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# SYNTACTIC ENHANCEMENT AND SECOND LANGUAGE LITERACY: AN EXPERIMENTAL STUDY

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This experimental study examined how the reading and writing development of sixth-grade L2 students was affected by syntactic enhancement. Visual-syntactic text formatting (VSTF) technology, which visualizes syntactic structures, was used to convert a textbook to the one with syntactic enhancement. The sample ($n$ = 282), which was drawn from a larger study conducted in Southern California, was a mixed population of English proficiency levels: low-proficiency L2 students ($n$ = 113) and high-proficiency L2 students ($n$ =169). Over a school year, VSTF students read their English language arts (ELA) textbooks in VSTF on their laptops and control students read their regular block-formatted textbooks either on their laptops or in print. Observations and interviews revealed that VSTF reading facilitated student engagement in ELA instruction by drawing students' attention to syntactic structures. The results of the California Standard Tests (CST) before and after the intervention were examined to evaluate participants' learning outcomes. Although high-proficiency students did not show a significant improvement on the post-test, low-proficiency made significant gains on two subtests of the CST: written conventions and writing strategies. These findings suggest that VSTF reading may facilitate improving syntactic awareness, which is essential for L2 students to develop their English reading and writing skills in academic contexts.

**Language(s) Learned in this Study:** English

**Keywords:** Computer-assisted Language Learning, Grammar, Reading, Writing

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## INTRODUCTION

Developing English proficiency for academic success presents great challenges for second language (L2) students, whether in English speaking countries or not. Among a wide range of registers, from oral to written and from informal to formal, in which L2 students need to engage, the formal features of written discourse—reading and writing—become more demanding, but crucial to learn, than other features as they advance through grade levels. For instance, L2 students in the U.S. tend to acquire basic conversational skills in the first few years, but it takes much longer for them to develop language proficiency for their academic success in schools (Scarcella, 2003). Thus, the academic performance of L2 students especially with low English proficiency is significantly behind their native peers, which leads to higher dropout rates for L2 students (Hill, Weston, & Hayes, 2014). Likewise, in non-English-speaking countries, improving written English proficiency is indispensable for academic or career success; however, even ten years of formal instruction may be insufficient for that (Sheu, 2003; Tanaka & Stapleton, 2007). Among various features of academic English, which is defined as "the language used in school to help students acquire and use knowledge" (Anstrom et al., 2010, p. iv), this study focuses on syntactic awareness, that is, the ability to reflect on sentence structures and relations between words. According to Scarcella's well-cited work (2003), the syntactic component of academic English for

reading and writing necessitates the accurate and effective use of words and phrases and their sophisticated grammatical features including complex syntactic structures. Although such syntactic knowledge continues to develop through high school (Nagy, Diakidoy, & Anderson, 1993), it has been given insufficient attention as a part of academic English in elementary and secondary schools (Fillmore & Snow, 2000). To address challenges in developing academic language proficiency, research has suggested that instructional support is necessary for students to meet such language expectations, which differ from those of the everyday registers of English (e.g., Schleppegrell, 2012). Commonly used instructional approaches to raise L2 syntactic awareness include the following: discrete-item exercises to increase metalinguistic knowledge, simplifying texts to reduce syntactic complexity, and input enhancement to make language input salient. This study aims to explore the use of reformatted text as input enhancement. An English language arts (ELA) textbook is reformatted in a way to emphasize syntactic structures and to facilitate developing academic English proficiency among L2 students while they read real-world texts. As such, we employ visual-syntactic text formatting (VSTF) technology to visualize syntactic structures without abridging content to offer L2 students the chance to acquire a solid foundation in syntax from reading real-world texts. We hypothesize that our reformatted textbook will serve as effective input enhancement for L2 students in the English classroom so that they can improve syntactic awareness. The increased syntactic awareness can in turn affect their reading and writing proficiency.

## SYNTACTIC AWARENESS IN L2 WRITTEN DISCOURSE

The extraction of syntactic information of words or word groups is essential for the construction of meaning from text (Grabe, 2009). The Structure Building Model proposed by Gernsbacher (1997), among widely recognized reading comprehension models, gives us insights into how syntactic awareness and processing support comprehension. Cognitive processes in this model involve laying a foundation, mapping information onto the foundation, and shifting to build new substructures. The first sentence that is read lays a foundation for comprehension. Readers then either map incoming information from a new clause or sentence, which relates to previously processed information, onto the existing foundation or shift to create a new substructure. There are two mechanisms that control these processes: suppression and enhancement. Readers can either suppress information that is irrelevant for structure building or enhance the activation of information that coheres with the previous information for further structure building. In these structure-building processes and mechanisms readers need to skillfully use linguistic cues, such as lexical and syntactic information, which signal coherence relations in text and guide the mapping process. What follows discusses how syntactic awareness affects L2 reading and writing development.

### Syntactic Awareness in L2 Reading Development

A clue to understanding the role of syntactic awareness in reading may lie in its association with reading fluency and vocabulary development. Successful reading necessitates accurate and rapid reading (Kame'enui & Simmons, 2001). Automatic syntactic processing (Grabe, 2009) and recognition of phrasing (Kuhn & Stahl, 2003) are among skill components needed for reading fluency. Fast and accurate syntactic processing can indicate that cognitive resources are little used in making connections among sentences but rather available for other comprehension-related activities, such as making inferences or retrieving background knowledge (Jenkins, Fuchs, van den Broek, Espin, & Deno, 2003). With regard to vocabulary development, syntactic awareness not only closely relates to the form-meaning mapping, but also assists identifying grammatical functions of a word in text (Nagy & Scott, 2000). For example, an ability to analyze the structure of a sentence assists building multiple meanings (e.g., *animal* or *to carry*) that connect to a single form (e.g., *bear*). Identifying the grammatical function of a word largely depends on morphological awareness (i.e., an ability to recognize morphological structure and employ word formation rules). Derivational suffixes, such as *-s* in *works*, which give crucial help in grasping meanings

of new words, reflect on a syntactic role of the suffixed word in a sentence.

