

Effects of Metacognitive Strategy Instruction on EST Reading Comprehension

後設認知策略教學對科技英文之閱讀理解成效

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Abstract

With the burgeoning attention committed to research on the various branches of English for Specific Purposes (ESP), English for Science and Technology (EST) courses have become popular for engineering students in universities all over Taiwan. This empirical study aims to examine the effects of metacognitive strategy instruction on EST reading comprehension. Based upon the results of a reading proficiency test, the experimental group received reading instruction with metacognitive strategy training, while the control group received standard reading instruction without any intervention. The results indicated that metacognitive strategy instruction was significantly more effective in facilitating learners' EST reading comprehension than standard reading instruction. Subsequent open-ended questionnaire administered to the experimental group showed positive perceptions of the training effectiveness. The responses revealed divergent perspectives with respect to the three metacognitive strategies. Finally, the pedagogical implications of the results and suggestions for further research will be provided.

Keyword : *metacognitive strategy instruction, ESP, EST, reading comprehension*

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摘要

隨著專業英文(ESP)的各分支的研究蓬勃發展,科技英文(EST)儼然成爲全台灣的大學工學院學生的熱門課程。本實證研究旨在探討後設認知策略教學對學生閱讀理解科技英文文章的成效。根據閱讀能力測驗結果,實驗組接受含後設認知策略訓練的閱讀教學,而控制組則接受無任何策略訓練的一般閱讀教學。研究結果指出後設認知策略訓練對增進學生科技英文的閱讀理解能力有顯著成效。隨後的開放式問卷結果顯示學生對此一訓練或全文抱持正面看法。此外,學生亦表達對三種後設認知策略實用程度的不同看法。最後,本研究結果將提供對教學上的啓示與對未來研究的建議。

關鍵字：後設認知策略教學，專業英文，科技英文，閱讀理解

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Introduction

For Taiwanese EFL university students in engineering colleges, the comprehension of English academic research articles in their specialty plays an essential role in learning. Those who fail to comprehend printed and online information effectively feel frustrated, and many seek help by taking English for Science and Technology (EST) courses. The most common course in these engineering colleges is “Science and Technical English Reading which teaches students to read EST research papers. This is typically the only way students can equip themselves with adequate academic reading comprehension for writing English technological research.

Numerous studies have shown that learners lacking metacognitive abilities cannot identify the problems they encounter during reading, and thus do not know how to monitor the reading process (Backer & Brown, 1984; Carrell, 1998; Garner, 1987; Paris, Wasik, & Westhuizen, 1988). In one instance, Bazerman (1985) conducted interviews and observed seven physics majors to investigate the EST reading process. He found that they skipped parts with familiar vocabulary and grammatical constructions, struggled to gain conversancy with unfamiliar or difficult passages, and reread lines that interested them or that were related to their ongoing work. More recently, Daoud (1991) used verbal reports to explore the reading habits of Arab and French EST learners. One significant finding was that they failed to perceive the rhetorical organization underpinning the overall meaning of the assigned texts, resulting in a fragmented and inappropriate mental representation of those texts.

On the other hand, some studies over the years have indicated that improvement in students' metacognitive strategy can facilitate the reading process, and thus enhance reading comprehension (Dole, Duffy, Roehler & Person, 1991; Kline, Deshler & Schumker, 1992; Paris, Wasik, & Westhuizen, 1988; Pressley, El-Dinary, Wharton-McDonald & Brown, 1998). Pressley et al. (1988) found that students' reading comprehension was not enhanced by merely reading more texts. In a more recent study, Vogt & Nagano (2003) indicated that with reading strategy training, struggling readers often achieved noteworthy improvements in comprehension. Among different reading strategy training, metacognitive methods have demonstrated the most impressive results (Ashman & Conway, 1993; Bauman, 1988; Benito, Foley, Lewis, & Prescott, 1993; Block, 1992; Brown & Palincsar, 1989; Carrell, Pharis, & Liberto, 1989). Carrell (1998) then specified two main components for successful metacognitive reading strategy instruction: a knowledge of cognition, which determines what, when, and how to use a strategy, and the regulation of cognition, which controls the monitoring, planning, and transferring phases. The latter component is the so-called metacognitive strategy, whose objective is

the self-regulation of the reading process by the reader. Using an EST text, Nebila (2003) evaluated the effectiveness of metacognitive strategy training on 61 Tunisian college biology students. This study revealed that training improved students' declarative and procedural knowledge while enhancing strategy use when reading research articles.

