Extending the Bounds of Morphology Instruction: Teaching Latin Roots Facilitates Academic Word Learning for English Learner Adolescents

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ABSTRACT

This study investigated the hypothesis that academic vocabulary instruction infused with morphological analysis of bound Latin roots—such as analysis of the relation between innovative and its bound root, nov (meaning "new")—will enhance word learning outcomes for English Learner (EL) adolescents. Latinate words with bound roots comprise a majority of general academic vocabulary words in English and are ubiquitous in texts across content areas. However, the effect of instruction in this area of morphology is unclear. Theory suggests that morphological knowledge is a critical component of lexical representations, binding a word's phonological, orthographic and semantic features. We hypothesized that instruction in bound Latin roots would (a) produce stronger outcomes for learning academic words by strengthening semantic and orthographic representations, and (b) equip students with morphological analysis skills to problem-solve new words. Employing a within-subjects design, 84 EL students participated in both of two counterbalanced conditions: vocabulary intervention without roots (comparison) and vocabulary intervention with roots (treatment). Effects on learning meanings of academic words were similar across conditions. However, the "with roots" condition showed large treatment effects for morphological problem-solving of unfamiliar words, and also suggested positive treatment effects on lexical access, lending partial support to our hypothesis that instruction about bound Latin roots contributes to EL adolescents' academic vocabulary learning.

Keywords: morphology, vocabulary, lexical decision, English Learners, dual language learners, intervention research, academic language

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Among the many factors that contribute to the challenges of adolescent literacy, the sheer quantity of abstract words in academic texts presents a formidable challenge for many students (Carnegie Council on Advancing Adolescent Literacy, 2010; Lesaux, Kieffer, Kelley & Harris, 2014; Townsend, Filippini, Collins & Biancarosa, 2012). In the middle school grades, demands on vocabulary knowledge intensify, as texts across disciplines are loaded with academic words that represent abstract meanings and essential for comprehension (Nagy & Townsend, 2012; Snow & Uccelli, 2009). In particular, general academic words (e.g., *diminish*, *benefit*, *innovative*) are frequently encountered across diverse subject areas (Coxhead, 2000; Gardner & Davies, 2014). These words are important for conveying abstract ideas, arguing positions, and communicating complex ideas in academic contexts; as such, knowledge of their meanings is vital to reading comprehension and academic success (Corson, 1997; Nagy & Townsend, 2012).

Notably, the vast majority of words encountered in text at this point in schooling are morphologically complex (Anglin, 1993; Nagy & Anderson, 1984). That is, they consist of multiple units of meaning, such as *detection*, which comprises the prefix *de* meaning "away from," the root *tect* meaning "cover," and the suffix *ion* indicating that the word functions as a noun (or, at the clausal level, is likely to appear in a nominal group). Students who are aware of the morphological structure of academic words, and who understand how to use information about word parts to access word meanings, may be able to leverage morphological information to support vocabulary growth (Anglin, 1993; Crosson & McKeown, 2016; Carlisle, 2010; Goodwin, 2016; McCutchen, Logan & Biangardi-Orpe, 2009; McCutchen & Logan, 2011;

Pacheco & Goodwin, 2013). However, the bulk of research on morphology interventions has focused on derivational relations (such as the role of *de* and *ion* in *detection*), leaving the potentially important role of bound roots (*tect*) unclear, despite that bound roots are often the major meaning-carrying constituent in the academic lexis.

Equipping students with the knowledge and metalinguistic skill to improve academic vocabulary knowledge could be beneficial for many adolescent learners in US schools, and this may be especially true for students who are designated English Learners (ELs)[1]. These students represent the fastest growing group in US schools, currently comprising nearly 10% of the school age population (US Department of Education, 2017). The population of language minority students in the US is widely considered among the most vulnerable of learners, as indicated by disparities in academic achievement (US Department of Education, 2013), low graduation rates (Rumberger, 2011; US Department of Education, 2008), and lagging enrollment and degree attainment in post-secondary education (Kanno & Cromley, 2015). Vocabulary knowledge in English has been repeatedly documented as an area of difficulty (August & Shanahan, 2006; Carlo et al. 2004; Galloway & Lesaux, 2015; Goldenberg, 2011; Kieffer, 2010; Lesaux, Kieffer, Faller, & Kelly, 2010; Nakamoto, Lindsey & Manis, 2008; Proctor, Carlo, August, & Snow, 2005; Reed, Petscher, & Foorman, 2016), and is associated with comprehension difficulties. Interventions to accelerate academic vocabulary learning of EL adolescents could have a significant impact on literacy and, more generally, on academic outcomes (Galloway & Lesaux, 2015).

[1] We adopt English Learner (EL) as a commonly used term in the literature. All participants, many of whom were multilingual, were designated English Learners by the school district per performance on the WIDA ACCESS-ELL English language proficiency assessment and all were enrolled in the district's English as a Second Language program.

This study employed a within-subjects design to investigate whether and how learning about bound Latin roots—that is, how the meaning of the bound root *nov* meaning "new" connects to the meaning of *innovative*, *renovate* and *novice*—can be leveraged to support academic word learning for students who are culturally and linguistically diverse ELs. We investigated the impact of a robust academic vocabulary condition infused with morphological analysis on EL adolescents' word learning by examining treatment effects on knowledge of word meanings, morphological problem-solving skill, and fluency of lexical access. We compared this condition to a nearly parallel version of the curriculum that provided robust vocabulary instruction without morphology instruction. To do so, EL students were divided into two groups and each group was assigned to receive both versions of the curriculum, beginning with either the robust academic vocabulary program infused with morphological analysis or the program without morphology instruction. In both versions, students were taught the same target words (Set A) for the same number of lessons and in the same time period. Subsequently, students switched to whichever condition they had not yet experienced, and received three new units of instruction. In this subsequent series of units, students were taught a new set of target words (Set B) for the same number of lessons and in the same time period. As such, a within-subjects design enabled us to examine the added value of instruction about bound roots, over and above robust vocabulary instruction.

Theoretical Bases

Our Latin roots condition focuses on morphological analysis as a tool to bolster academic vocabulary learning given the fundamental role of word knowledge in development of literacy skills. Word knowledge and reading comprehension are intimately linked (e.g. Adlof, Catts, & Little, 2006; Cromley & Azevedo, 2007; McKeown, Crosson, Moore & Beck, 2018; Perfetti &

Stafura, 2014; Tannebaum, Torgesen, & Wagner, 2006). Theory suggests that a critical factor in reading comprehension— for both EL students and monolinguals alike—is stores of high quality lexical representations. Our study was guided by theories articulated by Perfetti and colleagues suggesting that high quality mental representations of words are needed in order to efficiently integrate word meanings with context (Perfetti, 2007; Perfetti & Hart, 2001; Perfetti & Stafura, 2014), as well as by Schreuder & Baayen's (1995) theoretical framework of morphological processing.

According to the Lexical Quality Hypothesis (Perfetti, 2007; Perfetti & Hart, 2001), high quality mental representations entail precise and stable knowledge of a word's form—that is, its phonology and orthography—rich, flexible information about its meaning, and knowledge of its grammatical and pragmatic roles. Bowers, Kirby, and Deacon (2010) have argued that morphology, which bridges these aspects of word knowledge, may act as a "binding agent" (p. 168) pulling together orthographic, phonological and semantic aspects of word knowledge to result in more stable and robust lexical representations. Lexical quality embodies word knowledge that is flexible enough to accommodate variations, such as varied pronunciations required by different parts of speech, or meaning variations depending on context, and which facilitates efficient retrieval of word identities. Being able to quickly recognize a word is essential for comprehension (Perfetti & Adlof, 2012; Richter, Isberner, Naumann & Neeb, 2013), as it releases working memory resources, which can then be directed toward higher-level comprehension processes. Thus, instruction in morphology may lead to improved lexical quality, facilitating the kind of rapid, efficient retrieval of word identities essential to comprehension (Perfetti & Stafura, 2014).

Theory suggests that knowledge about bound Latin roots should contribute to the development of high-quality lexical representations. In Schreuder and Baayen's (1995) model, learners develop connections between orthographic strings representing morphological constituents and their corresponding meanings over multiple encounters. When a redundant relationship is detected between form and meaning, a "concept node" is created; each time the unit is encountered, the strength of the representation becomes stronger and accumulates additional semantic and syntactic information. According to this model, when a learner encounters an unfamiliar morphologically complex word, relevant concept nodes (i.e., the meanings indexed by the morphological constituents) are activated to hypothesize how the morphemes might be combined to infer word meaning, while also checking this hypothesis against other semantic and syntactic information from the context.

These theoretical foundations suggest that it is possible that learning to analyze a word's morphological units might lead to generalizable knowledge for learning the meanings of unfamiliar words (Bowers & Kirby, 2010; Crosson & McKeown, 2016; Crosson & Moore, 2017; Goodwin, 2016). For example, a learner who knows the meaning of the root *ami* (friendship, love) might be able to infer key information about the meaning of an *amiable conversation.* Thus, processes for building representations of morphemes and for whole words may operate in similar ways to support acquisition of productive vocabulary knowledge, with multiple encounters and incremental building of associations between orthographic strings and meaning.

The Importance of Bound Roots in Academic Vocabulary

These theoretical frameworks offer a seemingly promising basis for a role of bound Latin roots in academic word learning. However, empirical evidence of the development of bound morphemes in forming strong lexical representations of academic words is limited. To date, the

bulk of research on the role of morphological knowledge in literacy development has focused on derivational morphology. A focus on derivational morphology makes sense, as the great majority of words that students encounter in school texts are morphologically complex (Nagy & Anderson, 1984) and vocabulary growth in English starting around the fourth grade is driven by growth in derivations—a trend that continues through high school (Anglin, 1993; Kieffer & Lesaux, 2012; Sullivan, 2006).

