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Immediate and Long-Term Effects of "Learning By Teaching" on Knowledge of Cognition

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Abstract

Learning By Teaching (LBT) programs for pre-service teachers in two different environments (technological and face-to-face) were compared using 100 pre-service teachers as subjects. Both programs were based on the IMPROVE instructional method which provides explicit metacognitive steps for LBT with a dual perspective (2P): that of the teacher and that of the learner. The dependent variables Knowledge of Cognition (KC) in learning and in teaching were tested for their immediate and long-term effects in a Technology-Based System group (TBS+2P), and in a Face-to-Face group (F2F+2P). Post-test results of KC have indicated that the TBS+2P group had shown a higher level of conditional and procedural knowledge of teaching. The TBS+2P group has also performed better in measures of long-term effects of declarative knowledge in teaching. Both theoretical and practical implications of this study are discussed.

Keywords: Knowledge of Cognition, Learning By Teaching, pre-service teachers

1. Introduction

The latest research indicates that the "Learning by Teaching" method has great potential for pedagogical development of pre-service teachers, contributing both to cognitive and metacognitive flexibility and providing meaningful professional preparation (Fiorella & Mayer, 2013). Other researchers (Peeters et al., 2013; Van Beek et al., 2014; Pintrich, 2002) claim that in order to achieve this goal pre-service teacher training needs to include explicit guidance in the development of LBT abilities and include metacognitive types of knowledge and strategies. Pre-service teachers are expected to exhibit a range of applications of Knowledge of Cognition (KC) in both learning and teaching contexts (Young & Fly, 2012). For example, they have to be aware of appropriate strategies for successful pedagogical performance and to be able to declare how, when, and why these strategies should be used.

Efklides (2014) suggests emphasizing the teacher's "dual role" so as to nurture such abilities in pre-service teachers. This will enable them to become accustomed to alternate between being learners and teachers. The outcome is better implementation of high-order skills and crafting of learning problems in different environments. Little research has investigated the benefits on KC in technological and human LBT environments as a part of pre-service teacher development. The majority of studies in the LBT area lack empirically based knowledge of Dual Perspective Learning and do not measure its immediate and long-term effects in the pre-service teacher population. This lack has led us to conduct the current research.

Research has pointed out that "dual learning program" (or "dual perspective learning") affords pre-service teachers opportunities for active, student-centered learning that emphasize the *student perspective*. Although, the available opportunities for making various pedagogical decisions (e.g., what to teach, how to present the material, when to deviate from teaching plans, when to change or renew pedagogical strategies, and when to increase effort) develop also the KC from a *pedagogical perspective* (Liaw & Huang, 2013). In our previous study (Kramarski & Gutman, 2006), it was found that students exposed to dual-perspective learning interventions combined with different types of self-questioning both in real life and in simulated environments perform significantly better with respect to KC than those who were not so exposed.

In the current study, metacognitive questioning encourages the dual-perspective in both "students and in pedagogical activity". Students actively engage not only with factors pertaining to KC (declarative, procedural, and conditional knowledge) but also with the connection between different components of the learning/teaching situation: use of strategies, and reflection. The study investigates LBT which has been customized for pre-service teachers by "placing" them in two different environments: first, at the center of the learning process ("student perspective"), and then in the context of science teaching ("teacher's perspective").

1.1 LBT in a Technological Environment with IMPROVE

The term "Learning By Teaching" (LBT) refers to the development of high-order skills which simultaneously assist students in education both in structuring their knowledge and in sharpening their instructional skills (Leelawong & Biswas, 2008). The latest prominent researchers in the LBT area (Biswas, Segedy, & Bunchongchit, 2016) are convinced that the integration of explanatory structures into the domain of new learning and explicit metacognitive guidance develops self-regulated learning strategies and knowledge of cognition in particular. The underlying concept is: "students learn especially well when they take on the role of the teacher" (Palincsar, 2012). This positive effect is expected in situations where students teach other students and where students teach computer-represented teachable agents (Okita & Schwartz, 2013).