**Syntactic Awareness in L2 Writing Development**

Improved syntactic awareness through L2 reading can be beneficial for students to enhance their writing skills in the L2. Syntactic complexity is one of the most predictive indices of writing quality (McNamara, Crossley, & McCarthy, 2009); however, writing in the L2 with high syntactic complexity seems demanding. L2 writers tend to produce simpler text structures, such as shorter T-units, fewer clauses, less passivization, more run-on sentences, and fewer compound sentences, as compared to L1 writers (Hinkel, 2002; Montano-Harmon, 1991; Silva, 1993). Competent writing skills that involve using syntactic awareness are reciprocally related to reading skills, as literacy development models suggest (e.g., Fitzgerald & Shanahan, 2000). In other words, proficient writers tend to have more linguistic knowledge, including complex syntactic knowledge, derived from reading exposure than do less-proficient writers (McNamara et al., 2009). We expect that, if L2 students are able to enhance L2 syntactic awareness while learning to read, this knowledge can also serve as a valuable linguistic resource along the way as they develop L2 writing skills.

**Individual Differences in L2 and Syntactic Awareness**

From Gernsbacher's (1997) model in addition to the relationship between syntactic knowledge and meaning construction, we can learn how individual differences in comprehension skills are generated. According to her model, those who have difficulty utilizing linguistic cues may have inefficient suppression and enhancement mechanisms. As a result, less skilled readers tend to shift and create too many substructures that are hard to assemble, leading to their slow processing and inaccurate comprehension. In the same vein as Gernsbacher's (1997) model, Givón (1995) focuses on syntactic cues as basic and continuous resources for the construction of structures and meaning. L2 research has also discussed how an ability to exploit syntactic signals relates to individual differences among L2 students. Low-proficiency L2 readers are inefficient in using syntactic information (Skehan, 2003) and tend to compensate for their weak syntactic processing skills by relying on semantic and other sources (Bernhardt, 1986; Lee & VanPatten, 1995). High-proficiency L2 readers, in contrast, capitalize on syntactic information of words and efficiently integrate words into syntactic structures in a native-like manner (Frenck-Mestre & Pynte, 1997).

It seems reasonable to suggest that L2 students should develop syntactic processing skills to become proficient. However, it is challenging for L2 students to develop strong knowledge of the syntax to the extent that they can perform syntactic parsing nearly as effortlessly as L1 readers do. Challenges that L2 readers face may emerge from at least two sources: limited previous linguistic knowledge in L2 and restricted exposure to L2 print. L1 children already have oral knowledge of thousands of words (Cunningham, 2005) and of basic syntactic structures (Grabe, 2009) before they learn to read. Constantly building on such knowledge, children are usually exposed to extensive L1 print and can thereby further develop automaticity in L1 comprehension processes including word recognition and syntactic parsing (Grabe, 2009). L2 students, who are short of L2 linguistic knowledge and insufficiently exposed to L2 print, have demanding tasks to simultaneously develop linguistic knowledge and comprehension skills. In fact, syntactic awareness appears more difficult than other linguistic skills for L2 students to develop while they are learning to read. From synthesizing L2 reading research conducted over several decades, Bernhardt (2000) found that linguistic errors of L2 students decreased over time in many cases, such as sound-letter association and word recognition; however, this was not the case for syntactic errors. Rather, L2 students produced increasingly high syntactic error rates until they became highly proficient. We therefore speculate that external manipulation marking syntactic structure in the form of input enhancement can facilitate L2 learners to acquire linguistic knowledge while learning to read.

## INPUT ENHANCEMENT AND L2 SYNTACTIC AWARENESS

Manipulating texts in a manner to make syntactic chunks salient can be a way to positively affect the learning process of L2 students and thereby increase their syntactic awareness. This attempt is what Smith (1991) called input enhancement, a technique to draw L2 students' attention to formal language properties by deliberately making them salient. According to Smith, teachers can make input salient. However, such input enhancement is not always salient to students' internal learning mechanism. In other words, it will be desirable, but not always possible, for students to act on enhanced input and increase their linguistic knowledge. Smith argues that the growth in linguistic knowledge can be assessed best by students' output (e.g., to produce a correct form) and at least by an alternatives identification test (e.g., to identify a correct alternative to the error). An error detection test (e.g., to notice something sounds wrong) may provide insufficient evidence on student' growth. The following discusses previous research on input enhancement in L2 development and potentials of syntactic formatting as input enhancement.

### Typographical Enhancement

A common method of enhancing input is manipulating typographical conventions. Lee and Huang (2008) conducted a meta-analysis of relevant research based on 16 studies published over 26 years, offering insight into aspects and effects of input enhancement in written texts. Each experimental study included in this analysis focused on one ($n$ = 8) or two ($n$ = 8) target forms. Examples of target grammatical forms include determiners, relative clauses, and passive voice. Each study employed a single type of typographical conventions to highlight a target form for the experimental condition: boldfaced ($n$ = 14), underlined ($n$ = 11) or italicized ($n$ = 1). Additionally, texts in 15 out of 16 studies included input flooding, a technique to saturate readers with artificially increased occurrences of the target form. It should be noted that this technique was applied to both experimental and control conditions.

With regard to the effects on learning outcome, all these studies measured the extent of students' grammar learning and nine of them further assessed reading comprehension. To examine the overall effect across the studies, Lee and Huang (2008) calculated aggregating effect size $d$ in their meta-analysis. They found mixed results: visual input enhancement had small sized overall effects on the learning of target forms ($d$ = .22) and negative effects on comprehension ($d$ = -.26). As the authors pointed out, however, it is necessary, when interpreting the effect size, to take into consideration two aspects: the experimental conditions and the amount of exposure to the target form. Input flooding, which was available in both experimental and control conditions, might positively influence control students' incidental learning of the target form by strengthening the probability of noticing. Experimental students might be given an insufficient amount of exposure because the studies had a limited number of treatment sessions over a short period of time. The treatment duration ranged from one day to four weeks. Six studies administered one treatment session, five studies had two to three and the remaining four studies included more than six. In particular, studies with one treatment session lasted less than 30 minutes, reporting no significant treatment effects on participants' learning.

Lee (2007) conducted another typographical enhancement study to examine the effect of input enhancement on grammar learning (passive verb forms) and comprehension skills. This quasi-experimental study with Korean 11th graders ($N$ = 259) had two by two conditions: input enhancement (boldfaced verb forms vs. unenhanced verb forms) and topic familiarity (Korean culture vs. Egyptian culture). Participating students had three 50-minute sessions and took pre- and post-tests on grammar (a form correction task) and comprehension (a free recall task). Lee found that input enhancement assisted the learning of the passive form but not comprehension. On the contrary, topic familiarity aided comprehension but did not help students learn the passive form.