In elementary grades, however, analyzed words are typically of Germanic origin, comprising stem-words to which prefixes and suffixes are added and subtracted (Bar-ilan & Berman, 2007), such as the relationship between *think* and *unthinkable*. Morphological analysis becomes more complex in the secondary grades, as the vocabulary demands of school texts shift toward the Latinate layer of English (Bar-ilan & Berman, 2007). At this point, a majority of morphologically complex words contain bound roots as major meaning-carriers (Crosson & McKeown, 2016). Academic words rarely contain the kinds of transparent, freestanding stem-words characteristic of high frequency Germanic words (Tyler & Nagy, 1989); in fact, approximately 75% of words on Coxhead's (2000) Academic Word List are Latinate (Lubliner & Hiebert, 2011), with their main semantic components being bound roots.

Morphological analysis of bound roots could contribute to vocabulary learning, given that roots often carry substantial information about a word's meaning. Consider that the word *distort* contains the root *tort,* from Latin for *twist*; but if a learner does not know the meaning of *tort*, knowledge about the word's derivational affix *dis* is not likely to be helpful. Given the goal of expanding EL adolescents' knowledge of general academic words, a focus on derivational affixes may not be sufficient. To date, research on interventions focusing on bound Latin roots and effects on academic word learning has been relatively scarce (Crosson & McKeown, 2016).

For instance, in Bowers and colleagues' (Bowers, Kirby, and Deacon, 2010) meta-analysis of studies of morphological instruction, only three of 22 studies reviewed included bound roots as the morphological unit of study.

Effects of Morphology Interventions on Word Learning

A small number of recent studies lend some empirical evidence to the hypothesis that instruction about bound roots may improve word learning. Bowers and Kirby (2010) investigated how effectively fourth and fifth grade English-speaking monolingual students can learn to use morphological analysis to support target word learning and infer information about meanings of unfamiliar words. Instruction addressed derivational affixes, freestanding root words, and bound roots, and students were guided to investigate patterns of spelling and meaning of morphological components in complex words. Controlling for initial vocabulary knowledge, Bowers and Kirby found that, compared to a control group, students who participated in the intervention were better able to identify novel words that included freestanding root words and bound roots (e.g., *rupt* in disrupt) taught during the intervention, concluding that teaching morphological analysis helps students learn vocabulary beyond the words taught. As this study did not examine treatment effects on bound roots specifically, the implications for bound roots, while promising, are unclear.

Similarly, Goodwin and colleagues (Goodwin, 2016; Pacheco & Goodwin, 2013) investigated a range of morphological problem-solving strategies in interventions with adolescents, including some analysis with bound Latin roots. In an intervention study with a diverse group of fifth and sixth graders, Goodwin (2016) compared two conditions: comprehension strategy instruction alone versus comprehension strategy with integrated morphology instruction. The intervention with integrated morphology instruction guided

students to use "word solving" to analyze derivational relations (e.g., *movement*, *movers*, *remove*, *removable*, and/or *unmovable*) as well as root words and bound roots (e.g., using *astronaut* to infer the meaning of *astro* to problem-solve *astronomer*) to support word-solving as a reading comprehension strategy. Results from this relatively short (four 30-minute sessions) intervention indicated that the condition with integrated morphology instruction was more effective at supporting morphological awareness, measured as the ability to generate morphologically related words from a root word, and effects were larger for language minority students. No significant treatment effects were detected for knowledge of academic word meanings and reading fluency, among other literacy outcomes. While Goodwin's (2016) intervention included instruction in bound roots, instruction blended myriad strategies, and morphology measures tested only derivational relations and compound words. Both Goodwin's and Bowers and Kirby's (2010) interventions point to possible beneficial effects of teaching bound roots, but neither disentangles the role of learning bound Latin roots and their effects on word learning, fluency, and morphological problem-solving.

Finally, in an intervention study by Crosson and McKeown (2016), sixth and seventh grade monolingual English-speaking students received instruction in learning the meanings of bound Latin roots and how to apply this information for problem-solving new words. A small dose of morphology instruction was integrated into an academic vocabulary intervention, and was carried out in a series of nine lessons over 24 weeks in sixth grade and a series of five lessons over 30 weeks in seventh grade. The goals of instruction were to teach not only that bound roots are meaning-carrying constituents found within words, but also to teach cognitive flexibility in applying root meanings. Such flexibility is important, as relations between root and word meanings have evolved over time thus the relation is not always readily apparent.

Compared to a "business as usual" control group matched for overall reading achievement, treatment effects were observed for establishing meaning representations in memory for bound roots as well as for using roots to infer meaning of unfamiliar words. While this study provides direct evidence for the benefits of teaching bound roots, effects on aspects of word learning germane to the lexical quality hypothesis were not tested in relation to morphology instruction. Moreover, the participant group did not include English Learners, a population that might benefit from integrated morphology instruction, as observed in Goodwin's (2016) study.

Research Questions and Hypotheses

This study investigated the following research questions: 1) To what extent does instruction about bound Latin roots provide added value, compared to a comparison condition without a morphology component, for EL adolescents' *knowledge of target academic words*; 2) *morphological analysis skills*; and 3) l*exical access of academic words*? We anticipated that the Latin Roots condition would produce stronger outcomes for learning academic words by strengthening their semantic and orthographic representations, which are essential components of the lexical quality of a word's representation in memory and critical to skilled comprehension (Perfetti & Hart, 2002).

Specifically, we hypothesized that: a) instruction focused on morphological analysis of roots would strengthen semantic networks between words, leading to more robust semantic representations, and in turn, greater knowledge of instructed words; b) extensive guided practice using roots to analyze word meanings would lead to enhanced morphological analysis skills to fuel vocabulary growth; and c) knowledge of roots would support "constituent binding"—that is, strong, stable connections—between semantic and orthographic features of a word, leading to more efficient access of words.

Method

Participants

Eighty-four EL students of diverse linguistic backgrounds participated in the study. Participants were enrolled in five English as a Second Language (ESL) classes in a large, urban school district in the northeastern U.S. in which 77% of students were eligible for free or reduced lunch. Sixteen different home languages were represented; in this linguistically diverse group, 10.7% spoke a Latinate home language (Spanish or French). Table 1 presents information about distribution of participants among the five classes. Approximately one third of students had been in the U.S. for less than two years and another one third had been in the U.S. between three and five years. Approximately 78% of students were schooled in their home country or outside of the U.S. and approximately one third reported that they were able to read in their home language (L1).

ESL classes in the district were homogeneously grouped by grade into grade bands (6-8, 9-10, and 11-12) and homogenously grouped by English proficiency level (entering, beginning, intermediate or advanced). In this study, only intermediate and advanced classes were included. Two participating classes served grades 6-8, two served grades 9-10, and one served grades 11-12. Three teachers taught participating classes. All students in each class were invited to participate in the study (communication provided in English and students' home languages) and all students with informed consent were included. Across all classes, eight students declined to participate.

Research Design

We implemented a completely crossed, within-subject design, with all students participating in both of two instructional conditions: *Latin Roots* condition and a *comparison*

condition (both conditions are described in detail below). A major advantage to this design was that it enabled comparison of relative associations between conditions and learning outcomes without the near-impossible task of establishing comparison groups of ELs who tend to vary with respect to language and literacy skills and exposure to instruction in L1 and English (Kuo & Anderson, 2008).

The classes were divided into two groups. Group 1 comprised two 6-8th grade ESL classes; Group 2 comprised two 9-10th grade ESL classes and one 11-12th grade class (Table 1). The conditions were counterbalanced such that both groups participated in both conditions, but Group 1 experienced Latin Roots first and the comparision condition second, while Group 2 experienced the comparison condition first and the Latin Roots condition second. The condition experienced first will be referred to as Session I, implemented in fall, while the condition experienced second will be referred to as Session II, implemented in spring. A total of 48 target words were taught and these were divided into two sets: Set A (Table 2) and Set B (Table 3). In Session I, words from Set A were taught in both conditions and in Session II, words from Set B were taught in both conditions.

To make this possible, we created two versions of all instructional materials—one for each condition—and we did so for Sessions I and II. In both the Latin Roots and comparison versions, lessons were scripted such that the sequence of activities, instructions, and wording of initial teacher questions were provided. The two versions within each Session were parallel in that they focused on the same set of target words (24 words in Set A in Session I, 24 words in Set B in Session II), they comprised the same number of lessons (24 in Session I, 24 in Session II), and they were implemented during the same time period.

The time period for study implementation was a 10-week window in the fall for Session I and a 10-week window in the spring for Session II. All pretesting, post-testing and implementation for each session was carried out within this 10-week window. For each window, the total number of instructional days for lessons was 24; the total number of days for pretesting was three; and the total for post-testing was 10. Both Groups 1 and 2 experienced instruction during these 10-week windows, receiving either the Latin Roots or comparison instruction. Due to holidays and the district's testing calendar, there was some variation in the number of days between units in each participating class, but all instruction and assessment was implemented within the same 10-week windows.

The three collaborating teachers taught all lessons for both conditions in the order in which they were assigned to teach the conditions. Table 1 presents which teacher taught each of the classes. For each session, teachers were provided with all instructional materials (scripted lessons, charts, images on cardstock). Teacher materials included the purpose of each activity and "ideas to develop" indicating the kind of thinking teachers should aim to elicit through discussion. Student materials for all activities were provided in a three-ring binder for each student. Following Session I, all materials were collected by the research team. In the spring, the teacher and students were provided with a new set of materials for the other instructional condition in Session II. Instruction in both conditions was carefully scripted and highly detailed, as illustrated in Table 4. Based on our frequent observation and interactions with teachers and confirmed by the fidelity of implementation results (discussed below), our evidence confirms that teachers adhered to the scripted instruction within each instructional condition.