There is sufficient empirical evidence in the LBT literature. For example, Jeong and Biswas (2008), who investigated the interaction between learners and "computer-based teachable agents" by applying metacognitive models found positive effects in terms of learning strategies. Bannert and Mengelkamp (2013) claim that technologically based learning supported by explicit steps and metacognitive instruction both for learning and teaching has a powerful effect upon pre-service teachers' cognitive development.

I followed the above claims and confirmed the assumption that technologically based LBT has proven to enhance meta-cognitive skills and several higher order thinking skills such as evaluation in declarative, procedural and contextual knowledge (Allamnakhrah, 2013; Meng & Sam, 2013; Anderson, Cook, & Mathys, 2013). I directed the LBT training by following the seven instructional steps of the IMPROVE model: Introducing new concepts; Metacognitive questioning; Practicing; Reviewing; Obtaining mastery; Verification, and Enrichment (Kramarski & Michalsky, 2015).

1.2 LBT in an F2F Environment with IMPROVE

Guided by recently developed theoretical frameworks, researchers have discussed the impact of LBT on KC in pedagogical domains in Face-to-Face (F2F) environments. For example, Buraphadeja and Kumnuanta (2011) investigated reciprocal learning and teaching based upon a peer tutoring process for learning material presented in lecture format. Students first worked individually and then in small cooperative groups using an explicit metacognitive-based model. This procedure was designed to promote KC and metacognitive interaction. Similar intervention was applied by Palincsar (2012) whose purpose was to foster pre-service teacher ability to transform previously acquired knowledge by tutoring each other, with pre-service teachers taking turns both in leading teacher practice and in learning a new subject by teaching it. Their conclusions are supported by Fiorella and Mayer (2013) who claim that the LBT method creates a "teaching expectancy effect" which assists students in conveying KC by actually teaching in terms of both immediate and delayed measures. All researchers agree that such combinations of learning and teaching have a strong effect upon students' KC. However, those previous studies didn't offer any indication of the preferred LBT methodology for promoting effective pedagogical and cognitive processes (KC in teaching). This comparative study was designed to overcome the lack of empirical evidence regarding environmental impacts of LBT on pre-service teachers' knowledge and performance.

1.3 The Present Study

The main propose of this study is to apply Learning By Teaching training in both technological and F2F environments. Upon close examination of the literature, the author investigates the manner in which Knowledge of Cognition (KC) is expressed in those two environments. In order to encourage the development of KC, the metacognitive IMPROVE model (Mevarech & Kramarski, 1997; Kramarski & Michaksky, 2010) was adapted and customized to LBT training using the following steps: (a) Introducing new concepts, objectives, tasks and planning strategies; (b) Monitoring by metacognitive questioning; (c) Practicing teaching strategies; (d) Reviewing expected mistakes and cognitive misconceptions; (e) Obtaining instructional mastery; (f) Verification of comprehension; and (g) Improvement of pedagogical realization for future experience.

The author adduces that pre-service teachers exposed to the IMPROVE method will be able to transfer KC in learning and teaching in both immediate and long-term teaching experiences. The purpose of the study is threefold: (a) to investigate KC in the learning and teaching of pre-service teachers exposed to LBT with the IMPROVE method in different environments; (b) to compare differential immediate effects of KC in learning and teaching in the two groups; and (c) to examine the long-term transfer ability of the TBS+2P group as compared to the F2F+2P group in terms of KC in learning and teaching.

2. Method

2.1 Participants

The study involved 100 pre-service teachers (91 females, 9 males) in their first year of education at a large teaching institute in the center of Israel, all of whom participated in a Teaching Training Workshop as part of their curricular obligations. Their mean age was 25.13 years (M=25.13; SD=5.09), they had no prior theoretical and knowledge in pedagogy and either no practical experience in teaching in classroom. During this 28-hour workshop taking place over the course of one semester, participants were randomly divided into two groups: The first practiced LBT in a technology-based environment, while the second practiced LBT in a face-to-face environment (TBS+2P, F2F+2P).