In sum, typographical enhancement at least supports the learning of a target grammatical form, though it either did not affect or else negatively affected comprehension skills (Lee, 2007; Lee & Huang, 2008). The drawbacks of this method are the limited number of target forms (usually one or two) and a short

period of exposure to enhanced input.

**Syntactic Enhancement through Technology**

A way to resolve the abovementioned drawback of input enhancement is the use of technology, making it possible to increase the quantity and quality of targeted input (Gascoigne, 2006). There has been an attempt to draw readers' attention not to a single formal feature but to overall syntactic structure, which we refer to syntactic enhancement in this paper. Little research has been performed on syntactic enhancement in both L1 and L2 contexts. Studies by Jandreau and Bever (1992) and LeVasseur, Macaruso, and Shankweiler (2008) are among only few relevant L1 studies that investigated the effect of syntactic enhancement on reading skills. The former study used phrase-grouping algorithm to determine the size of space between phrases. In this study, high ($n$ = 69) and average ($n$ = 65) language proficiency college students read either phrase-sensitively formatted texts (extra spacing added to the end of each phrase and sentence) or evenly spaced texts. It was found that phrase-sensitive formatting was effective on comprehension, but only for average proficiency students. The study by LeVasseur, Macaruso, and Shankweiler (2008), which employed computer-based reading training, examined the relationship between text reformatting and young L1 students' reading skills. In this study, English L1 students (ages 7 to 9 years) were given texts in two formats: phrase-preserving (line breaks corresponding to syntactic boundaries) versus phrase-disrupting conditions (line breaks interrupting syntactic units). LeVasseur and her colleagues found that the phrase-preserving format supported reading fluency but not comprehension.

A set of studies has explored a recently developed syntactic enhancement through VSTF technology in both L1 and L2 contexts, though few studies were published in refereed journals. This phrase-based formatting depicts how phrases and clauses are hierarchically related, rather than simply grouping words into a series of phrases, which distinguishes VSTF from former syntactic enhancement methods. Figure 1 shows an example of a linear text (at the top) and how some of its clauses are nested within larger ones (in the middle). In order to present such complex structures in VSTF (on the bottom), computer calculations are performed for each sentence in the text (Walker, Schloss, Fletcher, Vogel, & Walker, 2005). Phrases that are nested within the original line are separated out and indented with an attempt to bring the meaning and underlying structures of a given sentence to a more prominent position.

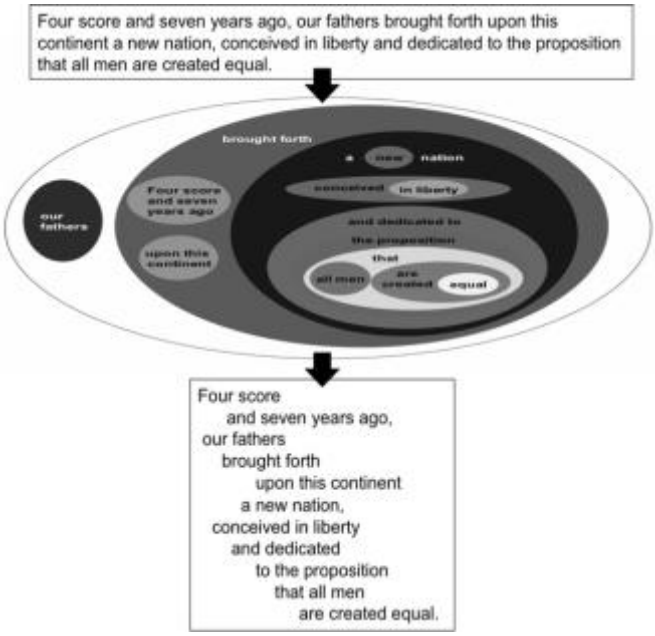


*Figure 1*. Visual-syntactic text formatting

Two studies on VSTF included L2 students as participants (Vogel, 2011; Walker & Vogel, 2005). Walker and Vogel (2005) had an intervention study to examine how VSTF affected high school students' reading retention. 10th grade students read their history texts in VSTF for a school year and took a number of tests (ten unit tests and a final test). VSTF students ($n$ = 40) showed greater improvement on all of the tests as compared to their control peers ($n$ = 44), who read block-formatted texts. Overall, the intervention effect became larger with a longer intervention: the effect size was larger in tests administered in the second half of the year (.55) than in those in the first half (.38). This study did not focus on, but included, L2 students. The authors reported that the L2 students ($n$ = 12) benefited from the use of VSTF, though it took more reading sessions for them to outperform their control peers ($n$ = 17) on unit tests. By the end of the year, L2 students in the experimental group had closed one-half to almost the full gap between themselves and L1 students in the control group.

Vogel (2011), a high school teacher in Colorado, reported his successful use of VSTF in a standardized test preparation program, in which two-thirds of students were L2 students. These students read sample test passages in VSTF in 20-minute sessions on a daily basis for four weeks. All of the students who started with an unsatisfactory or partially proficient level were able to increase their reading proficiency. In particular, 81% of the participants met the state standard for acceptable growth and 62% met the school goal of reading at a proficient level by the end of the school year. However, the results from these two successful VSTF intervention studies should be carefully interpreted given that they were not refereed publications. A systematic evaluation of intervention with VSTF needs to be performed to confirm its effects on L2 development.

## THE CURRENT STUDY

In responding to the challenges of increasing L2 syntactic awareness in academic English development, this study examined syntactic enhancement, VSTF, as a way to scaffold L2 syntactic awareness in written discourse. Addressing limitations of typographical enhancement studies, our intervention not only covered the whole syntactic structure in a given text, rather than a single feature, but also lasted a school year. Based on previous findings and implications concerning learning outcomes (Lee, 2007; Lee & Huang, 2008; LeVasseur et al., 2008) and participants' proficiency levels (Jandreau & Bever, 1992; Vogel, 2011), we developed hypotheses. First, syntactic enhancement would at least promote achievement gains in measures of syntactic knowledge. This expected result would, in turn, foster the development of reading and writing. Second, low-proficiency students would receive more benefit from syntactic enhancement than would high-proficiency students. Specific research questions are as follows:

1. Does VSTF as syntactic enhancement through text-formatting technology draw L2 students' attention to syntactic structure in their ELA textbook?
2. Does syntactic enhancement affect the development of L2 reading and writing?
   (1) Which ELA measures are most influenced by syntactic enhancement of VSTF?
   (2) How does this result relate to the development of L2 reading and writing?
3. How does the intervention effect, if any, vary depending on participants' proficiency levels?