Word and Root Selection

Forty-eight words were selected from the 570 headwords on the Academic Word List (AWL/Coxhead, 2000): 24 for Set A taught in Session I (fall) and 24 for Set B taught in Session II (spring). The AWL corpus was chosen as an adequate source of words that are high frequency in academic texts and dispersed across disciplines. For this study, we sought target words that carried a bound Latin root that was high frequency among bound morphemes in English, according to Becker et al.'s morphographic analysis (Becker, Dixon, & Anderson-Inman, 1980). Moreover, we sought words with bound roots that appeared in other academic and/or literary "tier 2" words that would be good candidates for morphological analysis in instruction. Forty-four of the 48 words selected met the selection criteria. The remaining four (two in each of Sets A and B) carried high-frequency Latin prefixes. See Tables 2 and 3 for a complete listing of target words.

Intervention and Comparison Conditions

Latin Roots condition. The "Latin Roots" condition integrated robust instruction of general academic words with instruction in morphological problem-solving using bound Latin roots. The Latin Roots condition was designed to reflect robust instruction techniques (Beck, McKeown, & Kucan, 2002) including analysis of target academic words in multiple, authentic contexts and ample opportunities for active processing of word meanings, such as analyzing examples of word use, producing examples, justifying use, and discussing nuances of word meanings. Morphological analysis focused on bound Latin roots—such as *min* meaning *small* or *ben* meaning *good*—as distinct from morphologically complex words that contain root words that are freestanding morphemes (e.g., *think* from *unthinkable*) or derivations (e.g., *diminishing* from *diminish*, *beneficial* from *benefit*).

A Latin root (or prefix) was taught in the Latin Roots condition for all 24 target academic words in Session I and for all 24 target academic words in Session II. Instruction about Latin roots was incorporated into every lesson, and emphasized: a) analysis of the relationship between the root meaning and the target academic word in which it appeared (e.g., the relation between *min* and *diminish*); and b) analysis of the relation between the root meaning and other "root-related words" in which they appear (e.g., *min* and *mince*, *miniscule*, and *minimal*). All instruction was whole-group and teacher-led. Lessons were scripted including questions, examples and model responses to guide morphological problem-solving. The structure of a unit and sample instructional elements from the Latin Roots condition appears in Table 4.

Instruction in the Latin Roots condition was designed around three units in each session, comprising eight daily scripted lessons per unit. In Session I (fall) the three units, *Goal Setter*, *Give and Take*, and *You Win*—were taught to Group 1 (Table 3). In Session II (spring), the three units, *Will I or Won't I?, Mind Games*, and *Together or Apart*—were taught to Group 2 (Table 4). A total of 24 lessons and 24 target words were taught in each session. The initial goal in each unit was to introduce target academic words with contextual and definitional information and to teach the Latin root meanings (as well as drawing attention to any orthographic variation). A second goal was to deepen students' knowledge of the target words through analysis of target word across multiple contexts. Finally, toward the end of the unit, the goal shifted to using the root for morphological analysis of new "root-related" words. Over the course of the unit, the teacher recorded information about the target words, roots and their meanings, and root-related words on a chart that was publically posted in the classroom.

Comparison condition. The comparison condition was a robust academic vocabulary program, Robust Academic Vocabulary Encounters (RAVE), which has demonstrated

significant, positive effects on word learning and comprehension for native English-speaking middle school students (McKeown et al., 2018). Intervention research that has similarly reflected principles of robust instruction—including provision of friendly definitions, followed by extensive active processing of word meanings in a variety of contexts—has been associated with positive treatment effects on word learning with adolescent ELs (August, Branum-Martin, Cardenas-Hagan & Francis, 2009; Carlo, August, & Snow, 2005; Lesaux, Kieffer, Faller, & Kelley, 2010; Vaughn et al., 2011). The comparison condition was parallel to the Latin Roots condition such that, in each session, the same units were taught in the same order; they comprised the same number of lessons and focused on the same target words; and they shared some overlapping instructional material (as indicated in Table 4). Similar to the Latin Roots condition, instruction in the comparison condition was designed around three units in each session, comprising eight daily scripted lessons per unit. In Session I (fall) the three units, *Goal Setter*, *Give and Take*, and *You Win* (Table 3)—were taught to Group 2. In Session II (spring), the three units, *Will I or Won't I?, Mind Games*, and *Together or Apart* (Table 4)—were taught to Group 1. A total of 24 lessons and 24 target words were taught in each session.

The difference between the two conditions was that the RAVE comparison condition provided robust instruction exclusively, whereas the Latin Roots condition provided robust instruction and also integrated instruction about Latin roots in every lesson. The comparison condition also provided more unique high quality encounters with each target word on average. The sequence of lessons in a unit is described below. As well, the structure of a unit and sample instructional elements from the RAVE comparison condition appears in Table 4.

In the RAVE comparision condition, introductory lessons presented target words in rich contextual information in two contexts that illustrate a range of the word's uses or senses. Two

target words per lesson were introduced in lessons 1, 2, 4 and 5. Approximately 90% of the material in these lessons overlapped with Latin Roots Lessons 2, 4, 5, and 6, that were designed to engage students in deep processing of target words including word-text integration in longer and more varied contexts, and active processing activities. However, in Lessons 3 and 6, the RAVE comparison condition presented new encounters with target words. For example, students were guided to consider how the meaning of *induce* fit with the following examples: "Give your brother a piece of candy to get him to make your bed" and "use cheese to get a mouse into a trap." In the final lessons 7 and 8, activities were designed to provide another unique encounter with each target word, with some of this material overlapping with the final lessons in the Latin Roots condition. All questions, examples, contexts, and instructions were scripted for every activity in every lesson in the teacher materials.

Professional development. The principal investigators met individually with each teacher for a half-day professional development meeting before launching the study. These meetings addressed background on the role of word knowledge in comprehension and the principles of robust vocabulary instruction, and addressed how morphology instruction might support generative word learning. A major focus of the meetings was examining the instructional materials for each condition to ensure that teachers understood the purpose of each activity, as well as students' potential misconceptions and potential follow up. The within-subjects research design was explained to teachers, and teachers were asked to adhere to the scripted materials as faithfully as possible and not to incorporate instructional practices outside the lessons provided. Researchers explained why the scripted materials were important within the context of this research design. Teachers were given flexibility around student grouping for

instructional activities within each condition (e.g., pair work could be replaced with small groups).

Measures

Measures were developed to tap a range of processes that may have been affected by teaching bound Latin roots: knowledge of target academic word meanings; morphological analysis skill using bound roots to problem-solve the meanings of unfamiliar words; and lexical access to target academic words. Two assessments of knowledge of target academic word meanings were administered to address the first research question, to include both a traditionally designed measure similar to that employed in vocabulary intervention studies for knowledge at the level of synonyms (Word Meanings Task), as well as a task of multifaceted word knowledge (Evaluation of Academic Vocabulary) that assesses word knowledge in context (Crosson, McKeown & Ward, in press).

Word Meanings Task. The group-administered Word Meanings Task was administered at pre and post for each session to test whether instruction about bound Latin roots, compared to the comparison condition without a morphology component, added value for EL adolescents' knowledge of target academic words. Two verisions of this assessment were administered to every participant: one with 16 words from Word Set A administered as pre and post-tests in Session I (fall); the other with 16 words from Word Set B administered as pre and post-tests in Session II (spring). Within each Session, the same words were tested pre and post. This task tests knowledge of target (i.e., instructed) words. Students were provided with groups of target academic words (eight per group) and were instructed to match target words to synonyms or short definitions. For each target word correctly matched to its synonym, students received 1

point (i.e., min = 0, max = 16). The measure exhibited acceptable internal consistency (Cronbach's α = .70).

Evaluation of Academic Vocabulary. The group-administered Evaluation of Academic Vocabulary (EAV) was administered at pre and post for each session to test whether instruction about bound Latin roots, compared to the comparison condition without a morphology component, added value for EL adolescents' knowledge of target academic words. Just as was the case for the Word Meanings task, two verisions of EAV were admiministered: one with 16 words from Word Set A administered as pre and post-tests in Session I (fall); the other with 16 words from Word Set B administered as pre and post-tests in Session II (spring). Within each session, the same words were tested pre and post and these were the same words that were tested on the Word Meanings Task. This task tests multidimensional knowledge of target words. It was designed to capture facets of word knowledge, including syntactic knowledge, understanding of multiple senses, and constraints of word use. For each target academic word, the EAV item comprised four cloze sentences, and students were instructed to decide whether the target word would fit in each sentence. EAV tests students' knowledge of multiple senses of academic words (e.g., sentences reflect polysemy, such as the item for *confine*, which reflects physical and mental senses: "He will _____ the toddlers to the little yard" and "I had lots to say, but I had to _____my comments to the topic") and provides foils that are systematically constructed to differentiate aspects of word knowledge. Foil types included a syntactic foil (e.g., for *confine*: "We saw a _____ on the busy highway") to assess understanding of the target word's syntactic role, and a semantic foil with a prototypical association to the target word to test understanding of semantic constraints around word use (*confine- jail:* "Prisoners often _____letters to their families from jail"). One point was awarded for each item correctly

accepted and one point for each foil correctly rejected. Each item was scored 0-4, thus the possible range for the task was 0-64. The measure exhibited strong internal consistency (Cronbach's $\alpha = .91$).