2.2 The Intervention Program

Both groups of pre-service teachers (TBS+2P, F2F+2P) participated in the Teaching Training Workshop once a week for one semester (28 hours). The main requirement of the workshop was for pre-service teachers to practice learning and teaching pedagogical problems using the following procedure: (a) Learn educational subjects; (b) Design lesson in the newly learned subjects; (c) Teach the newly learned subjects. The research was conducted using the LBT model with a dual-perspective based upon the learner and teacher IMPROVE model for promoting KC in learning and teaching in TBS or F2F environments.

2.3 Measures

A mixed method for data breakdown (Creswell, 2013) involving both offline and online analyses was selected. Three measures were employed to evaluate both immediate and long-term effects of the research intervention. The first measure was the Metacognitive Awareness Inventory (MAI) (Schraw & Dennison, 1994), which evaluates pre-service teachers' statements regarding KC in learning and teaching, both before and after the intervention (pretest/posttest). The second measure was Educational Computerized Data Mining (Romero & Ventura, 2013), which processed the online learning task one month after the intervention. I analyzed the Educational Computerized Data by means of a scoring scheme (Gutman, 2012) that indicates *long-term effects of KC in learning*. For the third measure I made direct observations of the pre-service teachers' actual classroom teaching one year after the intervention. This assisted us in determining *the long-term effects of KC in teaching*.

2.3.1 Statements Concerning KC in Learning and Teaching

A pre/post 38-item MAI (Schraw & Dennison, 1994) assessed pre-service teachers' statements regarding KC in learning and teaching. The MAI items focused on declarative, procedural, and conditional knowledge in learning and teaching (α=.87, α=.82 respectively). For example, a declarative item of KC in learning was: "I know what is the best strategy to cope with the task in this course", and the declarative item of KC in teaching was: "I know what the best strategy for solving pedagogical dilemmas is". Each item was measured on a 5-point Likert scale ranging from 1 (never) to 5 (always).

2.3.2 Long-Term Effects on KC in Learning

The long-term effect on KC was measured by Educational Computerized Data Mining by focusing on patterns of Help Seeking (HS) and Help Using (HU) by accessing help files during the process of online task solving. This data was gathered using TBS reports and trace logs. The data was analysed by means of a scoring scheme developed by the author (Gutman, 2012). In the first step of the analysis, statistics about the frequency of HS and HU patterns in the online learning task were extracted in order to draw conclusions about their interrelation and in order to provide a credible indication of conditional and procedural knowledge in online learning processes (Roll et al., 2014; Winne & Baker, 2013). In the third step, participants' explanations of their decisions regarding HS and HU (Linawati, 2016; Scheuer & McLaren, 2012) were collected. In the last step, both the level and the length of the explanations were evaluated with respect to HS and HU by using the scoring scheme to indicate declarative knowledge in learning (Table 1) developed for the current study (Gutman, 2012).

Table 1. Scoring scheme for reports on help seeking and help using in learning

Point	Length of report	Level of report	Example
1	Less than 7 words	No *explanation*	-
2	Less than 7 words	No relevant *explanation*	-
3	Less than 7 words	General claim without *explanation regarding HS or HU*	*It "pumps" me with more ideas*
4	7-11 words	Relevant report with *explanation regarding* HS	I opened this help file to refresh my memory.
5	7-11 words	Relevant report with *explanation regarding* HU	It seems like useful information for this task.
6	12-16 words	HS	*I did not understand the "hint" of this task, so I needed more help and explanation*
7	12-16 words	HU	*I used the help file to compare the given samples with the ones that I provided for this task*
8	More than 17 words	HS	*I just wanted to understand what each concept means and to fulfill the demands of exercise*
9	More than 17 words	HU	*I used the help file to understand the essence of the concept and to match the tasks requirements.*
			I used the help file to compare the given samples and the ones that I provided in this task
10	More than 17 words	HS & HU	*I used the help file to give accurate and in-depth answers to the task. The help files contributed to my perception*

