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The Effects of Cognitive Styles on Problem Solving in the Context of English Logics

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Abstract: To help learners improve logical abilities in English writing, we designed an Academic English Logic Training System (AELTS), where learners developed the understanding of English logic of academic writing via a problem-solving process. Furthermore, an empirical study was conduct to investigate how cognitive styles (i.e., Holists vs. Serilists) affects learners' reactions to the AELTS during the problem-solving process. The results indicated that Holists significantly obtained higher post-test scores than Serialists but no significant differences were found for task scores. This might be because Holists preferred to use hints to understand the meaning of sentences while Serialists tended to guess the answers by themselves. Furthermore, they also demonstrated different learning behaviors, which corresponded to their characteristics. More specifically, Holists preferred to jump between different objects while Serialists showed a sequential pattern. In summary, the findings from this study contribute the understandings of the development of a personalized AELTS that can accommodate the differences of Holists and Serialists.

Keywords: cognitive style, scaffolding, lag sequential analysis**,** academic English

1. Introduction

When students learn how to write English academic papers, they need to face two problems. One is English grammar while the other is English logic (Plakans & Gebril, 2017). The former has been taught in several courses but the latter has been ignored in educational settings (Plakans & Gebril, 2017). Accordingly, students were seldom award of the logical relationship between each sentence, which, in turn, it is hard to grasp the whole topic and content of materials (Yang, Xue & Zihan, 2016). On the other hand, using proper connectives to demonstrate logical relationships between sentences can make textual meaning explicit (Hu, 2016). More specifically, making sentences be entailed from each other can help readers the meaning of one sentence by inferring from another sentence (Sukumar & Gayathri, 2014). In brief, a clear logical relationship between each sentence is important so that readers can easily recognize contributions made by authors (Abdalrahman, 2016).

To this end, we designed an Academic English Logic Training System (AELTS), where learners developed the understanding of English logic of academic writing via a problem-solving process. More specifically, they need to learn how to order a number of sentences based on the logical meaning of the text during the problem-solving process. In other words, they were requested to find solutions to process and organize information. On the other hand, cognitive styles are considered as an essential human factor, which affects how learners process and organize information (Chen & Ford, 1998; Riding & Rayner, 2013).

A number of cognitive styles have great effects on learners' information processing and student learning. Among them, Pask's Holism and Serialism have been received great attention for the past ten year. Pask (1976) indicated that differences existed between Holists and Serialists. For instance, Holists and Serialists had different learning strategies. Holists tended to process information with a pattern of 'whole to part' while Serilaists preferred to use a 'part to whole' sequence to process information (Jonassen & Grabowski, 2012). More specifically, Holistic learners tended to take a global learning strategy while Serialistic learners preferred to use a local learning strategy (Ku, Hou & Chen, 2016).

Within the area of digital learning, several studies investigated behavior differences between Holists and Serialists. Clewley, Chen and Liu (2011) explored how Holists and Serialists interacted with a web-based learning system. Holists preferred to use hyperlinks to discover relationship between topics while Serialists preferred to use an index to locate specific information. Moreover, Chan, Hsieh and Chen (2014) also investigated that how learners with holistic and serialistic styles used electronic journals. Holists tended to use multiple methods to justify relationships between each topic while Serialists preferred to take a single way to browse the content. Additionally, Wu and Hou (2015) also examined learning behaviors of Holists and Serialists. The findings suggested that Serialists preferred to discuss the questions deeply and proposed the solution in details. Conversely, Holists tended to understand the frame of the problems and shared the information but they did not provide a detail solution against the problem. In other words, learners with holistic style and serialistic style demonstrated different approaches to solve the problems. Subsequently, Hsieh, Lin and Hou (2016) explored how Holists/Serilaists interacted with game-based learning systems. The results indicated that Holists favored to use searching tools to solve the problems. However, Serialists preferred to use the keywords to find the answers.

As mentioned in the aforementioned studies, Holists and Serialists have unique patterns to do information processing. Therefore, there is a need to examine how they process information when they solve problems. To this end, the aims of this study have two-fold. One is to develop the AELTS to improve learners' logical abilities in English writing via the problem-solving process. The other is to conducted empirical research to explore how Holists and Serialists reacted to the AELTS during the problem-solving process, in terms of their learning performance and learning behavior.

2. Academic English Logic Training System

In the past days, English learning mainly focused on vocabulary usages and proper punctuation. On the other hand, there was a lack of studies that paid attention to the sentence structures and logical abilities of English writing (Rakedzon & Baram-Tsabari, 2017). To fill this gap, we developed the Academic English Logic Training System (AELTS) to help learners improve their logical abilities of English writing. When using the AELTS, learners were allowed to swap sentences to organize the sentences with various hints. The design rationale of the AELTS is detailed below.