Morphological Analysis Task. The individually-administered Morphological Analysis Task (MAT) was designed to test whether instruction about bound Latin roots, compared to the comparison condition without a morphology component, added value for EL adolescents' morphological analysis skills. The MAT was administered only at posttest for each session. This task, a dynamic assessment used in our previous work (Crosson & McKeown, 2016) and modeled after related morphology assessments (Anglin, 1993; Wolter & Pike, 2015), was individually administered at post-test following each condition for each session. In this study, we assessed morphological problem-solving using a total of 18 bound Latin roots. To do so, two verisions of MAT were admiministered: one with a sample of nine roots from Set A at the end of Session I (fall); the other with a sample of nine roots from Set B administered at the end of Session II (spring). Each version of the task consisted of nine sentences. Every item comprised a sentence with a novel word that contained a root that was taught to the Latin Roots condition in that session; the novel word, however, was not taught. For example, "Most of their conversations were about the minutiae of daily life," with *minutiae* (i.e., the novel word that was not taught) sharing the root *min* (i.e., the root that was taught) from the target academic word *diminish* (i.e., the target academic word that was taught). Students were shown each sentence and asked to explain the meaning of the novel word in context (e.g., "What do you think this is saying about their conversations? How did you figure that out?"). If students did not mention the root as one source of information that gave clues to the word meaning, the administrator would direct the student to analyze the novel word by asking, "Do you see a word part or a root

that you recognize? What does that root mean? Does that give you any other ideas about their conversations?" For this study, we employed a stringent scoring system. The item was scored 1 point if the student recognized the root, knew its meaning, and used this information to infer meaning about the novel word. Otherwise the item was scored 0. Two members of the research team independently coded 20% of the transcripts, yielding 93% exact agreement. Differences were resolved through discussion and final scores were used for analysis.

Novel words were selected to be unfamiliar to students by consulting the Zeno word frequency list and the *Living Word Vocabulary* (Dale & O'Rourke, 1979). Sentences were constructed to be neutral such that the novel word meaning would not be inferable from the sentence alone (e.g., "The *corpulent* dog couldn't jump into the car"). To confirm that novel word meanings were not predictable from sentence contexts, we piloted the task with 16 graduate students in psychology. Novel words were deleted from each item and participants were asked to complete the sentences as a cloze task. If more than three participants guessed a synonym for the novel word, the item was replaced (e.g., "The ____ dog couldn't jump into the car" would be replaced if more than three graduate students responded "fat").

Sets A and B were developed to be as similar as possible along three dimensions: a) word frequency of novel word according to Zeno's (1995) SFI rating (Set A = 36.82; Set B = 36.41); b) phonological and/or orthographic shift from target academic word to novel word (Set A = 7 with no shift and 2 with both orthographic and phonological shift; Set B = 7 with no shift and 2 with just phonological shift); and c) root family size based on Becker's (Becker, Dixon, &

Anderson-Inman, 1980) morphographic and root word analysis (Set A = 33.22; Set B = 24.33[2]). Table 5 presents word and root statistics for novel words used in the task.

Lexical decision task. This task was administered to test whether instruction about bound Latin roots, compared to the comparison condition without a morphology component, added value for EL adolescents' lexical access of academic words. This computer-based lexical decision task using E-Prime software was administered to small groups (i.e., four students per group) to all participating students at as a post-test following Session I (fall) and Session II (spring) to assess word identification accuracy and fluency of target words. Students were presented with strings of letters on the screen and were instructed to decide as rapidly as possible whether the letter string was a real word in English. To accept a trial as a real word, students were instructed to press the key with a green dot (a sticker adhered to the "1" key) on the laptop keyboard; to reject the trial as a nonword, students were instructed to press the key with a red dot (adhered to the "0" key). Ten practice items including both real and nonwords were presented before beginning the task to ensure that students understood the instructions (e.g., *friend*, *classroom*, *wandaw*, etc.). Then, words and non-words appeared at random including: a) all 24 target academic words from the word set that corresponded to the session (i.e., Word Set A in Session I and Word Set B in Session II); b) 24 "filler" words, each matched to a target academic word for orthographic complexity (number of letters, bigram frequency, orthographic neighborhood size, number of syllables) and part of speech, but not matched for frequency; and

[2] Becker's corpus identifies all morphographs in the 26,000 highest frequency words in English. Becker and colleagues identified 6,531 total "morphographs"—that is, bound roots and all stem-words and their derivations. Of these, approximately half appeared only once in the corpus; 2,000 appeared in three to five words; 1,500 appeared in six or more words, and 800 appeared in 10 or more words. Thus target roots selected for the task are high-frequency.

c) 24 nonwords, each equated to a target word for orthographic complexity. For example, the target word, *induce*, was matched to the (higher frequency) filler word, *answer*, and to the nonword, *pamine*, as these words are closely matched along the dimensions of orthographic complexity.

Each trial was presented for 4000 milliseconds, in keeping with the English Lexicon Project (Balota et al., 2007); if students did not make a decision within this time limit, the nonresponse was recorded and coded as inaccurate. Following the student's response to each trial, the word "Correct!" in green font or "Incorrect!" in red font would appear for 500 milliseconds before presenting the subsequent trial. For each participant, responses that were more than two standard deviations faster or slower than that individual's average response time were not included in the analysis.

The filler words were higher frequency than the target words. We anticipated that 1) accuracy rates would be higher and reaction times faster for filler words than for target words for all students in both the Latin Roots and the comparison conditions since filler words were more familiar; 2) accuracy rates would be higher and reaction times faster for target words in the Latin Roots condition, relative to performance in the comparison condition. In other words, we predicted that while students should always show more accurate and faster performance on filler words, the relative difference between the filler and target words (for both response time and accuracy) would be smaller for words taught in the Latin Roots condition in comparison to differences between filler and target words taught in the comparison condition.

Assessing Comprehension and Communication in English State-to-State for English Learners (ACCESS-ELL). ACCESS ELL is a standardized task designed to assess English language proficiency in listening, speaking, reading, and writing developed by the WIDA

Consortium at the Wisconsin Center for Educational Research. The assessment is administered annually by the school district. Standardized composite scores from the administration in the year in which this study was carried out were obtained from the district to include as a covariate in the analyses.

Assessment procedures. Teachers administered the Word Meanings Task followed by the Evaluation of Academic Vocabulary Tasks as paper and pencil tests which were scored by the research team. The Lexical Decision and Morphological Analysis Tasks were administered by members of the research team at post-test only, following each session. The Morphological Analysis Task was administered individually in a quiet space in the school and lasted approximately 12 minutes per student. It was audiorecorded and transcribed, and all scoring was based on transcriptions. The Lexical Decision Task was administered to groups of four participants at a time in a conference room in the school using HP laptops provided by the research team.

Fidelity to Treatment

Following McKeown, Beck & Blake (2009), we analyzed transcripts of a sample of 20% of lessons to examine whether the teachers implemented the lessons as designed, and to ensure consistency in implementation across teachers and classes. First, working with both Latin Roots and comparison versions of the instructional materials from one unit in Session I (fall) and one unit in Session II (spring), we created a set of fidelity of implementation checklists for five lessons. To create checklists, scripted lesson materials were analyzed to identify key instructional components, including teacher questions, explanations and examples related to use of target word or Latin root meanings. Each key instructional component was included as an item for that lesson with 41 as the maximum number of items on a checklist. Next, a member of

the research team coded transcripts from the Latin Roots condition and "parallel" lessons from the comparison condition from each class. We report the average percentage of key instructional components from the scripted teacher materials implemented in each condition.

Results

Procedure

Analyses for all outcomes were performed using the PROC MIXED command in SAS. PROC MIXED allows for both between-subject and within-subject effects and accommodates unbalanced data by allowing for adjustment of unequal variances (Littell, Milliken, Stroup, Wolfinger, & Schabenberger, 2006). Convergence criteria were met for all models. Pairwise comparisons were performed using the LSMEANS statement with a Sheffé adjustment. Effect sizes for the between-subjects factor comparisons were calculated according to Rosenthal and Rosnow (1991) and those for the within-subjects factors according to Dunlop, Cortina, Vaslow, and Burke (1996).

Summary of Results

The Latin Roots condition showed large, positive treatment effects for morphological analysis to problem-solve the meanings of unfamiliar words. Latin Roots showed an advantage for lexical access, as lexical decisions were more accurate for target words after Latin Roots instruction, and reactions times were faster after Latin Roots instruction for one group (i.e., Group 2). Both the Latin Roots and comparison conditions were effective for teaching meanings of target academic words.

Effects on Knowledge of Target Academic Words

Word Meanings Task. Table 6 presents unadjusted and adjusted means, standard deviations and ranges for performance on the task in each condition for Groups 1 and 2. A 3-

way mixed general linear model (GLM) analysis was performed on Word Meanings Task pre- and post-test adjusted mean scores as a function of group and condition (Figure 1). Group was the between-subjects factor and condition (Latin Roots and Comparison) and time (pre- and post-test scores) were within-subject factors. To control for individual differences in English proficiency skill, ACCESS ELL scores were used as a covariate. The covariate was significant, F (1, 66) = 15.84, p <.0001.

The only significant interaction was between group and time, F (1,211) = 80.09, p <.0001. Post-test scores were significantly higher than pre-test scores regardless of condition or group (Group 1- Latin Roots: t (78.7) = -5.02, p = .002, mean diff = -2.72, d = .80; Group 1-Comparison: t (78.7) = -4.73, p = .005, mean diff = -2.56, d = .75; Group 2-Latin Roots: t (152) = -13.55, p < .0001, mean diff = -7.56, d = 1.55; Group 2- Comparison: t (152) = -13.55, p < .0001, mean diff = -7.56, d = 1.55). Also, post-test scores were significantly higher for Group 2 compared to Group 1 for both conditions, Latin Roots: t (138) = -7.07, p < .0001, mean diff = -5.46, d = 1.03; Comparison: t (138) = -6.80, p < .0001, mean diff = -5.26, d = 1.16. Notably, there was no significant difference for pre-test scores between groups and no significant interaction between group (or order) and condition.