2.3.3 Long-Term Effects of KC

The long-term effect of KC was observed in actual classroom teaching one year after the research intervention. The observed lesson was analyzed for evidence of declarative, procedural, and conditional knowledge in teaching (Kohen & Kramarski, 2012). Participants' declarations about tasks and the setting of pedagogical goals during actual teaching were used as an indication of declarative knowledge of teaching. Devising instructions regarding learning tasks and their strategies indicated procedural knowledge of teaching. The ability of pre-service teachers to recognize conditions for meaningful learning, setting appropriate strategies according to learner difficulties and misconceptions indicated conditional knowledge of teaching.

Scoring: The scoring scheme of the classroom teaching strategies was based on the Krebs and Roebers model (2012). Each type of statement during the lesson (declarative, procedural, and conditional knowledge in teaching) was scored on a 1-4 point scale. Statements which included dual-perspective highlights (learner and teacher focus) received a grade of either 4 (high level of conceptual arguments) or 3 (high level of conceptual arguments). Items with a single-perspective focus received a score of either 2 (low level of conceptual arguments) or 1 (low level of conceptual arguments). The total scores for lesson design ranged from 3-12 (Table 2).

Table 2. The scoring scheme of Knowledge of Cognition in teaching assessment

Level	Declarative knowledge in teaching	Procedural knowledge in teaching	Conditional knowledge in teaching
Theoretical low level-1P	**1 point**-no/raw task and declaration of objectives	**1 point**-no/raw declaration of expected difficulties	**1 point**-no/raw declaration of teaching strategies
Conceptual low level-2P	**2 points**-matter objectives with declaration of teacher's focus only	**2 points**-expected difficulties with declaration of teacher's focus only	**2 points**-declaration of teaching strategy only
Theoretical high	**3 points**-general operative	**3 points**-general expected	**3 points**-general teaching and declaration

level-3P	objectives with declaration of combined teacher's and students' focus	difficulties and their solution with declaration of combined teacher's and students' focus	of students' expected strategies without highlighting of conceptual long-term transfer and benefits
Conceptual high level-4P	**4 points**-detailed and coherent operative objectives with declaration of teacher's and students' combined focus	**4 points**-detailed and coherent expected difficulties and their solution with declaration of teacher's and students' combined focus	**4 points**-detailed and coherent teaching with declaration of students' expected strategies including highlighting of conceptual long-term transfer

3. Results

3.1 Statements of KC in Learning and Teaching

I performed the repeated measures 2 (testing occasion) X 2 (group) on each of the two measures of KC in learning and teaching. The differential effects on KC in learning and teaching in the two groups (TBS+2P, F2F+2P) were compared. The MANOVA for the pre-test indicated that before the research intervention no significant differences in KC between the two groups existed: $F(3, 94)=1.87$, $p>0.5$, partial $\eta2=0.056$ and $F(3, 94)=2.71$, $p>0.5$, partial $\eta2=0.08$ in learning and in teaching respectively. However, the post-test showed significant differences in KC in learning between the groups: $F(3, 91)=3.25$, $p<0.5$, partial $\eta2=0.097$ and in KC in teaching: $F(3, 91)=4.03$, $p<0.01$, partial $\eta2=0.117$. The results indicate significant differences between the groups at the end of the research intervention in ***procedural knowledge*** of KC in learning and teaching ($F(1, 95)=9.82$, $p<0.01$; $F(1, 95)=11.17$, $p<0.001$ respectively) and in ***conditional knowledge*** of KC in teaching: $F(1, 95)=6.29$, $p<0.05$. However, no significant interaction effect exists between the two groups with respect to ***declarative knowledge*** of KC in both learning and teaching ($F(1, 95)=1.02$, $p>0.05$; $F(1, 95)=1.72$, $p>0.05$, respectively) and in ***conditional knowledge*** of KC in learning: $F(1, 95)=3.32$, $p>0.05$.