### Study Context

This study was conducted in two suburban school districts in Southern California. The ELA curriculum for 6th grade students (aged 10 to 11 years old) in the participating schools was in line with district and state-adopted reading–language arts programs, and was tied to the State Content Standards for ELA (California State Board of Education, 1998). Students received instruction for approximately 2 hours daily, which emphasized systematic, explicit skills instruction in reading and writing, and were asked to read and comprehend a wide variety of grade-level-appropriate literature. All of L2 students in this

subsample received regular instruction with L1 peers in mainstream classrooms, except for 13 students. These 13 students received an intensive reading intervention at their school, which was provided to both L1 and L2 students who struggled with English.

## Participants

### *Teachers*

We invited teacher participants by making primary contact with school districts where each student had a laptop for use in school. Teachers read the study information sheet and 22 teachers agreed to participate in this study. This study was deemed IRB exempt protocol given that it was conducted within the already established 6th grade language arts curriculum. Therefore, no written consent form was obtained from teachers as well as students. The participating teachers had an average of 16 years of teaching experience (ranging from 7 to 34 years) and 4 years of using laptops for instruction (ranging from 1 to 7 years). One teacher taught ELA to three different classes in three different classrooms, while the rest of the teachers taught all subjects (including ELA) to their one respective class. Participating classrooms were randomly allocated by draw to one of two groups (VSTF vs. control). Two control teachers dropped out of the study following randomization, leaving 14 classrooms in the VSTF group and 10 in the control group.

### *Students*

This study constitutes a secondary analysis of a subsample drawn from a larger study. For the primary study, a total of 652 students, aged from 10 to 11 years, from 24 6th grade classrooms of 10 schools participated in this study during the 2011–2012 academic year. In the current study with the focus on L2 students, those whose home languages were other than English ($n$ = 282) were pooled from the primary study. These students fell into one of three groups depending on their proficiency: English Learners (EL, $n$ = 113), Initially Fluent English Proficient (IFEP, $n$ = 59), and Reclassified Fluent English Proficient (RFEP, $n$ = 110) Learners. ELs are students who require support to function in school due to their relatively low English proficiency. IFEPs are those who had gained full English proficiency by the time they entered school. RFEPs are those who once had low English proficiency but have attained English proficiency and no longer need language support. Because IFEPs and RFEPs were comparable to each other and to L1 peers in their English proficiency level, they were combined to make a high-proficiency group in a comparison to the low-proficiency group of ELs. As a result of the classroom assignment, 160 L2 students received VSTF intervention as compared to 122 L2 control students.

## VSTF Intervention

### *Apparatus*

All students in the intervention condition read the VSTF version of their ELA textbooks on their laptop, of which a sample page is shown in Figure 2. A table of contents, which appears in the left panel, has links that students click on to take them directly to each chapter or section, which is shown in the right panel. Extra space between sentences marks the beginning of new sentences. Alternate colors of background are used to distinguish between paragraphs. By using Options from the menu, users can change themes that include different background and font colors, along with font types and sizes, to customize their textbook. Bookmarking is also available for easier future access. There are two features that are unavailable in the VSTF version: page numbers and images.

### *Instruction*

For an academic school year (approximately 25 weeks), students received the typical standards-based instruction, during which experimental students used their VSTF-formatted textbook and control students read their textbook in regular block format, either on their laptops or in print. To obtain data on the fidelity of implementation, all participating teachers were asked to report the amount of time that their students spent on reading per day for three designated weeks during the experiment. The VSTF reading

time in class ranged between 30 to 120 minutes per the teacher's instruction ($M$ = 74.56, $SD$ = 33.23), whereas the textbook reading time of control students ranged between 65 and 130 minutes a week ($M$ = 88.62, $SD$ = 20.31). A $t$-test analysis indicated that the VSTF reading time of the VSTF group was significantly shorter than the textbook reading time of the control group ($p < .01$). However, the total reading time of VSTF students might match to that of control students, because VSTF students were sometimes allowed to use their paper version textbook to complete reading or writing tasks in class.


*Figure 2*. A screenshot of the VSTF version of the ELA textbook

## Design

This mixed-method study included a combination of standardized tests before and after the intervention, observations, and a semi-structured interview after the intervention. In order to learn whether syntactic enhancement helped L2 students pay attention to syntactic structure while reading, we made observations and conducted an interview with VSTF teachers. The ELA portion of the California Standards Test (CST) was used as pre- and post-tests. Students were assessed on CST at the end of the previous school year and at the end of the school year when the intervention was near completion. A comparison of achievement between the VSTF and control groups helped us detect any achievement gains after the intervention.

## Measures

### *Observation*

Two researchers observed all of the VSTF classes, intending to make three rounds in each class (for 40–50 mins each time) during the year. However, they were not able to complete three rounds in some of the classes, which will be discussed in the Results section. Filling out an observation form developed by the research team (See Appendix), the researchers attempted to capture how many students actually used their VSTF textbook, how comfortably they used it, what types of instructional strategies teachers used, and how VSTF facilitated teachers' instruction. Observations were not video recorded.

### *Interview*

A 90-minute semi-structured group interview was conducted with VSTF teachers at the end of the school

year. This interview was audio-recorded and then transcribed. Interview questions included what instructional approaches were facilitated by VSTF, how students were engaged in reading the VSTF version of the textbook, and whether the VSTF textbook supported low-proficiency students. Teachers were additionally asked to share vignettes to illustrate such moments.

### *ELA Performance in the CSTs*

At the end of each school year, California students in 2nd through 11th grade take the CSTs, which measure students' performance against content standards set by the State. The CSTs include ELA and mathematics throughout all grade levels and either or both of science and history–social science in upper grades (5th and above). Only at 4th and 7th grades does the ELA test include a writing component. Scaled scores and five performance levels are reported by the State.

In order to examine the intervention effect in this study, we used the results of ELA portion from the CST 2010–2011 and 2011–2012 as pre- and post-tests, respectively. The ELA test consisted of 75 multiple-choice questions with all test passages formatted in a conventional block pattern on paper. This test had reading and writing portions, which are further divided into three and two subtests, respectively, which are explained in the following.