Evaluation of Academic Vocabulary (EAV). Table 6 presents unadjusted and adjusted means, standard deviations and ranges for performance on the EAV in each condition for Groups 1 and 2. A 3-way mixed GLM analysis was performed on EAV pre- and post-test adjusted mean scores as a function of group and condition (Figure 2). Group was the between-subjects factor and Condition (Latin Roots and Comparison) and time (pre- and post-test scores) were within-subject factors. Since the design was counterbalanced by group, group also indicates order

effect. To control for individual differences in English proficiency skill, ACCESS ELL scores were used as a covariate. The covariate was significant, F (1, 83) = 9.95, p = .002.

The only significant interaction was, again, between group and time, F (1, 178) = 4.90, p = .03. Also, post-test scores were significantly higher than pre-test scores for Group 2 regardless of condition (Latin Roots: t (180) = -4.55, p = .006, mean diff = -6.71, d = .62; Comparison: t (180) = -4.55, p = .006, mean diff = -6.67, d = .62). However, there was no significant difference between pre- and post-test scores for Group 1 regardless of condition. Again, there was no significant difference on pre- or post-test scores between groups, no significant interaction between group (order) and condition, and no significant difference between pre- or post-test scores across conditions for either group.

Effects on Morphological Analysis Skill

Table 7 presents unadjusted and adjusted means, standard deviations and ranges for performance on the Morphological Analysis Task in both conditions for Groups 1 and 2. A 2-way mixed GLM analysis was performed on Morphological Analysis Task adjusted mean post-test scores (Figure 3). Group was the between-subject factor and condition (Latin Roots Treatment and Comparison) was the within-subject factor. Because the design was counterbalanced, different word sets were used for each training session, with Group 1 receiving the Latin Root Treatment at Session I and Group 2 receiving the Latin Roots Treatment at Session II. Again, to control for individual differences in English proficiency skill, ACCESS ELL scores used as a covariate. The covariate was significant, F(1, 59) = 7.21, p = .009.

The interaction between group and condition was significant, F(1,71.1) = 12.98, p < .001. Scores were higher for the Latin Roots Treatment condition for each group (Group 1: t (24.9) = 6.29, p < = .0001, mean diff = 1.61, d = 1.33; Group 2: t (88) = 10.39, p < .0001, mean diff =

3.00, d = 1.48) and between groups regardless of order (Session I: t (117) = 6.09, $p < .0001$, mean diff = 2.01, d = 1.20; Session II: t (117) = -7.86, $p < .0001$, mean diff = -2.60, d = 1.31).

Effects on Fluency of Lexical Access

The computer-based Lexical Decision Task was administered to assess lexical access operationalized as lexical decision response times and accuracy rate. We anticipated that experience analyzing word parts and attending to relationships between orthographic and semantic information of Latin roots would improve rapid lexical access, indicating the kind of fluent access that enhances comprehension. Recall that filler words were higher frequency than target academic words (and were otherwise matched on all other dimensions such as length, bigram frequency and part of speech). Therefore, we anticipated that reaction times would be faster and accuracy rates higher for filler words than for target words for all students in both the Latin Roots Treatment and the comparison conditions. Our hypothesis was that the difference between the more familiar filler and target words (for both accuracy and response time) would be smaller for words taught in the Latin Roots condition in comparison to differences between fillers and target words taught in the comparison condition, thus indicating more fluent access for words with learned roots.

Response time. Table 8 presents unadjusted and adjusted means, standard deviations and ranges for performance on response times on the lexical decision task in each condition for Groups 1 and 2. A 3-way mixed GLM analysis was performed on Response Time adjusted mean scores as a function of word type, group, and condition (Figure 4). Group was the between-subjects factor and Condition (Latin Roots Treatment and comparison) and Word Type (target academic word and filler) were the within-subject factors. To control for individual differences

in English proficiency skill, ACCESS ELL scores used as a covariate; the covariate was not significant but was retained for consistency across analyses.

The pattern of differences among groups between conditions was the only significant interaction, F (1, 77.8) = 4.59, p = .04. There was a significantly faster response time for both word types after the Latin Roots Treatment for Group 2 (Target: t (169) = -5.74, p < .0001, mean diff = -132.89, d = .62; Filler: t (169) = -3.77, p = .05, mean diff = -87.28, d = .41). A substantively important, but not statistically significant, trend was observed showing smaller differences between target academic words and filler words in the Latin Roots Treatment condition across both groups.

Accuracy. Table 9 presents unadjusted and adjusted means, standard deviations and ranges for performance on accuracy rates (percent accurate) on the Lexical Decision Task in each condition.

A 3-way mixed GLM analysis was performed on Accuracy adjusted mean scores as a function of group, word type, and condition. Group was the between-subject factor and Condition (Latin Roots Treatment and comparison) and Word Type (target academic word and filler) were the within-subject factors. To control for individual differences in English proficiency skill, ACCESS ELL scores used as a covariate. The covariate was not significant but again was maintained for consistency across analyses.

The pattern of differences among word types between conditions was the only significant interaction, F (1, 108) = 4.76, p = .03. There was a significantly higher accuracy rate for target academic words in comparison to filler words averaged across groups after Latin Roots Treatment condition, t (108) = 2.88, p = .04, mean diff = .04, d = .39). Thus our hypothesis was

supported that Latin Roots Treatment would be associated with higher accuracy rates of reading target academic words compared to matched, filler words.

Fidelity to Treatment

The fidelity of implementation measure is based on a sample of 20% of lessons from every class, with half from the Latin Roots and half from the comparison condition. When providing instruction in the Latin Roots condition, teachers implemented instructional materials with a high degree of fidelity; teachers followed 88.31% of the scripted material on average (with a range of 82.82%-95%). When providing instruction in the comparison condition, teachers also implemented instructional materials with a high degree of fidelity; teachers followed 91.89% of the scripted material on average (with a range of 85.16% - 98.21%).

Discussion

This study extends the research literature on morphology by providing evidence that robust academic vocabulary instruction infused with analysis of bound Latin roots enriches academic word learning for EL learners for some aspects of word learning. Prior work has overwhelmingly focused on derivational morphology. We anticipated that knowledge of roots would strengthen semantic networks, leading to more robust representations of target word meanings. We expected that extensive guided practice using roots to analyze word meanings (e.g., the relation between *min* meaning "small or less" and the meanings of root-related word such as *diminish, miniscule*, and *minimal)* would lead to enhanced morphological analysis skills to problem-solve the meanings of unfamiliar words. Finally, we hypothesized that instruction focused on morphological analysis of roots would support "constituent binding"—that is, strong, stable connections—between semantic and orthographic features of a word, leading to more efficient (faster and more accurate) access of words (Perfetti, 2007). Below, we summarize the

most salient findings, followed by an in-depth discussion of the results in order of research questions.

Our hypotheses were partially supported and overall lead us to assert that morphological analysis of bound Latin roots offers potential to enrich and accelerate academic word learning of EL adolescents when it is infused into a high quality, robust academic vocabulary program. First and most importantly, the Latin Roots Treatment showed large, positive treatment effects for morphological analysis. In this task, EL students were asked to problem-solve the meanings of unfamiliar words; these words contained bound Latin roots which had been taught only in the Latin Roots Treatment condition. Secondly, our results suggest some advantage for Latin Roots after instruction in Latin Roots condition, as lexical decisions were more accurate for target words after Latin Roots instruction, and reactions times were faster after Latin Roots instruction for Group 2. With respect to building robust representations of target word meanings, our results suggest no advantage for the Latin Roots condition, but at the same time suggest that Latin Roots instruction was equally effective as the rigorous counterfactual, the RAVE comparison condition, for teaching word meanings of target academic words.

Our first question was, *to what extent does instruction about bound Latin roots provide added value, compared to a comparison condition without a morphology component, for EL adolescents' knowledge of target academic words?* Interestingly, the Latin Roots Treatment did not show an advantage over the vocabulary only comparison condition for knowledge of target words—whether measured on a Word Meanings Task or our Evaluation of Academic Vocabulary (EAV) Task. In the Word Meanings Task, no advantage was observed for learning target word meanings for either condition. For EAV— which is context-embedded, exerts more demands on metalinguistic processing, and arguably taps deeper, multidimensional word

knowledge—only Group 2 seemed to benefit from the instruction, but equally so in both conditions.

While we did not find support for our hypothesis that knowledge of roots would strengthen semantic networks between words leading to more robust semantic representations of word meanings, both conditions showed large positive treatment effects for learning the meanings of target academic words. As well, both conditions evidenced positive treatment effects from pre- to post-test at similar magnitudes on the EAV test of multidimensional word knowledge for Group 2, yielding precisely the same effect size (Cohen's d = .62). Thus, when a portion of instructional material that focused on target academic words in the comparison RAVE academic vocabulary program was replaced with morphological analysis using bound Latin roots in the Latin Roots treatment, EL students did not seem to "lose out" on developing knowledge of the target words.

Our second research question was, *to what extent does instruction about bound Latin roots provide added value, compared to a comparison condition without a morphology component, for EL adolescents' morphological analysis skills?* The Latin Roots Treatment showed a large and positive treatment effect (Cohen's d = 1.61 for Group 1 and Cohen's d = 1.48 for Group 2) for morphological analysis. In this task, EL students were asked to problem-solve the meanings of unfamiliar word with bound Latin roots that had been taught only in the Latin Roots Treatment condition. Participation in the Latin Roots Treatment condition enabled EL students to figure out meanings of words such as *minutiae* by applying knowledge of Latin roots in neutral, sentence-level contexts.

Thus, morphology instruction addressing bound Latin roots may equip students to use bound roots for problem-solving unfamiliar words, as many of these words will be from the

Latinate layer of English (Bar-ilan & Berman, 2007) and of an academic register. This finding mirrors Goodwin's (2016) and Bowers and Kirby's (2010) findings about the potential of instruction on morphological constituents (including freestanding stem words and bound roots) for problem-solving novel words. Our study, however, hones in on whether this is possible specifically with bound Latin roots—which is critical given that these are major meaning-carrying constituents in many general academic words.