Despite these encouraging results, the training of metacognitive strategies used in Nebila's (2003) study was not detailed. However, in an earlier study, Blanton (1994) proposed three metacognitive strategic phases of reading: the planning strategy or the pre-reading phase; the monitoring strategy phase during reading; and the evaluating or reflecting phase after reading. In the first phase, the planning strategy facilitates a systematic approach when reading a text, such as adopting a consistent re-reading frequency for particular passages. During the reading process, the monitoring strategy phase enables the reader to examine his or her own comprehension, principally by identifying and isolating problematic items. The evaluating strategy then equips the reader with the ability to assess the efficacy of his or her approach, including the execution of strategy use. Conceived in the light of Nebila's work and employing Blanton's three phase approach, this study aims to examine the effects of training in metacognitive planning, monitoring, and evaluating strategies on the EST reading competence of Taiwanese university students in colleges of engineering. Therefore, two research questions are addressed:

- (a) Did the metacognitive strategy instruction improve engineering students' reading comprehension of EST articles?
- (b) How did the treatment group students perceive the three types of metacognitive strategy training?

Method

Participants

Two groups, with 52 and 53 engineering juniors respectively, from two intact Science and Technical English Reading classes in a southern Taiwanese University participated in this study. On the one hand, this elective course aimed to equip students with enhanced EST reading comprehension of research papers. On the other hand, it is a pre-requisite for senior elective Science and Technical English Writing. The two classes were randomly assigned into an experimental group and a control group. In advance of the pretest, the 2 groups were asked to take a reading proficiency test adapted from an IELTS sample test, in order to ensure their homogeneity. The *t*-test analysis of the results indicated that the two groups were in fact homogeneous with regard to their reading comprehension ($t = .742, p > .05$). Throughout this study, both groups used the same course materials, followed the same syllabus, and were taught by the same instructor.

Both groups met once a week for a two-period session, each period lasting 50 minutes.

Instruments

The Reading Comprehension Tests

The pre-test and the post-test were reading comprehension tests composed of an EST paper in the participants' field of specialty respectively and ten open-ended questions concerning the content. To ensure that the EST articles used in the pre-test and the post-test were of the same difficulty level, language and content domains were carefully evaluated. As shown in Table 1, a readability test was conducted to compare language difficulty while content difficulty was evaluated using a pilot test on ten engineering students. The ten open-ended questions, assigned ten points each, were related to the two research papers. To address the reliability of the rating criterion, a second rater participated in the evaluation process and achieved a high inter-rater reliability ($r = .82$).

Table 1 Readability of the Two EST Articles for the Pre-test and Post-test

	Pre-test	Post-test
Total words	4327	4432
Total sentences	223	229
Mean words per sentence	20.6	20.1
Mean sentence per paragraph	5.9	6.1
Passive sentences (%)	69	71

The open-ended questionnaire

The purpose of the open-ended questionnaire was to elicit more extensive data on how the subjects perceived the metacognitive strategy training. The researcher adapted the questions not only to suit college level students, but also to correspond with the research questions in this study.

Procedures

In order to evaluate the effectiveness of the training each group took a pre-test and a post-test. The experimental group received the metacognitive reading strategy instruction, while the control group received general reading instruction. The three metacognitive strategies: planning, monitoring and evaluating were separated into three five-week cycles to ensure the optimum learning effect. This cycle pattern and duration was adopted

for two reasons: Firstly, prior to taking Science and Technical Reading Courses, the participants had received no training in reading academic papers in their field. Secondly, the participants' intensive college course schedules reduced the intensity of exposure to metacognitive strategy training. Therefore, it was considered necessary to provide the participants with additional hours of instruction in order to enable them to thoroughly master each metacognitive strategy. The metacognitive strategy training was conducted according to the instructional model "CALLA" of Chamot, Barnhardt, El-Dinary & Robbins (1999), which features five typical phases: "preparation", "presentation", "practice", "evaluation", and "expansion". In each five-week cycle, the first week was devoted to preparation, the second presented the target strategy, the third focused on sufficient practice of the taught strategy, the fourth centered on evaluating the application of the taught strategy, and the fifth emphasized expansion of the taught strategy. Subsequent open-ended questionnaire were then administered to the experimental group after the instruction period. The qualitative data collected were analyzed to assess the students' perceptions of the semester-long metacognitive strategy instruction.