The three reading portion are word analysis, reading comprehension, and literary response and analysis. In the *word analysis subtest* (13–14 items), students were asked to use their knowledge of word origins and word relations, as well as word, sentence, and paragraph clues to determine meaning. Reading grade-level appropriate narrative and expository texts for the *reading comprehension subtest* (16–17 items), students described, connected, and criticized the essential ideas, arguments, and perspectives of the text by using their knowledge of text structure, organization, purpose, and related topics. In the *literary response and analysis subtest* (12 items), students read and responded to historically or culturally significant works of literature. For example, they were asked to define how tone, meaning or themes were conveyed in a given literary text, and to explain the effects of common literary devices, such as symbolism, imagery, or metaphor.

The writing portion of the ELA test[1] consists of written conventions and writing strategies. These tests did not assess how well the students write; however, they asked students to identify correct forms of writing. Students' performance in these tests can be a good indicator of how well they will write essays in the future, because standards for these two tests are also used as the scoring rubric for the writing test of CSTs (California Department of Education, 2006). A sound grasp of written conventions and effective use of writing strategies are significant indicators of successful writing development. The questions in the *written conventions subtest* (16–17 items) assessed students' command of Standard English conventions appropriate to the grade level, such as sentence structure, grammar, punctuation, capitalization, and spelling. The *writing strategies subtest* (16–17 items) had questions that assessed students' ability to revise a flawed text into a clear, coherent, and focused essay. The answers for this subtest exhibited students' awareness of appropriate forms of writing, precise use of vocabulary to develop a topic, knowledge of effective organizational patterns, including comparison and contrast or arrangement by a specific order, and ability to revise writing for improvement of organization.

## Data Analysis

### *Research Question 1*

Evidence from observations and interviews helped us to answer Research Question 1. Students' comfort and engagement levels were averaged for each round of observation. For students' comfort level, observation notes were coded from 1 (*very uncomfortable in dealing with the VSTF software*) to 5 (*very comfortable in navigating the VSTF-converted textbook and adjusting a reading mode to meet personal needs*). The students' engagement scale assessed students' attention and participation in a reading activity, ranging from 1 (*little engaged*) to 5 (*highly engaged*).

Strategies and comments both from teachers and students were logged during every observation. This data was coded using open coding (Strauss & Corbin, 1990). Examples of codes include sources of reading (paper-based vs. VSTF), methods of reading (e.g., individual vs. paired vs. group, silent vs. aloud), signs of improvement in student performance, and the prevalence of improvement among students with different proficiency levels. These codes were counted. The data collected during the group interview were used to triangulate findings from the analysis of observations. For interrater reliability, simple percentage agreement—the ratio of all coding agreements over the total number of coding decisions—was used. Two researchers coded part of observation notes and the interview transcript together until the coding process yielded 90 % of interrater reliability. After discussing how to deal with data about which disagreement arose, the researchers coded the rest of the data and counted codes.

***Research Question 2***

An analysis of variances (ANOVA) procedure was conducted to compare learning outcomes between groups. To begin, a multivariate ANOVA, instead of separate ANOVAs, was run to test if the random assignment procedure achieved the desired effect of initial group equivalence. Based on reasonable correlations among five subtests that assessed different literacy skills (Pearson's correlations ranging from .69 to .81), our analysis model took as dependent variables the pre-test of the five ELA CSTs subtests, as advised by Brace, Kemp, and Snelgar (2006). The main advantage of multivariate analysis, as opposed to separate ANOVAs on each dependent variable, is to control for any unmeasured confounding that variables might carry.

To compare the achievement of the VSTF group with the control group, a one-way multivariate ANOVA with covariates was performed on post-tests of the five ELA subtests. Participant's demographic information and the pre-test scores of ELA subtests were used as covariates to adjust for possible confounding and to reduce error variance in the intervention outcome. Five demographic variables include gender, ethnicity, disability, English proficiency, and social economic status.

***Research Question 3***

A two-way multivariate ANOVA on the five ELA subtests was conducted to examine whether the association between the treatment and students' proficiency levels could be found. The English proficiency variable (low vs. high) was included as an independent variable in addition to groups (VSTF vs. control). An interaction between these two independent variables was also tested. All covariates except for English proficiency included in the model for RQ 2 were retained in this analysis model.

## RESULTS

### Research Question 1

Two researchers attempted to visit each of 14 experimental classrooms for three times. They made three rounds of observation in nine classrooms but only two rounds in the other five due to scheduling conflicts. As a result, we had 37 observations in total. It should be noted that this section does not exclusively refer to L2 students, because observations took place in classrooms in which L2 students received instruction together with L1 students. Attempting to focus on L2 students, we included verbatim quotes from observations and interviews (in quotation marks) that particularly referred to L2 students.

Throughout observations, VSTF students used the reformatted textbook with little trouble and were actively engaged in ELA class. The average scores of students' comfort (out of 5) slightly increased from the first (4.25) to the second (4.83) and to the third observation (4.91); the students' engagement level remained steady, ranging from 4.4 to 4.6.

Data from observations helped us identify instructional strategies, areas of language learning to be facilitated, characteristics of students who benefited from the intervention, and any disadvantages of

VSTF that interfered with learning. Occurrences of codes were counted out of 37 times when VSTF was actually used. Table 1 summarizes this result.

Table 1. *The Result of VSTF Classroom Observations*

| | | Counts | Percent of Occurrence (%) |
|---|---|---|---|
| Source of reading | VSTF only | 22 | 59.5 |
| | VSTF primarily, paper secondarily | 13 | 35.1 |
| | VSTF and paper equally | 2 | 5.4 |
| Methods of reading | Individual | 10 | 27.0 |
| | Paired | 30 | 81.1 |
| | Whole class | 14 | 37.8 |
| Modes of reading | Silent | 29 | 78.4 |
| | Aloud | 8 | 21.6 |
| | With audiobook | 5 | 13.5 |
| **Notice of improvement in student performance** | | 11 | 29.7 |
| Positive changes due to VSTF | Fluency | 7 | 18.9 |
| | Confidence | 6 | 16.2 |
| | Comprehension | 2 | 5.4 |
| | Amount of reading time | . | . |
| | Syntactic awareness | 2 | 5.4 |
| | Concentration | 4 | 10.8 |
| | Writing | 1 | 2.7 |
| | Retention | 2 | 5.4 |
| Types of students supported by VSTF | Struggling readers | 7 | 18.9 |
| | Advanced readers | | |
| | Those with disability | 2 | 5.4 |
| | Readers in general | 6 | 16.2 |
| **Notice of decrease in student performance** | | 8 | 21.6 |
| Negative changes due to VSTF | Fluency | 4 | 10.8 |
| | Confidence | . | . |
| | Comprehension | . | . |
| | Amount of reading time | 1 | 2.7 |
| | Syntactic awareness | | |
| | Concentration | 6 | 16.2 |
| | Writing | . | . |
| | Retention | . | . |