The effect size (Cohen's d) for pre- and post-test differences within each group show that at the end of the study pre-service teachers exposed to TBS+2P outperformed the F2F+2P group in conditional and procedural knowledge in learning (Cohen's d 0.42 and 0.49, respectively) and in conditional and procedural knowledge in teaching (d=0.57; d=0.47, respectively). By contrast, the F2F+2P group didn't experience such improvement in the same components of KC in both learning and teaching (see Table 3).

Table 3. Means, SD and Cohen's d effect (d) of statements of *KC* in learning and teaching, by groups

			TBS+2P group (*N=51*)		**F2F+2P group** (*N=47*)	
			Pre	**Post**	**Pre**	**Post**
KC in learning	**Conditional**					
		M	3.38	3.73	3.74	3.68
		SD	83	69	81	90
		d	**-0.42**		**0.07**	
	Procedural					
		M	3.55	3.93	3.85	3.77
		SD	77	64	74	81
		d	**0.49***		**-0.11**	
	Declarative					
		M	3.82	3.91	3.67	3.75
		SD	82	70	92	78
		d	**0.03**		**0.08**	
KC in teaching	**Conditional**					

	M	3.75	4.13	4.13	4.06
	SD	67	65	65	77
	d	**0.57***		**-0.04**	
Procedural					
	M	4	4.28	4.29	4.17
	SD	59	58	58	58
	d	**0.47***		**0.2**	
Declarative					
	M	3.92	4.11	4.11	4.08
	SD	64	75	75	67
	d	0.29		**0**	

3.2 Long-Term Effects of KC in Learning

Long-term effects of KC in learning in the different research groups were compared by a One-way ANOVA test. The dependent variables were Help-Seeking patterns (HS), Help-Using patterns (HU), and the Explanatory Level regarding Decisions (ELD), during the online learning task. The independent variable was the research groups (TBS+2P; F2F+2P).

The One-way ANOVA test results indicated significant differences between the groups for Help-Using (Procedural Knowledge): $F(1, 98)=10.51$, $p<.01$, partial $\eta 2=0.097$. However, no difference emerged for Help-Seeking (Conditional Knowledge): $F(1, 98)=0.63$, $p>05$, partial $\eta 2=0.006$, and for the explanatory level regarding decisions (Declarative knowledge): $F(1, 98)=0.51$, $p>05$, partial $\eta 2=0.005$. Table 4 presents the means, standard deviations, and Cohen effects for *HS*, *HU*, *and ELD* (see Table 4).

Table 4. Means, SD and Cohen's effects (d) of Help-seeking, Help-using and Level of explanation during online learning task, by groups

		TBS+2P *(N=53)*		F2F+2P *(N=47)*
Help Seeking	M	8.23		7.70
	SD	2.8		3.76
Conditional knowledge	*d*		0.14	
Help Using	M	5.70		3.55
	SD	3.62		2.89
Procedural knowledge	*d*		0.74	
Explanation	M	5.94		6.51
	SD	3.71		4.25
Declarative knowledge	*d*		0.13	

Scale: 0-10 according to help-files of Help-seeking and Help-using.

3.3 The Long-Term Effect of KC in Teaching in Teal-Time

The long-term effect of KC in teaching in different research settings was compared by a MANOVA test. The one-way simultaneous MANOVA test results indicate significant differences between the groups for KC in teaching in general: $F(6, 93)=7.90$, $p<.001$, $\eta 2=0.34$.

The pre-test ANOVA indicated no difference between the research groups in KC in teaching components: **conditional knowledge**: $F(1, 98)=1.99$, $p>.05$, $\eta 2=0.02$, **procedural knowledge**: $F(6, 93)=2.45$, $p>.05$, $\eta 2=0.02$, and **declarative knowledge**: $F(1, 52)=3.45$, $p>.05$, $\eta 2=0.34$. The post-test ANOVA results indicate that pre-service teachers in the TBS+2P group significantly outperform their peers in the F2F+2P group in **conditional knowledge**: $F(1, 52)=26.97$, $p<.001$, $\eta 2=0.216$; **procedural knowledge**: $F(6, 93)=25.22$, $p<.001$, $\eta 2=0.205$; and **declarative knowledge**: $F(1, 52)=18.48$, $p<.001$, $\eta 2=0.159$. Table 5 presents the means, standard deviations, and Cohen's d effect sizes for KC in teaching by testing occasion (pre- and post-test) and group (TBS+2P; F2F+2P).