- *Learning by Doing:* The AELTS provided five academic articles for learners and the content of the articles would be presented by single sentences of which the order was not logical. Learners were required to reorganize the sentences into the correct order (Figure 1).
- *Costed Scaffoldings:* In order to reduce frustration of learners, the AELTS provided multiple types of scaffolding instruction, such as direct hints and indirect hints (Table 1). However, there was a reduction of scores when learners used the hints, apart from the text hint and picture hint. By doing so, learners did not rely on scaffolding instruction too much.
- *Multiple Tools:* The AELTS provided multiple tools for learners when they undertook tasks, such as notebook and the current state of answer (Table 2). Such tools could facilitate learners to complete the tasks and to identify what they had done and what they would need to do.

Table 1: Scaffolding hints in the AELTS.

Type	Hints	Contents	Deduction points
Direct hints	location hints	To know the position of one sentence.	20
	answer hint	To present the correct answers to the current task.	100
	Chinese hints	To explain the meaning of vocabularies in Chinese.	20
	text hints	To provide the topic of the article.	0
Indirect hints	English hints	To explain the meaning of vocabularies in Chinese.	10

	synonyms hints	To provide the synonyms of each vocabulary.	5
	picture hints	To provide the picture related to the topic of the article.	0

Table 2: The tools of the AELTS.

Tools	Functions
notebook	To take a note for important information that learners want to write down.
full view	To present sentences of the article within a paragraph.
current state	To make learners know how many sentences are presented in a correct order
answer record	To inform learners of the history of their answers.

Figure 1. Overview of the AELTS

Figure 2. English hints

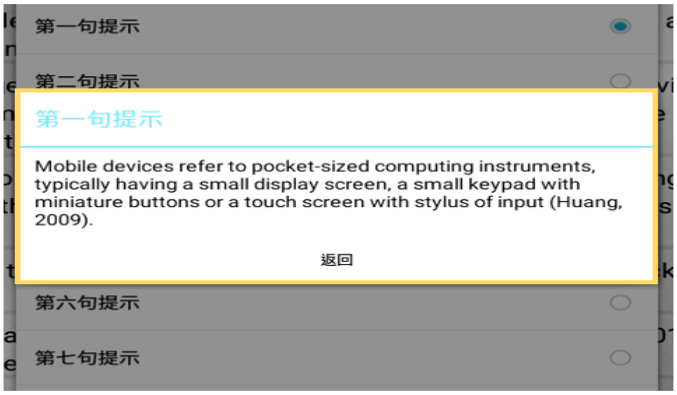

Figure 3. Location hints

3. Methodology design

3.1. Study Preference Questionnaire

The Study Preference Questionnaire (SPQ) originally developed by Ford (1985) was applied to classify students into Holists or Serialists in this study. The SPQ had been used in the previous research (Ku, Hou & Chen, 2016) and showed adequate reliability (Cronbach's α = 0.67) in such research that was the reason why we selected the SPQ to measure learners' cognitive styles. The SPQ included 17 statements, each of which contained two statements. One was related to Holists' preferences while the other was associated with Serialists' preferences. Learners needed to choose one of the statements that they agreed. According to their choices, if the learners selected over half of the statements regarding Holists, they were determined as Holists. On the contrary, they were identified as Serilaists.

3.2. Experiment procedure

University students from north Taiwan voluntarily participated in this study. According to the SPQ, we filtered 34 learners, who consisted of Holists and 16 Serialists. All of these learners did not take the course of Academic English before so it was not necessary for them to take a pre-test. Subsequently, learners started to complete the same tasks by interacting with the AELTS via the tablets. More specifically, they need to reorganize a number of sentences in a logical way. After completing the tasks, learners were asked to take the same post-test, where no scaffolding instruction was provided. The post-test included five questions, where learners needed to sort the sentences into a correct order. However, such questions were not the same as learning tasks. By doing so, the improvement that Holists and Serialists made could be discovered.

3.3. Data analyses

The study aimed to explore how cognitive styles affect students' learning performance and learning behavior when they interacted with the AELTS. Learning performance was measured based on task scores collected from the log file and post-test scores collected from the paper-based test. An independent *t* was applied to explore significant differences between Holists and Serialists, in terms of tasks scores and post-test scores. Learning behavior was collected from the log files which recorded how each learner interacted with the AELTS. A Lag Sequential Analysis (LSA) was employed to find out sequential relationships hidden in the learning behavior, regardless of Holists or Serialists. More specifically, the LSA could represent behavior sequences with visual diagram so we could clearly observe the relationships between each behavior sequence. Additionally, the LSA also could explain why different behavior sequences would lead to performance differences between Holists and Serialists.

