Title:
Latent Profile and Transition Analysis of Reading Proficiency among Grade 4 students: The Intervention Effect of Intelligent Tutoring System

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Background:

Fourth-grade students start to read more expository than narrative texts (Sáenz & Fuch, 2002). However, as expository *text structure* maybe still unfamiliar to these students, they may find these texts challenging to read (Roehling et al., 2017). Text structure refers to the way that ideas are presented in a text, and understanding it can help readers learn the relationships among these ideas (Meyer & Poon, 2001). Common text structures are *comparison, cause and effect, problem and solution, description, and sequencing* (Meyer, 1975), and studies have found that text structure strategy (TSS) interventions have positive impacts on students' reading outcomes (see Hebert et al., 2016, for a meta-analysis). As a common TSS practice, instructors may teach students to learn signaling words that can help identify text structure (e.g., the words "as opposed to" signals a comparison structure), and then students can organize these ideas using the comparison structure (Tomkins, 1998). Therefore, students learning TSS can identify the structure and organization of texts, and can better recall its main ideas, top-level structure, and essential details (Roehling et al., 2017). Hence, learning the comparison structure may facilitate text comprehension (Meyer & Poon, 2001).

Recently, Wijekumar and colleagues have developed an intelligent tutoring system for the TSS (or ITSS) and studied its impact on students' reading outcome (Wijekumar, Meyer, & Lei, 2012, 2013, 2017). ITSS intervention is designed to offer students opportunities to practice TSS at their own pace with immediate scaffolding feedback based on students' performance. ITSS intervention has its advantage compared to traditional TSS intervention because it allows for individualized and differentiated instruction, and implementing ITSS intervention may overcome teacher knowledge deficits (Beerwinkle et al., 2018). ITSS intervention has had a positive effect on elementary and secondary school students' reading comprehension (e.g., Wijekumar et al., 2012, 2017).

Previous ITSS studies focused more on its overall effect, but few studies have tapped into how ITSS influences different types of readers. Ji et al. (2018) examined both problem and solution (PS) texts and comparison texts, identified four types of readers (poor, proficient, delayed and readers with deficits in PS texts reading), and found that ITSS was particularly effective on 7th grade students who had difficulty with PS texts. However, the ITSS begins with the comparison text structure instruction based on previous reports suggesting that PS texts maybe difficulty for elementary students (see Ray & Meyer, 2011, for a review). Therefore, the focus of this research was to study whether ITSS had a differential effect on the profiles of 4th grade learners on comparison texts.

Research Questions

1. What are the reading proficiency classifications of 4th grade students when they read comparison texts?
2. Is ITSS more effective than the control condition in helping students transition from lower-performing classes to the proficient class(s)?

Participants

One hundred and thirty-one teachers' classrooms were randomly assigned to experimental conditions (ITSS and control) within schools. The total number of students was 3,067.

Research Design:

Teachers in the intervention group used the ITSS software in their classrooms or in a computer lab once a week for approximately 40 minutes for five months. Teachers in the control group followed their business-as-usual curriculum.

Students with parental permission were taking the following 5 tests at both pretest and posttest conditions. A standardized reading comprehension measure, *Gray Silent Reading Test* (GSRT), was administered (pretest: GSRT Form B; posttest: Form A). The test manual reported high reliability on the norm group. Also, a researcher-designed cloze task was adopted to assess *signaling word knowledge* in a comparison text. Then students were asked to write a *main idea* with the passage in view. Finally, students were requested to recall the entire comparison text without consulting the passage, from which *top-level structure* (TLS) and total number of ideas recalled (i.e., *recall competence* or RCC) were evaluated by 2 trained raters. The inter-rater reliabilities of these scores were all above .93.

Data Analysis:

Latent profile analysis (LPA) and latent profile transition analysis (LPTA) were conducted to answer our research questions. We determined the number of profiles (classes) based on AIC, BIC, and sample-size adjusted BIC (SBIC) values as suggested by Masyn (2013). However, we made the final decision based on educational meaningfulness. Then LPTA was be performed to understand if experimental condition affected transitional probabilities.