Table 5. Means (M), Standard Deviations (SD) for immediate and long-term effect of KC in teaching by TBS+2P and F2F+2P groups

	TBS+2P group *(N=53)*		F2F+2P group *(N=47)*	
	Pre	**Post**	**Pre**	**Post**
Declarative Knowledge				
M	1.31	3.06	1.53	1.94
SD	0.61	1.06	1.00	1.09
d	2.28		0.41	
Procedural Knowledge				
M	1.47	2.75	1.74	1.64
SD	0.82	1.23	0.92	0.94
d	1.56		-0.11	
Conditional Knowledge				
M	2.32	3.02	1.96	2.25
SD	1.00	1.00	0.95	1.16
d	0.70		0.3	

4. Discussion

The findings of the present study indicate that pre-service teachers exposed to a LBT technological environment significantly outperform their peers in the Face-to-Face group in procedural knowledge of KC in learning and teaching. The immediate effect is reflected in their statements, while the long-term effect manifests in the online measurements. However, there was no significant difference in conditional knowledge between groups with respect to KC in learning (both immediate and long-term), but it did manifest in both effects of KC in teaching. There was no significant difference in declarative knowledge in the two groups with respect to KC in learning (both immediate and long-term), but did manifest in the long-term effects of KC in teaching only. Table 6 contains a summary of the results. The outcomes shed light on new aspects of LBT methods in different training environments and their immediate and long-term effects on knowledge of cognition in learning and teaching.

Table 6. Significance of Variability of KC in learning and teaching, measured at immediate and Long-term effects

		Immediate effect	Long-term effect
KC in Learning	Declarative Knowledge	1.02	0.51
	Procedural Knowledge	**9.82****	**10.51***
	Conditional Knowledge	3.32	0.63
KC in Teaching	Declarative Knowledge	1.72	**18.48*****

	Procedural Knowledge	**11.17*****	**25.22*****
	Conditional Knowledge	**6.29***	**26.97*****

* p<0.05, ** p<0.01, *** p<0.001.

I first discuss the possible reasons for significant and insignificant differences in KC in learning between the two groups in terms of immediate and long-term effects. Second, I suggest new interpretations of the immediate and long-term effects of KC in teaching as a consequence of LBT in different environments.

4.1 Declarative Knowledge in Learning and Teaching

Declarative knowledge in learning and teaching is defined as awareness of general instructions regarding specific learning or teaching tasks and about appropriate strategies to apply in order to obtain it (Chatzipanteli et al., 2015). In this study declarative knowledge was also measured as an ability to declare, explain and reflect upon specific instructions (in oral and written formats) in tasks and their consideration during the online learning task and actual teaching (long-term effect). Based on both measures, no significant difference between the groups in declarative knowledge of KC in learning was found. Nevertheless, the TBS+2P group was found to have succeeded primarily in declarative knowledge of teaching with respect to long-term measures, while the F2F+2P group expressed no significantly higher teaching performance. Possible explanations for these findings are being suggested.

According to Stürmer et al. (2012), successful development and implementation of declarative knowledge in learning is based upon explicit metacognitive training requiring students to apply newly learned material in new contexts. In this study, both research groups were exposed to such training in different environments which allowed them to improve their declarative knowledge of learning in similar ways without any significant differences between them. Declarative knowledge which usually has been conveyed by long-term reflective activities (e.g., learning by teaching in different pedagogical situations) is less differentiated in learning tasks and more prominent in "participants' ability to observe and interpret instructions in a professional manner" (Sturmer et al., 2012) and in implementing pedagogical skills in practice. This argument clarifies the data that our study's participants manifested declarative knowledge in teaching as measured by long-term effects in teaching practice only, although lack of declarative knowledge in learning and teaching were manifest as an immediate effect.

