particularly prominent at the end of the study ($d = 1.57, 0.97, 1.40$, and 1.71 respectively).

5.2 Designing skills

Analysis of variance (ANOVA) with repeated measures (2 times x 2 groups) on designing skills revealed a significant main effect for time and a significant interaction between time and the learning environment ($F(1, 93) = 43.2, 36.2, p < 0.001$). Results indicated that at the end of the study the

HYP+Meta student-teachers outperformed the HYP student-teachers on designing learning units (HYP+Meta: $M = 12.9, 22.8, SD = 5.3, 6.1$; HYP: $M = 13.2, 17.6, SD = 5.6, 5.7$ respectively for the pretest and posttest, $d = 1.74, 0.79$).

5.3 Relationships between SRL and designing skills

We examined the relationships *between* SRL perspectives (offline and online) and designing skills in each learning group.

Table 3. Correlations (Fisher, Z) between SRL perspectives (offline and online) and designing skills by learning group

6.Design	5.Evalu	4.Debuggi	3.Monitor	2.Motiva	1.Meta	
<i>Hypermedia & metacognition environment (n = 47)</i>						
					0.42**	2
				0.40**	0.44**	3
			0.48**	0.48**	0.56*	4
		0.43**	0.51**	0.53**	0.51*	5
-	0.46**	0.52**	0.49**	0.51**	0.50*	6
<i>Hypermedia alone environment (n = 48)</i>						
					0.31*	2
				0.34*	0.36**	3
			0.42**	0.41**	0.43*	4
		0.37*	0.43**	0.47**	0.45*	5
-	0.40**	0.47**	0.43**	0.46**	0.42*	6

* $p < 0.01$, ** $p < 0.00$

Results revealed significant positive correlations in both learning groups (HYP+Meta and HYP) between offline and online measures of SRL (self-report questionnaire and self-reflections diary). Furthermore, positive significant correlations were found between SRL (offline and online) measures and designing skills. Particularly high correlations were found between metacognition, motivation and designing skills. However, Fisher Z test indicated higher positive correlations between the variables in the HYP+Meta group compared to the HYP group.

6. Conclusion, practical implications and future research

The data presented here indicate that beginning teachers can engage in practices that promote SRL and design tasks in a hypermedia environment. In our study, the metacognitive support was based only on the IMPROVE metacognitive self-questioning model (comprehension, connection, strategy,

and reflection), which was found to enhance SRL (offline and online) and foster pedagogical knowledge through designing complex tasks.

We suggest for future study to expand the investigation of diverse metacognitive instructional models in innovative technology environments, and to investigate these models' implementation in SRL of student-teachers. Future research may also include further investigation of the role pedagogical agents play in challenging the use of self-questions guidance at different points during the solution process: before the beginning of the process, during the process and at the end of the process.

Another direction for future research may be the comparison of the effects of the different methods of implementation of self questions guidance (receiving automatic prompts at certain times versus the students' actively seeking the guidance for help). It would also be interesting to examine the use of general vs. specific prompts embedded in the pedagogical content, or perhaps the use of different combinations of a variety of prompts (e.g. procedural, elaboration and reflection).

We recommend that future studies continue to include both self-reports and online measures, such as computer traces, so as to triangulate the findings in complementary perspectives of SRL.

References

- [1] Mevarech, Z. R., & Kramarski, B. (1997). IMPROVE: A multidimensional method for teaching mathematics in heterogeneous classrooms. *American Educational Research Journal*, 34, 365-395.
- [2] Pintrich, P. R. (2000). The role of goal orientation in self-regulated learning. In M. Boekaerts, P. Pintrich, & M. Zeidner (Eds.), *Handbook of self-regulation* (pp. 451-502). San Diego, CA: Academic Press.
- [3] Schmitz, B., & Wiese, B. S. (2006). New perspectives for the evaluation of training sessions in self-regulated learning: Time-series analyses of diary data. *Contemporary Educational Psychology*, 31, 64-96.
- [4] Zimmerman, B. (2008). Investigating self-Regulated and motivation: historical background, methodological development, and future prospects. *American Educational Research Journal*, 45 (1), 166-183.
- [5] Veenman, M. (2008). *Metacognitive Skills: where are we now?*. 3rd Biennial Meeting of the EARLI Special Interest Group 16 "Metacognition", Greece.
- [6] Azevedo, R., & Cromley, J. G. (2004). Does training on self-regulated learning facilitate students' learning with hypermedia? *Journal of Educational Psychology*, 96, 523-535.
- [7] Azevedo, R., Cromley, J. G., & Seibert, D. (2004). Does adaptive scaffolding facilitate students' ability to regulate their learning with hypermedia? *Contemporary Educational Psychology*, 29, 344-370.
- [8] Kramarski & Michalsky, (in press). Investigating Preservice Teachers' Professional Growth in Self-Regulated Learning Environments. *Journal of Educational Psychology*.
- [9] Kramarski, B., & Mevarech, Z. R. (2003). Enhancing mathematical reasoning in the classroom: Effects of cooperative learning and metacognitive training. *American Educational Research Journal*, 40 (1), 281-310.

- [10] Kramarski & Gutman, (2006). How can self-regulated learning be supported in mathematical e-learning environments? *Journal of Computer Assisted Learning*, 22, 24-33.
- [11] Kramarski, B. & Mizrachi, N. (2006). Online Discussion and Self-Regulated Learning: Effects of Four Instructional Methods on Mathematical Literacy. *The Journal of Educational Research*, 99(4), 218-230.
- [12] Pintrich, P. R., Smith, D. A. F., Garcia, T., & McKeachie, W. J. (1991). *A manual for the use of the motivational strategies learning questionnaire (MSLQ)*. Ann Arbor, MI: University of Michigan, National Center for Research to Improve Postsecondary Teaching and Learning.
- [13] Schraw, G. & Dennison, R. S. (1994). Assessing metacognitive awareness. *Contemporary Educational Psychology*, 19, 460-475.
- [14] Leou, S. (1998). Teaching competencies assessment approaches for mathematics teachers. *Proceedings of the National Science Council, Republic of China: Part D: mathematics, science, and technology education*, (8) 3. pp.102-107.

<http://hl2.biu.ac.il/>