Results and Discussion

The Pre-test and Post-test

As shown in Table 2, there is no statistically significant difference between the experimental group and the control group in the pre-test ($t = .034, p > .05$). The two groups showed similar ability in EST reading comprehension in the pre-test. Specifically, the two groups achieved identical, low, scores in their EST reading comprehension before the training. Notably, the juniors taking the Science and Technical Reading elective display a lack of systematic organization in their reading. Although they have adequate background knowledge in their specialty, they lack sufficient reading strategies when reading the EST articles. In fact, they have no previous training in reading strategy, which may account for their poor performance in the EST reading comprehension in the initial stage.

Table 2 Pre-test between the Two Groups

	N	Mean	S.D.	<i>t</i> -value	Sig.
Experimental group	52	54.23	5.39	.034	.873
Control group	53	54.09	4.92		

* $p < .05$, ** $p < .001$

As presented in Table 3, after a semester’s instruction in strategy training, a statistically significant difference is found between the experimental group and the control group in the post-tests ($t = 2.67, p < .001$). Evidently, the experimental group improved appreciatively in EST reading comprehension. The findings supported the results of previous studies showing that metacognitive strategy instruction improves readers’ metacognitive awareness and metastrategic control in processing new information, thus helping them to become more successful readers (Kuhn, 2000; Warian, 2003). The use of more metacognitive strategies increase reading proficiency over time, as individual readers become aware of which strategies most significantly assist their comprehension (Darabie, 2000).

Table 3 Post-test between the Two Groups

Group	N	Mean	S.D.	t-value	Sig.
Experimental group	52	70.31	7.14	2.67	.001 **
Control group	53	54.17	4.78		

* $p < .05$, ** $p < .001$

Table 4 demonstrates the performance differences between the pre-test and the post-test for both groups. A statistically significant difference was observed for the experimental group ($t = 2.52, p < .001$), while the difference for the control group was not statistically significant ($t = .031, p > .05$). As such, the results supported the claims that without training, readers fail to employ metacognitive strategies to process their reading (Yuill & Oakhill, 1991). In other words, metacognitive strategy training greatly enhanced readers’ metacognitive awareness in reading, thereby increasing their reading effectiveness (Nabila, 2003; Eme, Puustinen, & Coutelet, 2006).

Table 4 Pre-test and Post-test Difference between the Two Groups

Group	Test	Mean	S.D.	t-value	Sig.
Experimental group	pre-test	54.23	5.39	2.52	.001 **
	post-test	70.31	7.14		
Control group	pre-test	54.09	4.92	.031	.854
	post-test	54.17	4.78		

* $p < .05$, ** $p < .001$

The Open-ended Questionnaire

As a whole, the participants responded positively towards the metacognitive strategy instruction (93.1%), and the extracts in Table 5 illustrate their typical responses. The majority of experimental group participants considered the training useful to the extents its practicality. The findings also support the results of previous studies (Abdul Rashid, Chew, & Kabilan, 2006; Lee, 2006; Presssley, 2000) showing that metacognitive strategy instruction is deemed beneficial to reading comprehension.

Table 5 Extracts from the open-ended questionnaire (Q1)

In general, how do you perceive the metacognitive strategy training you had this semester? Why?
“Yes....It’s very useful to me. I wish the training course had started earlier in the sophomore year. “
“It is certainly helpful. I felt like a mess before the trainingNow I have guidelines for what to do before, during, and after reading EST articles.”
“I think so. At least I am not that afraid of reading EST articles any more. I’ve been trained. ”
“Although it was not easy to keep up in the very beginning, I am impressed with the instruction. ”

Perceptions of the effectiveness of the training are presented in Table 6. In terms of the most helpful effects, 74.3% of participants reported that the training had improved their reading habits and thought patterns, thereby demonstrating that their EST reading comprehension had improved according to the specific aims of the metacognitive strategy instruction. Furthermore, 21.8% of the subjects perceived the training as a confidence builder, an effect less directly related to its aims. It is crucial for the development of reading autonomy for the students to be receptive to application of training. More often than not, once the participant’s confidence in reading research articles was improved, their reading autonomy would be significantly increased (Huang & An, 2005; Lu, 2006).