4.2 Procedural Knowledge in Learning and Teaching

Procedural knowledge is defined as knowledge of how to perform a specific task in the learning and teaching context (Chatzipanteli et al., 2015). Our results show significant differences in procedural knowledge in learning and teaching. This is evident in all the immediate and long-term measures: statements regarding KC in learning and teaching and KC in learning patterns in the online task and in actual teaching one year after the intervention. Researchers (Fayol & Thevenot, 2012; Star, 2013) make a clear distinction between procedural and other types of knowledge. For example, Star (2013) describes procedural knowledge as an immediate and unequivocal indicator of students' learning performance ability in that "students either know how to do a procedure (or therefore can execute it successfully) or do not know how to do the procedure". This is in contrast to softer kinds of knowledge (conceptual, conditional, declarative types) which are more complex and nuance based. The fact that pre-service teachers from the TBS+2P group outperformed their F2F+2P peers in procedural knowledge in all immediate and long-term tests certainly supports this fact. The TBS+2P intervention program required students to apply their procedural skills in both learning and teaching and was based on strengthening the perception of their interrelationship. The LBT model gives extensive guidance in teaching procedural performance. This was not so explicit in the F2F+2P group whose students perceived it as "casual" workshop-based training. I suggest further research to investigate additional technology-based environments more deeply for immediate and long-term effects of procedural knowledge among pre-service teachers.

4.3 Conditional Knowledge in Learning and Teaching

Conditional knowledge in learning and teaching refers to pre-service teachers' awareness of how, when, and why some learning and teaching strategies are appropriate for successful performance (Tarricone, 2011). The results don't reveal any significant differences between the two groups in conditional knowledge of learning. On the other hand, significant long-term effects in teaching are revealed. The immediate measures of conditional knowledge reveal similar findings: while conditional knowledge of learning doesn't show significant improvement in the repeated measures, the teaching aspect of it did show significant differences. A possible explanation for the empowerment of conditional knowledge over the long-term may be the fact that this kind of knowledge refers to knowing the appropriate usages of the two other (declarative and procedural) types of knowledge (Wilson & Bai, 2010), and over time it develops in reflective processes in both learning and teaching. It seems the pre-service teachers' processes of learning by teaching in a TBS environment which repeatedly practices the learning and teaching perspectives embed a deeper awareness of the appropriate implementation of all three kinds of knowledge in learning and teaching. This was especially revealed in knowledge of high order learning and teaching-conditional knowledge. Our findings conform to the accepted conclusion that "conditional knowledge concerns the local situational and general social, conventional, and cultural norms" for using various learning and pedagogical strategies (Pintrich, 2002, p. 221). I maintain that pre-service teachers who internalize the importance of such type of knowledge that has been supported extensively in TBS, succeed in assimilating and applying high level learning and teaching after a prolonged period of time.

4.4 Practical Implications, Future Research, and Limitations

This study offers potential contributions on both theoretical and practical levels. On the theoretical level, this research examines immediate and long-term effects of LBT methods in different environments. In so doing it enhances our knowledge of metacognitive LBT-based interventions and their impact upon immediate and delayed comprehension (Fiorella & Mayer, 2013). In addition, this study offers important insights on perspectives of knowledge of cognition in learning and in teaching, both of which haven't as yet received enough attention.

On the practical level, this study provides a perspective on integrating the IMPROVE method into LBT training, an innovation not included in previous studies. Based on our conclusions, future studies are suggested in order to expand and explore these issues among pre-service teachers using different metacognitive interventions. It is suggested that future research would focus on LBT methods and its influence upon the pedagogical and professional development of pre-service teachers. Finally, conducting studies that compare immediate and long-term effects of metacognitive intervention in different environments is suggested, in order to increase the theoretical knowledge in this area.

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