This finding converges with Crosson and McKeown (2016), but extends this finding to a far more rigorous comparison (i.e., counterfactual nature of the comparison group was robust vocabulary instruction rather than "business as usual") and to a population of ELs. Of course, there is the possibility that other words carrying these roots may be more or less solvable through bound Latin root analysis, as we know that words vary in how much the root relates to the meaning of the word (Crosson & McKeown, 2016). This is an area to be addressed in future research. Given the proverbial vocabulary "gap" between EL adolescents and native English-speaking peers, it is noteworthy that we have documented potential of morphological analysis using bound Latin roots to spur generative learning of new academic words.

Our third research question was, *to what extent does instruction about bound Latin roots provide added value, compared to a comparison condition without a morphology component, for EL adolescents' lexical access of academic words?* Participation in the Latin roots condition was found to show some advantage in lexical access and accuracy of reading target academic words as measured by our Lexical Decision Task. It is possible that when students have established semantic representations for bound Latin roots, this may facilitate word recognition speed and accuracy, as would also be in keeping with the idea of "constituent binding" in the Lexical Quality Hypothesis (Perfetti, 2007). For EL students, this may be especially important,

as bilinguals' word recognition in their non-dominant language is markedly slower when compared to word recognition in their dominant language or when compared to monolinguals, whether this is due to differences in bilingual lexical processing (Lehtonen et al., 2012) or is a matter of target language exposure (Cop, Keuleers, Drieghe, & Duyck, 2015).

Building lexical access has two components: speed and accuracy. We founds different effects for each. For fluency of lexical access, a positive effect was observed only for Group 2, and the effect was observed for both target and filler words. Recall that filler words were matched to target words along dimensions such as bigram frequency, length, and orthographic neighborhood size, but filler words were higher frequency and thus expected to be more familiar to students. We had expected to find that faster reaction times for filler words in both conditions, but that faster processing of target words in the Latin Roots condition would result in a less pronounced difference between target and filler words, only for words learned in that condition. Instead reaction times for both filler and target words were significantly faster for Group 2 following the Latin Roots Treatment. One possible explanation for this unexpected outcome is that students' raised awareness of morphological constituents via multiple opportunities for morphological analysis during the Latin Roots treatment resulted in transfer effects to the filler words such that both target and filler words were processed more quickly. However, this outcome was observed for Group 2 only; there is no evidence for this revised hypothesis from Group 1. As Group 2 comprised older students, it is possible that developmental differences influenced the difference in fluency outcomes.

An advantage for accuracy of reading target academic words was found for both groups when those words were taught in the Latin Roots condition, with a notable treatment effect (Cohen's $d = .39$). Results from the lexical decision task suggest that integrated lexical

morphology instruction may contribute to improved quality of target academic word representations (Perfetti, 2007)—at least for the accuracy component of lexical access—which underlies comprehension via more efficient access of words (Perfetti & Stafura, 2014).

Implications and Future Directions

Taken together, our findings point toward added value of infusing lexical morphology instruction a robust academic vocabulary program. Integrated instruction about bound Latin roots seems to enhance the accuracy aspect of lexical access of academic words and may enhance fluency. Most importantly, instruction about Latin roots seems to equip EL students with an enhanced set of morphological analysis skills to enable additional learning of a larger set of academic words containing the bound Latin roots they have been taught. EL students were able to use to those skills to comprehend sentences with new words carrying the instructed Latin roots.

There are several directions for research to address unanswered questions that emerged from this study, and also to address its limitations. First and most notably, while comprehension is incontrovertibly the core purpose of any reading task, in this study our purpose was to assess processing of academic words from several aspects related to lexical quality, and we did not measure comprehension at a general level. Nonetheless, many researchers see morphological awareness as critical to developing the kind of high quality lexical representations needed for successful comprehension (Bowers, Kirby, & Deacon, 2010; Levesque, Kieffer, & Deacon, 2017; Nagy, Berninger, & Abbott, 2006). We sought to shed light on the effects of instruction in morphological analysis using bound Latin roots on processes that are associated with comprehension outcomes. Results from our Morphological Analysis Task suggests that students did use morphological analysis skills to comprehend sentences with novel words carrying the

instructed roots. Beyond this, we would not expect an intervention that is relatively brief to show general comprehension effects (Murphy, Wilkinson, Soter, Hennessey, & Alexander, 2009); instead we anticipated treatment effects on processes related to comprehension. Future intervention work should be carried out over a longer period of time and should test for relations to a range of comprehension tasks.

A limitation of note in our research design is that group assignment corresponded with grade level. The order of conditions was counterbalanced, but we cannot rule out the possibility of an interaction between order and grade level that our design would not allow us to detect. That said, we believe that the likelihood that order influenced outcomes is unlikely, as Session II contained a completely new set of target academic words and target roots. The only task that holds potential to show carryover effects is the Morphological Analysis Task. We might expect this to become a generalized skill over a longer period of instruction. However, in this study, transfer was very unlikely given that these were brief instructional conditions with non-overlapping roots taught in each session.

As part of this future work, path models might explore the relationships between vocabulary knowledge, morphological analysis skills with bound roots, and word reading as they relate to comprehension. For example, there is evidence that orthographic mapping skill contributes to vocabulary learning (Chilton & Ehri, 2015); within a morphology intervention about Latin roots, such contributions might be even more pronounced. Kuo and Anderson (2008) posited that "exposure to two languages might render abstract word formation rules more accessible and explicit" (p.48), creating an advantage for some ELs. Our results suggest that such an advantage would not be automatic, but may well depend on explicit instruction in morphology.

Along these lines, Kieffer, Mancilla-Martinez and Biancarosa (2013) examined the relation between derivational morphological awareness and comprehension for middle school EL students from Spanish-speaking backgrounds. They examined the direct role of derivational morphological awareness on reading comprehension, as well as indirect paths of morphological awareness through vocabulary knowledge, sight word reading efficiency, and passage reading efficiency on comprehension. They found that derivational morphological awareness made a significant contribution to comprehension via vocabulary but not via sight word reading efficiency. Whether similar relations would be observed for bound Latin roots is unclear.

The participants in this study all spoke at least one language in addition to English, with varying levels of literacy skill in their home language(s). Although limited, there is evidence that morphological awareness is susceptible to cross-linguistic transfer (Ramirez, Chen, Geva & Kiefer, 2010). It is likely that the type of morphological knowledge and analysis emphasized in the treatment condition might be affected by home language literacy skills. Specifically, for EL adolescents with some literacy skill in a Latinate home language, relations between that home language and Latin roots might facilitate learning bound Latin roots for analysis of academic words in English. For example, the Latin root, *nov*, appears in very high-frequency Spanish words such as *nuevo* and *nueva* (meaning "new"), and also appears in several academic words in English, such as *innovative*, *novice*, *novelty*, and *renovate*. Accessing the related meanings in English and Spanish via the Latin root holds potential for learning several academic words in English that do not have direct cognates in English, but are derived from the same Latin root. However, taking advantage of common roots increases the portion of the wordstock that can be supported for students' learning. Moreover, our findings show that linguistically diverse EL adolescents were able to leverage bound Latin roots, whereas cognate instruction alone would

not have benefitted the majority of participants in this study whose home languages were not Latinate.

A future investigation that takes into consideration the moderating effects of home language and literacy skills in Latin Roots instruction might also contribute to a theory of lexical quality for bilinguals. The Lexical Quality Hypothesis does not yet account for bilinguals' interrelated language systems (e.g., Kroll, Dussias, Bice, & Perrotti, 2015). Native and non-native English speakers differ in lexical organization and acquisition of dimensions of word knowledge (Nation, 2013) and there is evidence that the quality (i.e., multifacted knowledge) of meaning representations for second language learners relates to comprehension (Li & Kirby, 2012; Qian & Schedl, 2004). It will be important to understand how lexical representations tap both L1 and L2 phonological, orthographic, and semantic information, as well as how these representations change over time with developing proficiency and instruction in morphological analysis with bound roots.

Conclusion

This study offers evidence that in comparison to a rigorous academic vocabulary program with no morphology component, instruction about bound roots may offer a partial advantage for EL students to develop morphological analysis skill and lexical access to morphologically complex and high-utility academic words, while not interfering with learning target word meanings. As part of the growing scholarship to understand effects of morphology instruction (e.g., Bowers et al., 2010; Goodwin & Ahn, 2013), our study offers empirical evidence for the benefits of extending the relatively overlooked area of morphology instruction beyond the well-investigated area of derivational morphology to analysis of bound roots for improving academic word learning.

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Tables

Table 1
Participant Information Regarding Sample Sizes, Teacher Assignments, English Language Proficiency, Sequence of Conditions, and Group Assignment.

Teacher	n	Grade	Session I Condition	Session II Condition	Group
Mehan	13	6-8	Latin Roots	Comparison	1
Mehan	12	6-8	Latin Roots	Comparison	1
Toki	16	9-10	Comparison	Latin Roots	2
Toki	27	11-12	Comparison	Latin Roots	2
Casey	16	9-10	Comparison	Latin Roots	2

Note. All teacher names are pseudonyms.