Table 6 Extracts from the Open-ended Questionnaire (Q2)

In what way does the metacognitive strategy training help you most in reading EST articles? Why?
“I think it changed my reading habits. I know more ways to deal with EST articles, instead of consulting the dictionary for every word.”
“My way of thinking. I am able to “think” in the process of reading. It’s a great improvement for me.”
“Probably how to think when reading. In the past, I used to spend more hours reading, but now I feel I can read EST articles faster, after the training.”
“Confidence, I guess. I feel more confident when facing EST articles.It reduced a lot of my anxiety during the reading process.”

Table 7 presents the wide range of subjects’ views on the least helpful aspect of the training. A large majority of the participants regarded the training as generally helpful but could not determine in what way the training was least helpful. However, for 11.5% of the participants, the least helpful aspect of the training was that it did not help them overcome reading difficulties that resulted from an inadequate lexicon and deficiencies in their grammar knowledge. Although they were trained in metacognitive strategies, their lack of sufficient linguistic knowledge thwarted their comprehension of EST articles. Therefore, their responses reflected their needs in the integration of basic components and metacognitive strategy (Nebila, 2003).

Table 7 Extracts from the Open-ended Questionnaire (Q3)

In what way does the metacognitive strategy training help you least in reading EST articles? Why?
“I feel it was okay. I have no specific thoughts on how it least helped me.”
“Well, the training was good. I cannot think of a least helpful aspect.”
“The grammar would hinder me from using the metacognitive strategy. Some of the syntactic structures were difficult. For example, a lot of past-tense sentences were found in the EST articles.”
“I encountered many vocabulary and phrases that were new to me, or that I had forgotten.”

Table 8 and 9 reveal the different degrees of helpfulness of the three metacognitive strategies in EST reading comprehension. In terms of the most helpful strategy for reading EST articles, 47.4% of the participants credited the monitoring strategy training. The results correspond to Pintrich's (1999) finding that "the monitoring process suggests the need for regulation processes to bring behavior back in line with the goal or to come closer to the criterion" (p.461). 46.7% of the participants considered the planning strategy most beneficial, finding its easy application on par with the monitoring strategy training. The results conformed to previous studies which found that pre-reading metacognitive planning helped correct reading behaviors and repair comprehending deficits strategy when reading a text (Carrell, 1998; Whyte, 1993). In terms of the least helpful strategy, 92.7% of the participants considered the evaluating strategy least helpful. Such a high percentage is probably because among the three metacognitive strategies which aim to direct and remedy problems in the reading process, the evaluating strategy is the most abstract and advanced, and thereby more difficult to be adopted and applied to EST article reading (Baker & Brown, 1984; Capelli & Markman, 1982; Garner, 1987).

Table 8 Extracts from the Open-ended Questionnaire (Q4)

Among the three kinds of metacognitive reading strategy training, which one is the most helpful to you in reading EST articles? Why?

"Well, if I have to choose only one strategy, I think it would be the monitoring strategy because before the training I have never thought during the reading process."

"I would say the monitoring strategy, because the strategy is new to me and useful. Before I applied this strategy, I would be lost in the lines."

"I don't really know which one is the most helpful. But the planning strategy is the easiest for me to use in reading EST articles. It was taught first and I remember it best."

"I guess it is the planning strategy.As for the reason, I found it is easy to apply when starting to read an article.The other two are comparatively difficult to use."

Table 9 Extracts from the Open-ended Questionnaire (Q5)

Among the three kinds of metacognitive reading strategy training, which one is the least helpful to you in reading EST articles? Why?

“Actually, if I can apply the taught strategy well, the three strategies are all helpful.”

“The least helpful? I would say the evaluating strategy. Hmmm, it’s more difficult To apply to EST reading.”