A general description of the VSTF classroom, which was revealed from observations, is as follows. The VSTF textbook was a primary means of instruction, though the paper version was sometimes used either before or after reading VSTF textbook to have students look through pictures unavailable in VSTF. There were also a few students in some classes who chose to read their paper-based book if they felt paper version more efficient for their reading, while their classmates read the VSTF version. Attempting to

engage all students in ELA activities, whole class reading was used at the beginning of class, in which a teacher or a student read aloud while the whole class followed along using their own VSTF textbook. Follow-up activities, such as completing a worksheet or creating a brochure, were mostly accompanied by paired or individual reading, during which a teacher monitored students reading and helped them if asked. Several teachers agreed that VSTF textbook was appropriate for paired reading because low-proficiency students in particular were lost less often and read faster than they would in the paper version. Teachers attributed this effectiveness to sentence structure of VSTF and alternate paragraph colors in VSTF. These features made paired reading using the VSTF version "funner and easier" compared to the paper version, as a number of students spoke up.

Teachers acknowledged positive changes in literacy skills. Almost half of the teachers stated in observation that they noticed students' reading fluency was increased for the same reason that VSTF facilitated paired reading. During interview, teachers specified that this was usually the case with low-proficiency students. A teacher added that some L2 students in her class started to "read in phrases" as opposed to reading phonetically. This feature, making it less likely for low-proficiency readers to get "mixed up," led to keep their attention during reading, as some teachers acknowledged. It is noteworthy that a couple of teachers mentioned their students started to recognize sentence structures. This positive change in syntactic awareness was not limited to reading activities. One day a low-proficiency L2 student used VSTF format in her writing, saying that she tried to parse out her sentences.

A decrease in students' performance was also noticed, which happened in the first two rounds of observation. Two teachers said that their students were reluctant to use the VSTF version in general. One of them worried that VSTF format slowed down his advanced students' reading. A high-proficiency girl, though, suggested a positive view in the second round of observation: the VSTF version gave her a better grasp of content than the paper version. She added that while reading the former she did not miss out information, which commonly happened when she read (usually skimmed) the latter. Though she was a L1 student, her comment provided an insight into potential effects of syntactic enhancement. Another issue germane to a negative intervention effect was the lack of images and page numbers in VSTF rather than its format. The aforementioned teacher pointed out visual aids as an essential part for low-proficiency readers to better understand important scenes and characters. The lack of page numbers as well as images in VSTF made all passages look the same to some students, hindering effective searching of words or parts in passages to answer comprehension questions. Some other students, however, commented that they would still prefer to read in VSTF, despite missing out on pictures and certain details. They said the picture-free textbook not only kept them from being distracted by pictures, but also enabled them to imagine what was happening in a story.

**Research Question 2**

We examined the effect of VSTF reading on 6th grade L2 students' ELA achievement. Table 2 shows descriptive statistics of participants' achievement on the pre- and post-tests (scaled scores) by group. A one-way multivariate ANOVA on the pre-tests revealed that there was no significant effect for groups ($\lambda = .986$, $F(4, 281) = 0.979$, $p > .05$), suggesting that the two groups were comparable at pre-tests.

Table 2. *Descriptive Statistics of Dependent Variables by Condition (Scaled Scores)*

| | | Total | | Low proficiency | | High Proficiency | |
|---|---|---|---|---|---|---|---|
| | | Control ($n$ = 122) M SD | VSTF ($n$ = 160) M SD | Control ($n$ = 41) M SD | VSTF ($n$ = 72) M SD | Control ($n$ = 81) M SD | VSTF ($n$ = 88) M SD |
| Pre-test | Word Analysis | 69.73 | 67.93 | 49.44 | 56.46 | 80.00 | 77.32 |
| | | 21.86 | 21.44 | 21.69 | 20.07 | 13.03 | 17.71 |
| | Reading Comprehension | 68.77 | 67.33 | 45.98 | 54.69 | 80.31 | 77.67 |
| | | 24.23 | 23.29 | 24.41 | 22.04 | 13.76 | 18.84 |
| | Literary Response | 66.69 | 68.39 | 44.56 | 54.86 | 77.89 | 79.45 |
| | | 24.95 | 23.39 | 23.09 | 20.49 | 17.23 | 19.53 |
| | Written Conventions | 71.77 | 69.91 | 54.02 | 60.08 | 80.75 | 77.95 |
| | | 20.68 | 21.09 | 21.38 | 19.59 | 13.24 | 18.82 |
| | Writing Strategies | 67.43 | 65.86 | 46.93 | 55.08 | 77.80 | 74.68 |
| | | 24.00 | 21.59 | 22.83 | 18.67 | 16.92 | 19.81 |
| Post-test | Word Analysis | 68.10 | 69.00 | 45.00 | 54.97 | 79.79 | 80.48 |
| | | 24.84 | 20.69 | 24.77 | 18.56 | 14.65 | 14.33 |
| | Reading Comprehension | 60.92 | 60.20 | 39.29 | 47.46 | 71.86 | 70.63 |
| | | 23.50 | 20.68 | 19.71 | 18.67 | 16.73 | 15.89 |
| | Literary Response | 67.00 | 64.68 | 48.15 | 53.32 | 76.54 | 73.98 |
| | | 23.04 | 20.02 | 24.58 | 18.65 | 15.04 | 15.94 |
| | Written Conventions | 72.60 | 73.87 | 51.46 | 63.50 | 83.30 | 82.35 |
| | | 23.13 | 17.76 | 24.35 | 17.93 | 12.94 | 12.33 |
| | Writing Strategies | 64.06 | 66.79 | 38.44 | 53.79 | 77.02 | 77.43 |
| | | 25.18 | 21.01 | 19.34 | 19.29 | 16.29 | 15.77 |

A one-way multivariate ANOVA analysis compared the VSTF and control groups' ELA achievement after intervention. The result showed that there was no group difference on the post-tests. However, a follow-up analysis with covariate, adding pre-test scores and demographic variables as covariates, revealed a significant group difference on the post-test ($\lambda = .949$, $F(5, 263) = 2.819$, $p < .05$, $\eta^2_p = .051$). The analyses of the univariate outcomes for each subtest showed a beneficial effect of the intervention in the writing portion: written conventions ($F(1, 267) = 5.518$, $p < .05$, $\eta^2_p = .020$) and writing strategies ($F(1, 267) = 9.870$, $p < .05$, $\eta^2_p = .036$). Marginal significance was also found in one of three subtests in the reading portion: word analysis ($F(1, 267) = 3.523$, $p = .06$, $\eta^2_p = .013$). *Figure 3* shows estimated marginal means of the five subtests after controlling for pre-tests and the demographic covariates.