Results:

Figure 1 presents the AIC, BIC, SBIC statistics from one- to six- class solutions (or the "elbow plot"; Masyn, 2013). The "elbow" appears at the 5-class solution, that is, the fit indices did not differ substantially between 5-class and 6-class solution, meaning the 5-class solution is perhaps the most efficient solution. However, as Figure 2a and 2b show, the 4-class solution yielded clearer classifications than the 5-class solution. Hence, we chose the 4-class solution, and these classes can be named as "poor", "weak in TLS and RCC", "strong in TLS and RCC", and "proficient" readers.

Table 1 presents the LPA results with gender as a covariate. It appears that when setting "Proficient readers" as the reference group, females were less likely than males to be classified as "poor" readers (OR=0.61) or "weak in TLS and RCC" readers (OR=0.71).

As Table 2 shows, after controlling for gender effects, control group students were more likely than the ITSS group students to stay in lower performing classes (e.g., probability of staying as "poor readers": 0.602 [control] vs. 0.438[ITSS]).

As Table 3 shows, students in the ITSS group were more likely than control group to transition from "poor" to "proficient" (OR=2.61) and from "weak in TLS and RCC" to "proficient" class (OR=1.71). However, ITSS did not have better effect on students who already had strong TLS and RCC capabilities (OR=1.00).

Conclusions:

Our findings suggested that the ITSS was more effective than the control condition in helping students who had poor reading skills or those with specific deficits in recalling and top-level structure. Future research may explore ITSS's effect on different types of learners when reading other types of texts (e.g., cause and effect texts).

[Word count: 988]