Table 2

Word Statistics for Set A Target Words and Roots Taught in Session I

Unit	Word	Root	Root meaning	Word Freq	Root Freq
Goal Setter	*funct*ion	funct	do or perform	57.8	8
	sus*tain*	tain	hold	45.2	36
	*found*ation	found/fund	bottom	52.3	12
	ap*proach*	prox/proach	near	57	5
	*dur*ation	dur	last	43.5	14
	con*sequ*ences	seque	follow	51.7	15
	in*nov*ative	nov	new	41.1	11
	*pri*ority	pri	before	45	11
Give or Take	ex*tract*	tract	drag	45.2	49
	com*pens*ate	pens	weigh	43.8	20
	*cap*acity	cap	catch	54.3	12
	*reg*ulate	reg	rule	50.9	24
	ac*cumul*ate	cumul	pile	47.2	6
	di*min*ish	min	small or less	42	17
	sup*plem*ent	plem/plen/plet	full	45.2	49
	*trans*mit	trans	across	48.7	59
You Win	ad*voc*ate	voc	speak	45.7	23
	*sig*nificant	sig	sign	55.1	45
	*init*iative	init	beginning	46.3	6
	*pot*ential	pot	power	56.5	13
	ac*quir*e	quir/quis	want	50.7	15
	con*struct*ive	struct	build	44.8	28
	*ben*efit	ben	good	54.1	15
	*ex*ceed	ex	out	47.9	328
	*val*id	val	strong	49.9	15
	e*vid*ent	vid/vis	see	50.7	61

Note. Word Freq = Standard Frequency Index score (log transformation of "U-score" of frequency and dispersion across written English corpus of over 17 million tokens) from *Educator's Word Frequency Guide* (Zeno, Ivens, Millard & Duvvuri, 1995); AWL = Sublist in which the target word appears on the Academic Word List (Coxhead, 2000) with sublists representing frequency of headwords on the AWL and there are 10 sublists of word families (60 words per sublist except for sublist 10 which has 30 word families); Root Freq = frequency of morphograph in Becker's corpus (Becker, Dixon, & Anderson-Inman, 1980) based on analysis of 26,000 highest frequency words in English.

Table 3

Word Statistics for Set B Target Words and Roots Taught in Session II

Unit	Word	Root	Root meaning	Word Freq	Root Freq
Will I or Won't I	in*dic*ate	dict	tell or speak	55.4	31
	*ambi*guous	ambi	both	43	12
	in*duc*e	duc	lead	45.6	36
	sus*pend*	pend	hanging	40.8	35
	con*form*	form	shape	46.3	64
	de*via*te	via	road	37	16
	con*sent*	sent	feel	50.7	40
	*circum*stances	circum	around	54.8	35
Mind Games	*contro*versy	contra/contro	against	48.7	14
	*man*ipulate	man	hand	44.8	10
	*no*tion	no	know	51.4	32
	de*tect*	tect	cover	50	19
	*anti*cipate	anti/ante	before	45.8	15
	dis*tort*	tort	twist	42.5	17
	*val*id	val	strong	49.9	15
	e*vid*ent	vid/vis	see	50.7	61
Together or Apart	re*sid*e	sid/sed	sit or settle	42.3	9
	*uni*fy	uni	one	36.9	34
	con*tempo*rary	temp	time	50.8	13
	i*sol*ate	sol	alone	44.4	8
	con*fin*e	fin	border	42.5	49
	*inter*act	inter	between	49.2	5
	con*ven*e	ven	come	20.8	18
	in*corp*orate	corp	body	42.2	10

Note. Word Freq = Standard Frequency Index score (log transformation of "U-score" of frequency and dispersion across written English corpus of over 17 million tokens) from *Educator's Word Frequency Guide* (Zeno, Ivens, Millard & Duvvuri, 1995); AWL = Sublist in which the target word appears on the Academic Word List (Coxhead, 2000) with sublists representing frequency of headwords on the AWL and there are 10 sublists of word families (60 words per sublist except for sublist 10 which has 30 word families); Root Freq = frequency of morphograph in Becker's corpus (Becker, Dixon, & Anderson-Inman, 1980) based on analysis of 26,000 highest frequency words in English.

Table 4

Lesson Components in Latin Roots and Comparison Conditions

Lesson	Latin Roots	Comparison
1	Lesson begins with introduction to first four target words and roots *(*e.g.*, indicate-dic, ambiguous-ambi, induce-duc, suspend-pend)*. Words are introduced in sentence-level contexts; friendly definitions are provided; students are asked to integrate word meaning with context. For each root, a "Spanish friend" is introduced (i.e., a high frequency word in Spanish that carries the root such as the root, *dic,* meaning "tell or speak" and the Spanish Friend, *dice*, meaning "s/he says." Teacher guides students to examine semantic and orthographic connections between target word, root, and Spanish Friend; teacher records on *Words and Roots Chart.* Closure provided via fast-paced review of word meaning, root identification and root meaning	Lesson begins with introduction to first two target words (*indicate, ambiguous*). Words are introduced using two paragraph-level contexts; friendly definitions are provided; students are guided to integrate word meaning with context. Contexts (approximately 75 words each) represent concrete and abstract senses when possible (*ambiguous* shapes; *ambiguous* statements). Following introduction to each word, students engage in "activate vocabulary" interactions applying target words to discuss a personal context (e.g., "What symptoms might *indicate* that you are about to come down with a cold?") Closure provided via review linking "everyday" language to first two word meanings.
2	Lesson begins with fast-paced review of first four roots (e.g., teacher calls out root meaning, students write roots on mini-dry erase boards). Lesson focuses on deepening understanding of first two words (*indicate, ambiguous*). (Note that materials used here overlap with Comparison condition Lesson 1.) Each word is presented in two paragraph-level contexts and students are guided to integrate word meaning with context. Contexts (approximately 75 words each) represent concrete and abstract senses when possible (*ambiguous* shapes; *ambiguous* statements). Following introduction to each word, students engage in "activate vocabulary" interactions applying target words to discuss a personal context (e.g., "What symptoms might *indicate* that you are about to come down with a cold?") Closure provided via final review of first two words linking "everyday" language to word meanings.	Lesson begins with fast-paced review of first two words (*indicate*, *ambiguous*). For example, teacher projects an example and students write on mini dry erase board the word that corresponds to context meaning, e.g., for the example, "a child's drawing that could be a horse or a cow"- students write *ambiguous*). The next two target words (*induce, suspend*) are introduced using two paragraph-level contexts as in Lesson 1. As in Lesson 1, friendly definitions are provided and students are guided to integrate word meaning with context. Students then engage in "activate vocabulary" interactions for each of these two words, as in Lesson 1. Closure provided via final review of second two words linking "everyday" language to word meanings.
3	Lesson begins with fast-paced review of the first four roots (one student acts out root meaning; others call out root). Lesson focuses on deepening understanding of the second two words (*induce, suspend*) using two paragraph-level contexts as in Latin Roots Lesson 2. (Note that materials used overlap with Comparison condition Lesson 2.) As in Lesson 2, students are guided to integrate word meaning with context. Students then engage in "activate vocabulary" interactions for each of these two words, as in Lesson 2. Closure provided via final review of second two words linking "everyday" language to target word meanings.	Lesson begins with fast-paced review of word meanings of second two words (*induce, suspend*), as in Lesson 2. A second fast-paced review focuses on word meanings of first four words (*indicate, ambiguous, induce, suspend*). Teacher leads an active processing activity focused on the first four words. For example, in the activity, "Show Us," the teacher describes situations that incorporate the target words and students act out the situations (e.g., "a new food *induces* an allergic reaction").
4	This lesson is exactly the same as Latin Roots Lesson 1 but focuses on the final four target words and roots *(conform-form, deviate-via, consent-sent, circumstances-circum*).	This lesson is exactly the same as Lesson 1 but focuses on the 5th and 6th target words in the unit *(conform, deviate*).
5	This lesson is exactly the same as Latin Roots Lesson 2 but focuses on the 5th and 6th (of 8 total) target words in the unit and their roots *(conform, deviate*). (Note that materials used overlap with Comparison condition Lesson 4.)	This lesson is exactly the same as Lesson 2 but focuses on the 7th and 8th target words in the unit *(consent, circumstances*).
6	This lesson is exactly the same as Lesson 3 but focuses on the 7th and 8th (of 8 total) target words in the unit and their roots *(consent, circumstances*). (Note that materials used overlap with Comparison condition Lesson 5.)	Lesson begins with review of word meanings of 7th and 8th target words (*consent, circumstances*). For example, in Triple Play, students jot down responses to questions and three students share responses (e.g., "Why should your principal *consent* to letting students use cell phones at lunch?")

		A fast-paced review focuses on target word meanings of final four words (*conform, deviate, consent, circumstances*). Teacher then leads an active processing activity using all eight words. For example, in "Why this word?," pairs of target words are presented in parallel contexts; students select which target word fits each context, and explain differences (e.g., for the words *conform* and *deviate*, student materials read, "You might fail the driving test if you ____ from the traffic rules. If you want to pass your driving test be sure to _____ to the rules").
7	Teacher leads an active processing of all target words and roots. For example, in Picture This, students are guided to associate a target word and root with an image and justify the association. (Note that materials used partially overlap with Comparison condition Lesson 7.) Teacher then leads activity to introduce a "root-related word" (words that carry the roots) for each root. For example, in Word Drama, each root-related word is presented in short (approx. 25 word) scripts (e.g., **Script**: "Art Lesson", **Roles**: Friend 1, Friend 2, Art Teacher; **Art teacher**: Why are you drawing your dog like that? **Student 1**: Why? What's wrong with it? **Student 2**: It has two tails! **Student 1**: So? **Student 2:** It looks *deformed*!) ; students perform the brief scripts, and after each teacher asks: 1) What do you think [root-related word (*deformed*)] means? 2) What is the root (*form* = "shape")?; 3) How does the root connect to the meaning? Closure provided via final review by adding root-related words to *Words and Roots Chart.*	Lesson begins with review of all eight target words by associating each with a new context. For example, in the activity, "What did you do?", the teacher projects a paragraph-length (~100 words) context and asks which target word corresponds to each sentence (e.g., 1. Everyone else was building a model airplane, so your sister wanted to build one too. 2. You agreed to help her build the plane. 3. You let her know exactly how to build the model. 4. She thought your directions weren't very clear…" corresponding to *conform, consent, indicate, ambiguous*, respectively) Finally, teacher leads an active processing activity using all eight words. For example, in Picture This, students associate a word with an image. Students must justify their matches by explaining how the situation depicted in the image related to the target word.
8	Teacher leads an active processing activity focused on all eight target words. For example, in the activity, "Show Us," the teacher describes situations that incorporate the target words and students act out the situations (e.g., "a new food is *inducing* an allergic reaction"). (Note that materials used partially overlap with Comparison condition Lesson 3.) Teacher then leads activity to introduce a second "root-related word for each root. For example, in Overheard Conversations, each root-related word is presented in 1-2 sentence-level sentence bubbles (<20 words) such as, "Sorry we're late! We took a *circuitous* route to get here." Teacher guides students to: 1) identify the word that contains a root; 2) circle the root; 3) use the meaning of the root to figure out the meaning of the root-related word. Closure provided via "Rapid Fire Roots." Students complete a chart with root, root meaning, words, and root-related words as quickly as possible.	Lesson comprises a writing activity using all eight target words. For example, in "Finish the Thought," the teacher provides a sentence stem and specifies the target word to be used in completing the sentence (e.g., for *indicate*, The librarian frowned at us___).