4. Results and discussions

4.1. Learning performance

In this research, we applied an independent *t*-test to analyze task scores and post-test scores (Table 3). The results from the *t*-test indicated that Holists and Serialists obtained similar task scores. However, a significant difference was found for the post-test scores ($t = 2.317$, $p = .027^{*} < .05$). More specifically, Holists significantly obtained higher post-test scores than Serialists. The findings suggested that Serialists might require more assistances. Such a finding was consistent with that of Chen and Chang (2016).

Table 3: Learning performance between Holists and Serialists.

	CS	N	M	SD	df	t	p
Task scores	Holists	18	86.39	13.836	32	.187	.853
	Serialists	16	85.38	17.735			
Post-test scores	Holists	18	85.56	27.273	32	2.317	.027*
	Serialists	16	61.25	33.838			

*p<.05

4.2. Learning behavior

A Lag Sequential Analysis (LSA) was applied in this study because LAS could discover hidden relationships in learning behavior (Yang, Chen & Hwang, 2015). Table 4 presents the codes of learning behavior for Holists and Serialists. According to the results of the LSA, significant behavior sequences were converted to the behavioral transition diagrams of Holists and Serialists (Figure 4). The diagrams demonstrated that learners with different cognitive styles shared some similarities but they also showed different learning behavior patterns.

Table 4: Coding scheme of learning behavior.

Behavior	Codes	Description
next question	N	To answer the next question when completing the current learning tasks.
moving	M	To move the sentences when completing the current learning tasks.
checking answer	A	To identify whether the current answer is correct or not.
direct hint	D	To use the direct hint, e.g., Chinese hint or location hint.
indirect hint	I	To use indirect hint, e.g., English hints, synonym hints, and picture hints.
function	F	To use the tools that can remove difficulties, e.g., the answer record, notebook.

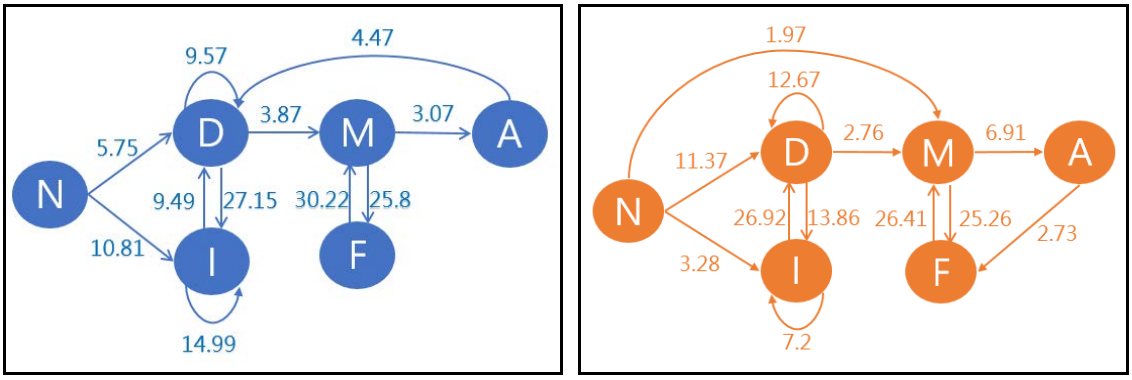

Figure 4. The behavioral transition diagram of Holists(left) and Serialists(right).

4.3. Similarities

The findings from the LSA indicated that Holists and Serialists demonstrated some similar behavior sequences i.e., N→I, N→D, F↔M, D↔I (Figure 4), which are discussed below.

- N→I: Learners used the indirect hints after they started a new task.
- N→D: Learners used the direct hint after they started the new task.
- D↔I: Learners switched between the direct hints and indirect hints
- F↔M: Learners moved the sentences after using the tools and then went back to move the sentence

These findings suggested that hints were helpful to learners when they started new tasks. This was because they tended to use both direct hints (N→D) and indirect hints (N→I) when they started new tasks. Furthermore, they switched between the direct hints and indirect hints (D↔I). Such significant behavior sequence suggested that both direct hints and indirect hints could help learners understand the meaning of sentences. On the other hand, they relied on the tools, instead of hints, when they moved the sentences (F↔M). The aforementioned findings implied that learners used different types of scaffolding instruction at different stages, instead of using a single type of scaffolding instruction all the time.

4.4. Differences

On the other hands, the results of LSA demonstrated that several differences between Holists and Serialists (Figure 4). Such behavior sequences expressed several significant information. The details meaning of the behavior sequences would be discussed subsections below.