“I think the three strategies are all more or less helpful. The least helpful strategy is probably the evaluating strategy.I don’t know. I think I use this strategy less.”

“Let me see. It’s the evaluating strategy..... I don’t really have the ability to apply it to EST reading. Yeah...it’s very difficult for me.”

“Well, I hardly ever use the evaluating strategy when reading EST articles. I don’t exactly know how to use this strategy well, even after the training.”

Lastly, Table 10 reveals necessary improvements in the strategy training. In general, 56.8% of the participants cited examples of the strategy training deficits. Among the responses, 74.1% considered “time” an issue. They felt that the whole training session should be longer, for example, a year instead of a semester. They expected longer exposure to the training, and would have preferred more time spent each week on training. They felt that they needed more practice implementing the reading strategies taught in the classroom. In short, intense systematic metacognitive strategy instruction is associated with positive effects for reading comprehension (Mokhtari, & Reichard, 2002; Singhal, 2001). However, implementing metacognitive strategies training might be more difficult in operation than other strategies, because they are more abstract in their nature involving learners’ awareness of their reading processes (McKeown & Gentilucci, 2007).

Table 10 Extracts from the Open-ended Questionnaire (Q6)

What do you think need to be improved in the metacognitive reading strategy training? Why?

“I think sufficient practice is needed in order to naturally apply the metacognitive strategy when reading EST articles. The exposure time to the strategy training should be increased.”

“If the hours of instruction each week were doubled, the effectiveness would improve a great deal. Extensive exposure to the strategy would help facilitate continual application of the strategy and further improve EST reading comprehension.”

“I feel positive towards the whole set of training, but I cannot digest it well in only a semester. If the instruction time was longer, I believe the results would be better. Yeah, one year is better than a semester.”

“The instructor explained and guided us well in class, but I still cannot apply the strategies to the EST articles I read outside the classroom. Maybe I need more time to practice, then the strategy would transfer to outside reading. I hope to receive one year of training on metacognitive reading strategies.”

Conclusion

This study investigated whether training EFL engineering students in the use of metacognitive strategies would assist them in their comprehension of EST research articles. Traditionally, EST reading teachers have focused on the decoding ability of learners. They tended to randomly explain the linguistic components without implementing metacognitive strategy training. As such, most learners were inclined to translate word for word without strategic thinking, and thus easily become frustrated and lose focus when reading EST articles. In this study, despite the inadequate sample size, it was apparent that metacognitive strategy instruction was correlated to reading comprehension improvement. Therefore, it can be concluded that the metacognitive reading strategy instruction helped students evaluate different reading strategies in an effective way, helped them focus on the reading process, and facilitated their reading comprehension. Significant evidence from both quantitative and qualitative data verified that the EST learners benefited tremendously from the explicit metacognitive strategy training. When encountering EST research articles, they were more confident and less anxious. Moreover, they found the taught strategies useful for making pre-reading plans, monitoring their understanding while reading, and evaluating the information they processed after reading. On the other hand, the fact that a majority of the learners demanded more intense and longer strategy training sessions indicates that EST reading

teachers should devote more time and energy to guide the students. Although the introduction of metacognitive strategy training may be innovative to both EST instructors and learners, such training should be incorporated into EST courses in order to effectively increase learners' reading proficiency and confidence. The curriculum design for Science and Technical Reading should also allow three hours instead of two hours a week, and longer sessions for optimum effectiveness. Teachers should also select articles from more than one content domain of materials engineering to allow more flexibility in metacognitive strategy applications.

All in all, this study has provided evidence that overall metacognitive strategy training is effective in enhancing EST reading comprehension. However, a further empirical study is needed in which instruction in each of the three metacognitive strategies is provided to three respective groups, in order to evaluate which metacognitive strategy is most conducive to facilitating EST reading comprehension. By comparing the effects of three experimental groups with a control group, more detailed information on the effects could be determined. Moreover, this study could also utilize additional qualitative methods, such as think-aloud protocols, to depict in greater depth when, where, and how different metacognitive strategies are applied when reading EST research articles. In particular, the similarities and differences between the learners' perceptions and actual strategy use could be examined in greater depth.

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