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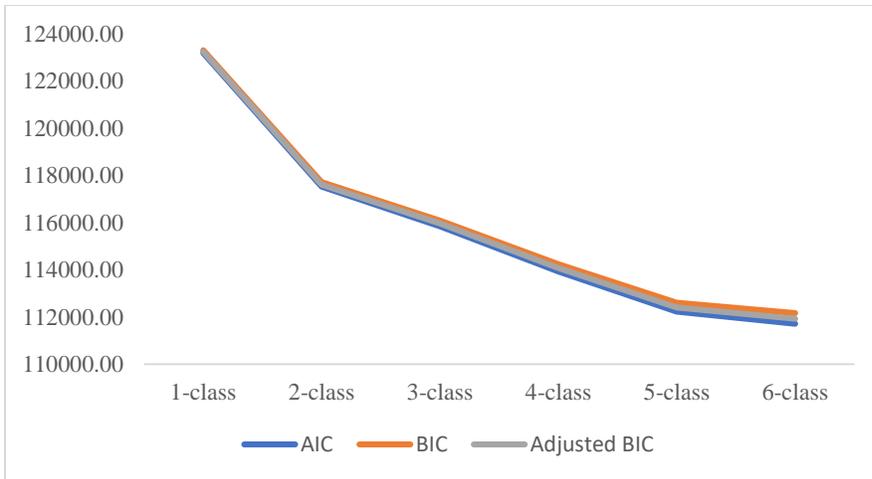
Figure 1. Pretest and posttest classification fit statistics plot without covariates
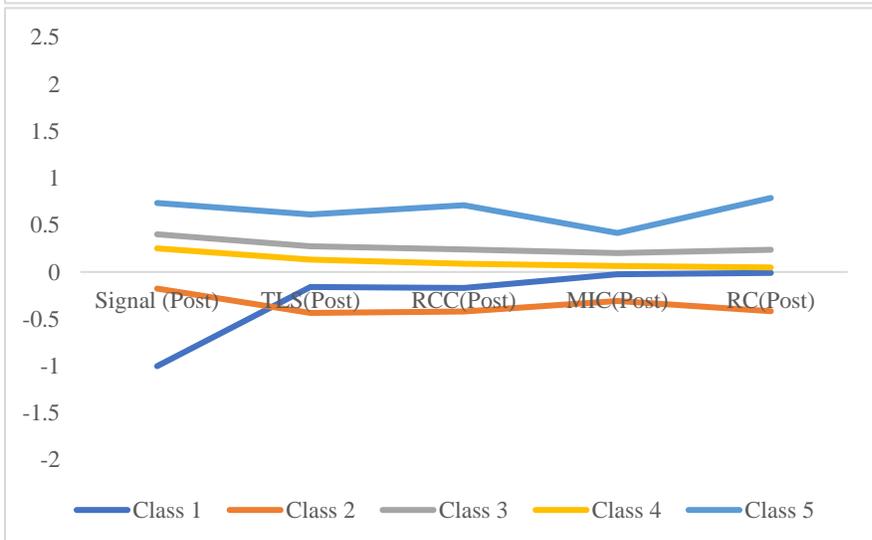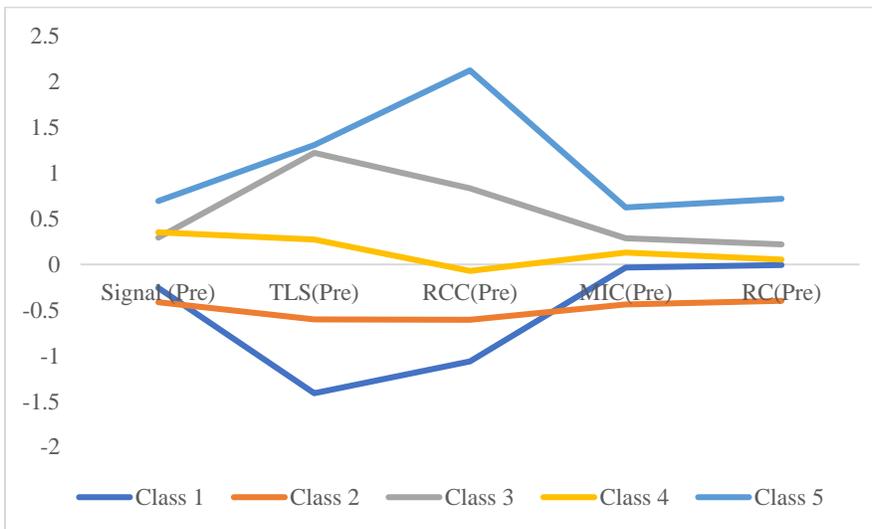
Figure 2a. LPA five-class solution based on pretest and posttest performances; left panel=Pretest classification; right panel= Posttest classification.
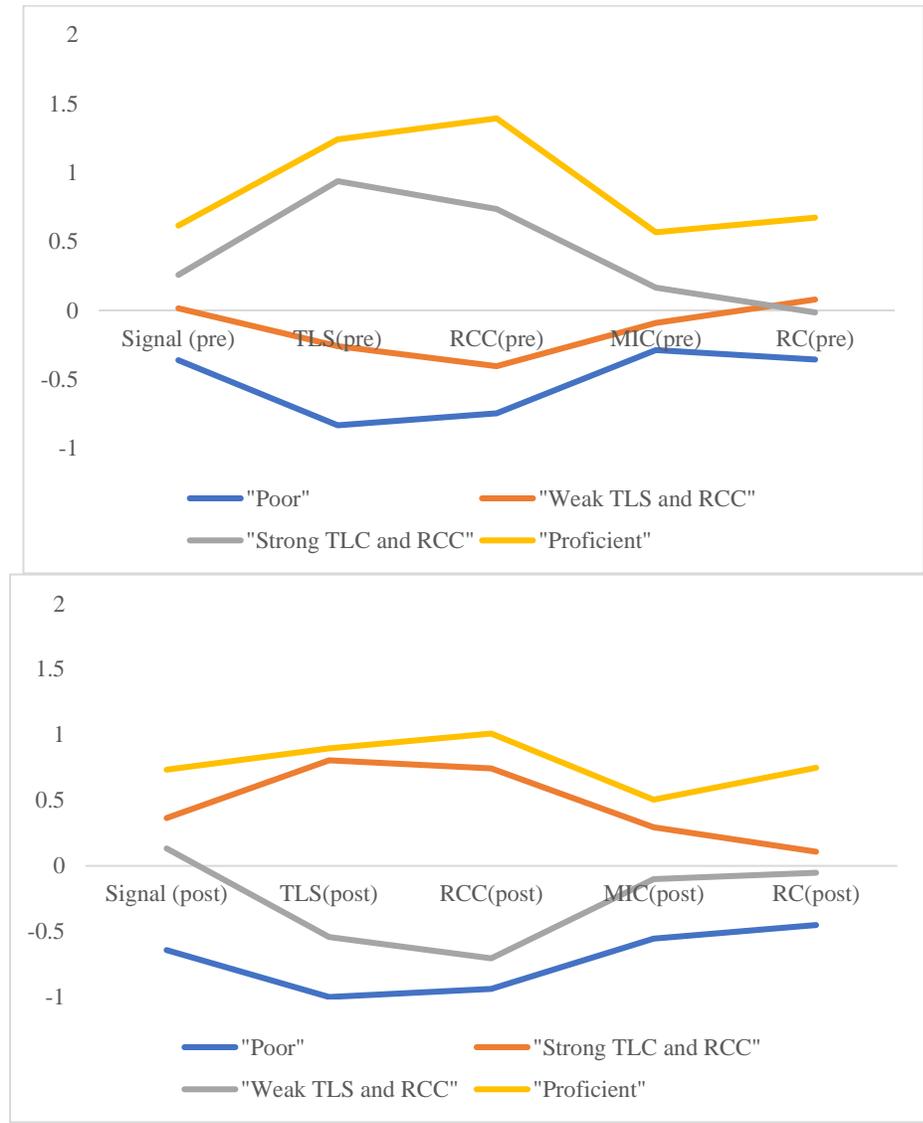