- A→F (Serialists) vs. A→D (Holists): Serialists used the tools after checking the answers while Holists used the direct hints after checking the answers.
- N→M (Serialists) vs. None (Holists): Serialists moved the sentences by themselves while starting the new tasks, but Holists did not have the behavior.

These findings revealed that Holists would use the direct hints after checking the answers (A→D). In contrast, Serialists would use the tools after checking the answers (A→F). The difference between the direct hints and tools lied within the fact that the former could help learners understand the meanings and logics of the sentences while the latter could assist learners to identify their current status. In other words, Holists could better acquire the knowledge of how to organize the sentences via the direct hints. This might be the reason why Holists could obtain better post-test scores than Serialists.

Furthermore, Serialists would move the sentences immediately after they start a new task (N→M). This finding suggested that Serialists might attempt to try errors by themselves. Trying errors might be helpful for them to guess a correct answer so the task scores that they obtained were similar to those from Holists. However, trying errors was not useful for them to get better understandings. Thus, the post test scores that they obtained were lower than those from Holists.

4.5. Discussions

As the above section, the findings of learning behavior patterns indicated that learners with different cognitive styles had some behavior differences, which corresponded to their characteristics. More specifically, Serialists demonstrated a sequential pattern (i.e., N→D→M→A→F) when they did the learning tasks. This might be because Serialists tended to do things one by one (Chan, Hsieh & Chen, 2014). On the other hand, Holists preferred to jump between objects (Clewley, Chen, & Liu, 2011) so they showed an iterative pattern (i.e., N→D→M→A→D). These findings suggested that cognitive styles had great effects on their behavior sequences when they completed the tasks in the context of academic English.

5. Conclusions

In this study, we aim to investigate how Holists/Serialists reacted to the AELTS during the problem-solving process, especially for learning behavior and learning performance. Regarding learning performance, the results indicated that Serialists significantly obtained lower post-test scores than Holists. However, no significant differences were found for task scores. Regarding learning behavior, the results suggested that Holists preferred to jump between different objects so they showed an iterative pattern. Conversely, Serialists tended to do things step by step so they demonstrated a sequential pattern. Such behavior corresponded to their characteristics.

On the other hand, the result from the LSA indicated that different cognitive style groups chose different scaffoldings to help themselves. Holists preferred to use the hints to understand the meaning of sentences while Serialists attempted to try errors by themselves. These findings suggested that cognitive styles had great effects on their behavior sequences. Therefore, there is a need to incorporate the findings obtained from this study into the development of personalized learning systems that can support the preferences and needs of different cognitive style groups.

A framework was proposed to illustrate differences between Holists and Serialists based on the aforementioned findings (Figure 5). As shown in this framework, this study presented fruitful results. However, it also had several limitations. Firstly, the sample is small so we need to expand the sample to verify the findings presented in this study in the future. Moreover, we only considered differences between Holists and Serialists in this study. Additionally, we did not explore learners' behavior frequencies. Thus, further research should take into account other human factors, such as ages, prior knowledge, and gender, and investigate their behavior frequencies so that more comprehensive knowledge could be obtained.

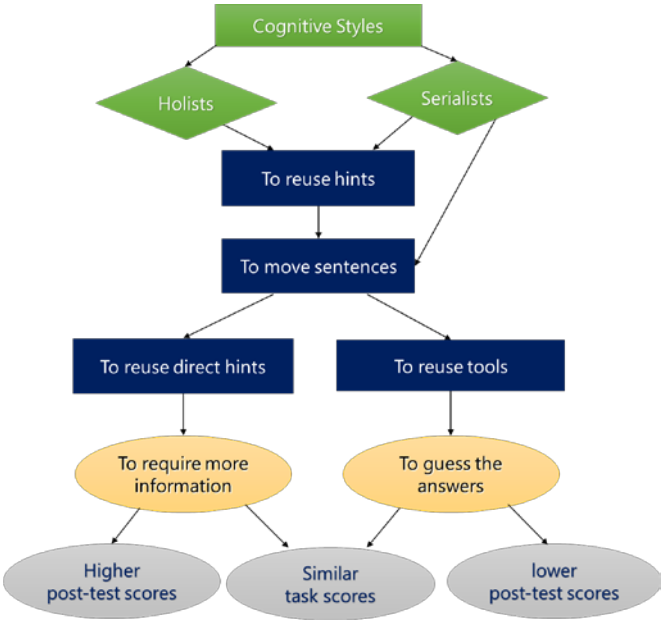

Figure 5. The framework to summarize the findings.

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