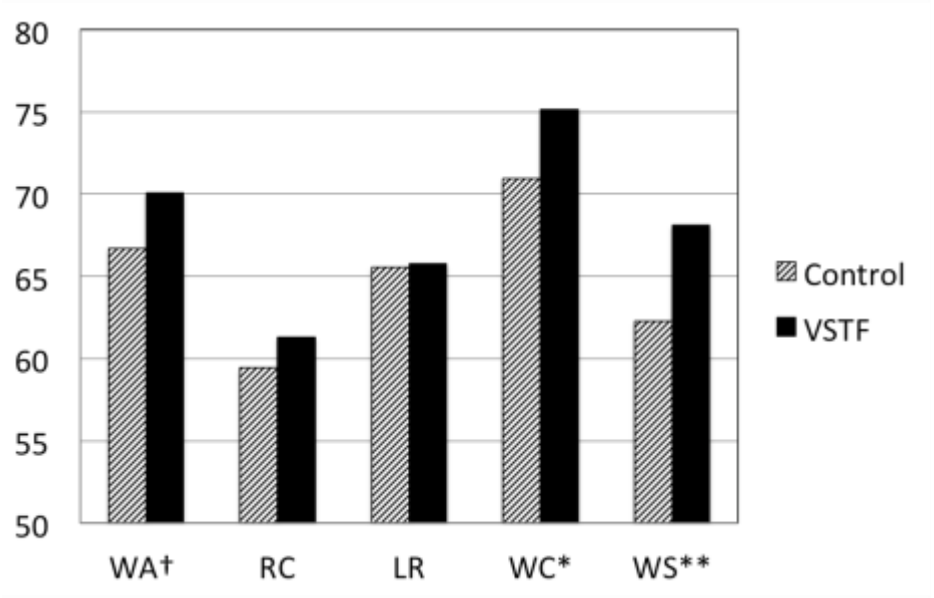


*Figure 3*. Estimated marginal means of each post-test. WA = Word Analysis; RC = Reading Comprehension; LR = Literary Response; WC = Written Conventions; WS = Writing Strategies. † indicates $p < .1$, * indicates $p < .05$ ** indicates $p < .001$

**Research Question 3**

A two-way multivariate ANOVA (Group × Proficiency) with covariate was conducted to test whether the intervention effect differed depending on students' proficiency levels. A trend was found suggesting an association between Group and English Proficiency ($\lambda = .965$, $F(5, 265) = 1.942$, $p = .08$, $\eta^2_p = .035$). The univariate comparisons showed that the interaction approached significance only in the writing portion: written convention ($F(1, 269) = 4.789$, $p < .05$, $\eta^2_p = .017$) and writing strategies ($F(1, 269) = 5.627$, $p < .05$, $\eta^2_p = .020$). To partition this interaction, a follow-up simple main effects analysis using a Bonferroni correction ($\alpha = 0.05$) was performed. Findings suggested that the low-proficiency students in the VSTF group outperformed those in the control group in the post-tests of written conventions ($p = .003$) and writing strategies ($p = .000$), while there was no group difference among those with high-proficiency. These results verify that VSTF reading can influence at least low-proficiency L2 students' achievement on writing measures. Estimated marginal means of the post-tests across groups and English proficiency are presented in Figure 4.

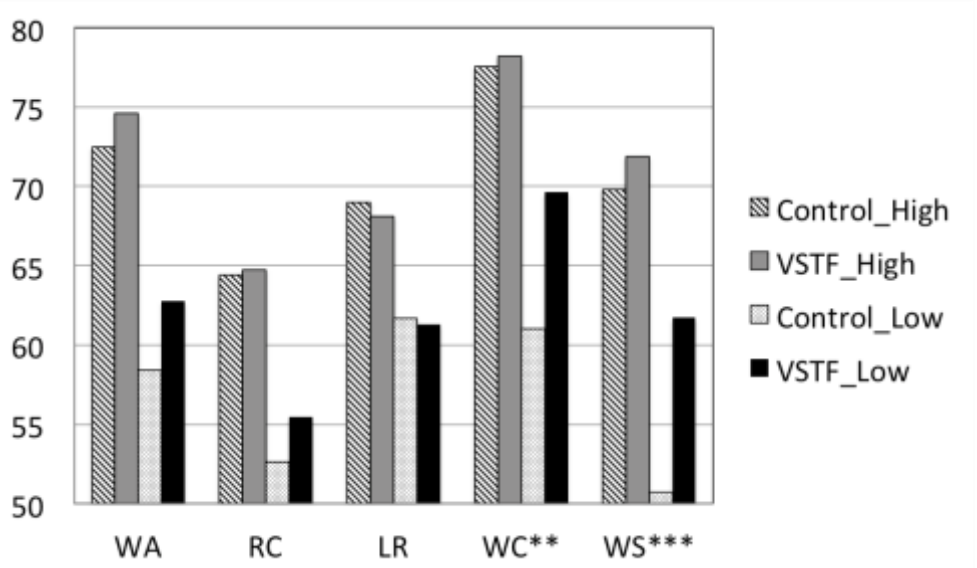


*Figure 4*. Estimated marginal means of the post-tests across groups and English proficiency. Significant differences were only found between low-proficiency students. Control_High = control group students with high English proficiency; VSTF_High = VSTF group students with high English proficiency; Control_Low = control group students with low English proficiency; VSTF_Low = VSTF group students with low English proficiency. WA = Word Analysis; RC = Reading Comprehension; LR = Literary Response; WC = Written Conventions; WS = Writing Strategies.
** indicates $p < .001$, *** indicates $p < .0001$