Figure 2b. LPA four-class solution based on pretest and posttest performances; left panel=Pretest classification; right panel= Posttest classification[1]

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[1]In all tables and figures, Signal=Signaling test; TLS=Top-level Structure; RCC=Recall competence; MIC=Main idea recall competence; RC=Reading comprehension.

Table 1

Latent Profile Analysis with Gender and ITSS as Covariates

	Grade 4 Latent Status			
Covariate	Poor Readers	Weak in TLS and RCC	Strong in TLS and RCC	Proficient Readers
Female				
Odds Ratio	0.61	0.71	1.00	Reference
ITSS				
Odds Ratio	0.83	0.83	1.18	Reference

Table 2

Control and ITSS group Transitional Probabilities based on 4-class Solutions Controlling for Gender Effects

Overall	Poor readers %	Weak in TLC and RCC readers %	Strong in TLC and RCC %	Proficient readers %
Pretest	58.70%	13.84%	16.36%	11.10%
Posttest	45.41%	12.31%	11.26%	31.02%
Control group	To poor readers	To Weak TLC and RCC readers	To Strong TLC and RCC readers	To Proficient readers
From Poor readers	**0.602**	0.115	0.144	0.139
From Weak TLC and RCC readers	0.346	**0.211**	0.229	0.214
From Strong TLC and RCC readers	0.134	0.178	**0.223**	0.465
From Proficient readers	0.073	0.111	0.232	**0.584**
ITSS group				
From Poor readers	**0.438**	0.192	0.106	0.264
From Weak TLS and RCC readers	0.205	**0.240**	0.137	0.417
From Strong TLS and RCC readers	0.134	0.178	**0.223**	0.465
From Proficient readers	0.082	0.154	0.059	**0.705**

Note. bolded texts are stayer probabilities

Table 3

Comparing the Odds Ratio of Lower-Class Readers move to Class of "Proficient" Readers Controlling for Gender Effects

From Poor to Proficient	Stayer probability	Probability of moving to "Proficient"	Odds Ratio
Control	0.602	0.139	
ITSS	0.438	0.264	2.61
From Weak TLS and RCC to Proficient			
Control	0.211	0.214	
ITSS	0.240	0.417	1.71
From Strong TCP and RCC to Proficient			
Control	0.223	0.465	
ITSS	0.223	0.465	1.00