## DISCUSSION

This study addresses three questions concerning the effect of visualizing syntactic structures on reading and writing development among L2 English students. Our hypotheses that VSTF will raise awareness to L2 syntactic structure and improve L2 literacy development are partly evidenced by our qualitative and quantitative results. First, the qualitative findings from observations and interviews suggest that syntactic structure caught students' attention. Meaning-based phrasing and spaces in between lines in VSTF can help students, especially those with low proficiency, to increase fluency. This finding is in line with the research by LeVasseur et al. (2008) on the effect of syntactic enhancement on reading fluency. Drawing on Gernsbacher's (1997) model, we postulate that already parsed sentences particularly help low-proficiency students with structure building processes at a faster rate than would otherwise be possible. A degree of caution is required though because a VSTF version of a textbook may negatively affect some students by slowing down their reading speed. This is mainly attributed to features of the VSTF textbook as compared to paper textbook: the lack of images and page numbers in VSTF and, in part, its broken-up phrasing. Such drawbacks, however, do not relate to syntactic enhancement. Some students can be negatively influenced by VSTF phrasing, which may be due to its unfamiliarity rather than syntactic enhancement. This negative effect can be overcome once students become used to its format, as shown in this study. To increase the effectiveness of VSTF, teachers would be well advised to attend to two important considerations: providing visual aids to compensate for the missing images and allocating adequate time and training for students to benefit from syntactic enhancement.

Research Question 2 concerns the effects of VSTF reading on L2 students' learning outcomes: whether syntactic enhancement of VSTF can support the development of L2 literacy. The quantitative findings from standardized tests suggest that syntactic enhancement can support L2 students in improving the knowledge necessary for writing development. The achievement gain of VSTF students in written conventions and writing strategies is of significance for two reasons. First, the result implies that syntactic

enhancement can affect the improvement in syntactic awareness, which is the part of the knowledge that the two measures assess. These measures assess how well students identify correct alternatives to ill-formed words or structures. This type of tests is not the best but a fairly effective method for detecting students' growth in syntactic knowledge, according to Smith (1991). Second, this result implies that increased syntactic enhancement through reading may contribute to the development of skilled writing, affirming the view that reading and writing share a reciprocal relationship (Fitzgerald & Shanahan, 2000). A limitation of this finding is that it does not offer direct evidence of skilled writing because the measures used in this study did not require students' writing output. However, the knowledge tested in the two measures represents important tools to communicate efficiently through writing.

Our results with regards to reading are not as strong as in the case of writing. The quantitative findings cannot fully confirm findings from previous studies on VSTF (Vogel, 2011; Walker & Vogel, 2005), in which VSTF helped students improve their reading performance. However, this result, taken together with our qualitative findings, helps us identify reading skills to be further evaluated in syntactic enhancement studies: vocabulary and reading fluency. The positive trend in word analysis found in this study may support for the important role of syntactic awareness in vocabulary development, which was suggested in the literature (e.g., Nagy & Scott, 2000). Our qualitative finding of VSTF students' increased fluency is consistent with previous literature on the relationship between syntactic awareness and reading fluency (Jenkins et al., 2003). Further studies with an emphasis on vocabulary learning and reading fluency are needed to ascertain these points.

The last question focuses on who may benefit most from syntactic enhancement. It appears that syntactic enhancement is particularly effective among low-proficiency L2 students. This result is similar to the findings from the study by Jandreau and Bever (1992), in which phrase-sensitive formatting supported average-proficiency students only. Such mixed results suggest that varying syntactic processing skills among L2 students presumably affected how effectively input enhancement worked. Low-proficiency L2 students have weaker syntactic processing skills (Bernhardt, 1986; Lee & VanPatten, 1995), which may be otherwise troubled with structure building and fluent and accurate comprehension. Their pattern is in contrast to high-proficiency L2 students who employ syntactic processing in a similar way to L1 students as found in previous research (e.g., Frenck-Mestre & Pynte, 1997). Therefore, low-proficiency students are likely more responsive to already parsed sentences than are those with high proficiency.

## LIMITATIONS AND FUTURE RESEARCH

The limitations of this study suggest directions for future research. First, despite the considerable improvement in VSTF students' achievement, our qualitative data does not provide a sufficiently detailed insight into specific effects of syntactic scaffolding for L2 students. Because this study is based on the subsample of our study that includes both L1 and L2 students, the valuable information about low-proficiency students we learned from our data includes, but is not confined to, L2 students. Qualitative research methods, such as observations and interviews, focusing exclusively on L2 students will help us better understand how syntactic scaffolding affects English development of L2 students.

The generalizability of this study is limited to low-proficiency L2 students in the US. Of particular interest is whether the findings can be applied to other contexts or with other age groups of L2 students. In non-English-speaking contexts, there is a huge number of L2 students who have limited syntactic knowledge but have to understand grade-appropriate materials. Their English competency in written academic discourse is frequently a requisite for college and professions even in non-English-speaking contexts. Syntactic enhancement can be a viable approach to facilitate written English competency in such contexts. Regardless of curricular and learning environments, instructors can easily employ syntactic enhancement by using VSTF technology, because it only changes syntactic structures without making any amendment to the original content. Future studies need to evaluate if the effect of syntactic enhancement persists across various contexts.

## CONCLUSION

Our study shows that syntactic enhancement can facilitate the development of L2 reading and writing by assisting with syntactic awareness. Further, our finding suggests that though the specific gains from syntactic enhancement were limited to low-proficiency students, VSTF as syntactic enhancement can be a useful instructional tool to support L2 literacy development. We conclude that it will be beneficial to provide such an aid to young L2 students who need to pay attention to syntactic structures that become increasingly complicated early on, even before the secondary school grades. In addition, we encourage research on syntactic enhancement in non-English speaking contexts where L2 students face challenges in transitioning into being proficient.

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## APPENDIX. VSTF Observation Note

VSTF Observation Note

Observer: District:

School: Teacher:

Student comfort (5 = high, circle one): 5 4 3 2 1

Student engagement (5 = high, circle one): 5 4 3 2 1

| | | | |
|---|---|---|---|
| Date | | Time Used | |
| Unit | | Section | |
| # Students | | # Using VSTF | |

| | |
|---|---|
| Problems | |
| Teacher Strategies | |
| Student Strategies or Practices | |
| Teacher Comments | |
| Student Comments | |
| Observer Suggestions for Improvement | |
| Other Observer Comments | |

Continue any section on back as necessary

## NOTES

1. Sample tests, including written conventions and writing strategies, can be found through the California Department of Education website.

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