Note. All target words, roots and examples in this table are drawn from the instructional unit, "Will I or Won't I?" Each unit focused on a different set of eight target words and eight target roots. Within each condition, the structure and sequence of lessons within any given unit was the same.

Table 5

Word Statistics for Novel Words in Morphological Analysis Task

Session	Word Set	Novel Word	Instructed Word	Novel Word Freq	Root Freq
I	A	e*dict*	indicate	38.1	31
		con*form*	formative	38.1	64
		con*sent*	sentiments	42.8	40
		*circum*stanc es	circumvent	35	35
		valor	valid	37.2	15
		*vist*a	evident	38.2	61
		re*sid*e	sedate	32.5	9
		*uni*fy	unison	42.5	34
		in*corp*orate	corpulent	34.7	10
II	B	di*min*ish	minutiae	20.8	17
		*ben*efit	benefactor	35.3	15
		*found*ation	unfounded	37.1	12
		in*nov*ative	novelty	43.4	11
		ex*tract*	retract	35	49
		sup*plem*ent	implement	45	49
		ac*quir*e	inquire	44.4	15
		con*struct*ive	obstruct	37.9	28

Note. Session = I was in Fall and II was in Spring; Novel Word = word tested in Morphological Analysis Task; Novel Word Freq = Standard Frequency Index score (log transformation of "U-score" of frequency and dispersion across written English corpus of over 17 million tokens) from *Educator's Word Frequency Guide* (Zeno, Ivens, Millard & Duvvuri, 1995);

Table 6

Descriptive Results from the Word Meanings and Evaluation of Academic Vocabulary (EAV) Tasks in the Latin Roots Treatment and Comparison Conditions

			Pre-test							Post-test					
Assessment	Condition	Group	*n*	Min	Max	Mean	*SD*	Adj. Mean	*se*	Min	Max	Mean	*SD*	Adj. Mean	*se*
Word Meanings Task	Latin roots														
		1	25	0.00	4.00	1.68	1.28	2.79	0.56	0.00	12.00	4.40	3.00	5.51	0.56
		2	57	0.00	14.00	3.89	2.86	3.41	0.46	0.00	16.00	11.46	4.11	10.97	0.46
	Comparison														
		1	25	0.00	7.00	2.40	1.55	3.51	0.56	0.00	12.00	4.96	2.84	6.07	0.56
		2	57	1.00	12.00	4.25	2.34	3.76	0.46	0.00	16.00	11.81	4.65	11.32	0.46
EAV															
	Latin roots														
		1	25	23.00	39.00	32.16	4.37	34.90	1.77	15.00	45.00	33.28	6.46	36.01	1.77
		2	57	12.00	50.00	31.65	10.21	30.45	1.30	20.00	54.00	38.32	7.86	37.16	1.30
	Comparison														
		1	25	0.00	42.00	29.28	10.17	32.02	1.77	0.00	51.00	34.68	12.04	37.42	1.77
		2	57	15.00	47.00	29.86	7.01	28.66	1.30	0.00	52.00	36.53	11.20	35.33	1.30

Note. Adjusted mean was calculated with Mean WIDA = 383.01.

Table 7

Descriptive Results from the Morphological Analysis Task in the Latin Roots Treatment and Comparison Conditions

	Latin Roots							Comparison					
Group	*n*	Min	Max	Mean	*SD*	Adj. Mean	*se*	Min	Max	Mean	*SD*	Adj. Mean	*se*
1	23	0.00	4.00	1.61	1.23	1.95	0.22	0.00	0.00	0.00	0.00	0.35	0.22
2	56	0.00	8.00	3.09	2.21	2.95	0.21	0.00	2.00	0.09	0.35	-0.05	0.21

Note. Adjusted mean was calculated with Mean WIDA = 385.20.

Table 8

Descriptive Results from the Lexical Decision Task for Response Time in the Latin Roots Treatment and Comparison Conditions

			Target						Filler					
Condition	Group	*n*	Min	Max	Mean	*SD*	Adj. Mean	*se*	Min	Max	Mean	*SD*	Adj. Mean	*se*
Latin roots														
	1	23	603.13	1838.83	971.34	291.18	936.04	70.16	569.24	2035.24	891.62	334.31	856.32	70.16
	2	57	555.83	1231.50	778.91	158.16	793.16	26.35	512.57	1317.93	742.06	153.02	756.31	26.35
Comparison														
	1	23	600.70	2233.53	1002.89	392.57	967.59	70.16	597.58	1684.06	967.17	306.83	931.86	70.16
	2	57	579.35	1542.95	911.81	213.69	926.05	26.35	531.05	1391.07	829.34	191.84	843.58	26.35

Note. Time expressed in milliseconds. Adjusted mean was calculated with Mean WIDA = 385.25.

Table 9

Descriptive Results from the Lexical Decision Task for Accuracy Rates in the Latin Roots Treatment and Comparison Conditions

			Target						Filler					
Condition	Group	*n*	Min	Max	Mean	*SD*	Adj. Mean	*se*	Min	Max	Mean	*SD*	Adj. Mean	*se*
Latin roots														
	1	23	0.75	1.00	0.96	0.08	0.97	0.02	0.69	1.00	0.92	0.07	0.93	0.02
	2	57	0.67	1.00	0.94	0.07	0.95	0.01	0.77	1.00	0.97	0.05	0.96	0.01
Comparison														
	1	23	0.58	1.00	0.90	0.11	0.91	0.02	0.75	1.00	0.93	0.07	0.96	0.02
	1	57	0.63	1.00	0.95	0.08	0.93	0.01	0.77	1.00	0.97	0.05	0.96	0.01

Note. Adjusted mean was calculated with Mean WIDA = 385.25.

Figure 1. Results on the Word Meanings Task from a 3-way mixed general linear model (GLM) analysis for the Latin Roots Treatment and Comparison conditions. (Adjusted mean was calculated with Mean WIDA=383.01.)

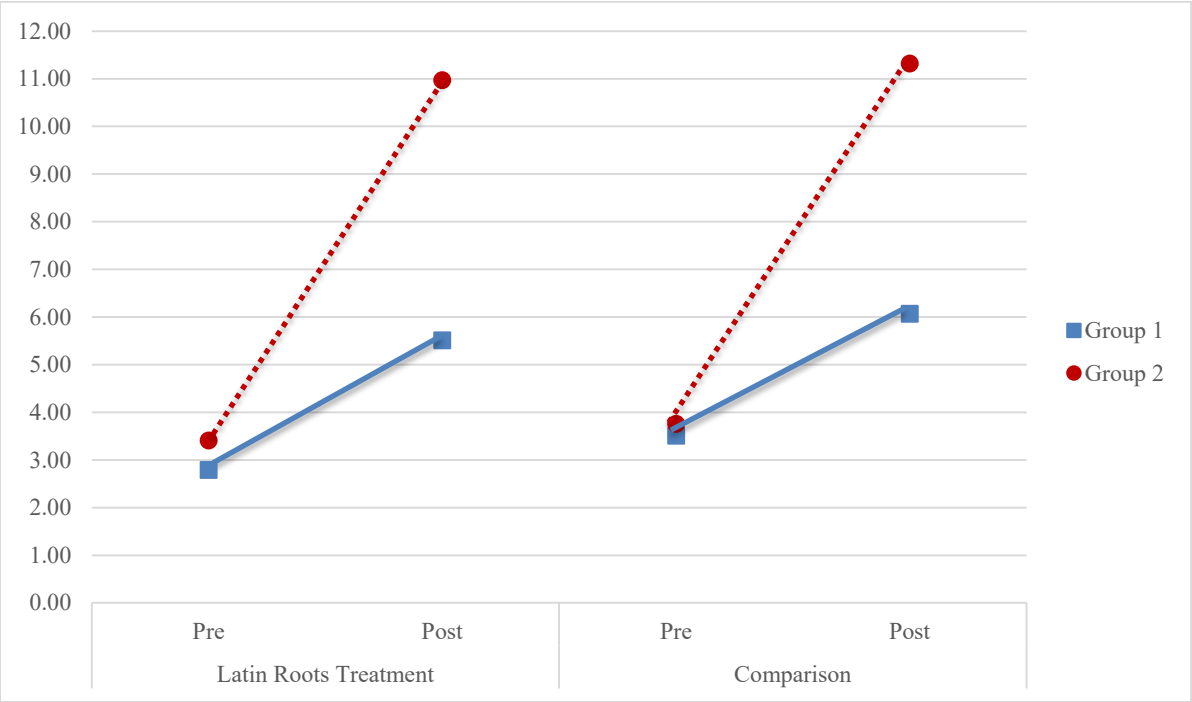

Figure 2. Results on the Evaluation of Academic Vocabulary Task from a 3-way mixed general linear model (GLM) analysis for the Latin Roots Treatment and Comparison conditions. (Adjusted mean was calculated with Mean WIDA=383.01.)

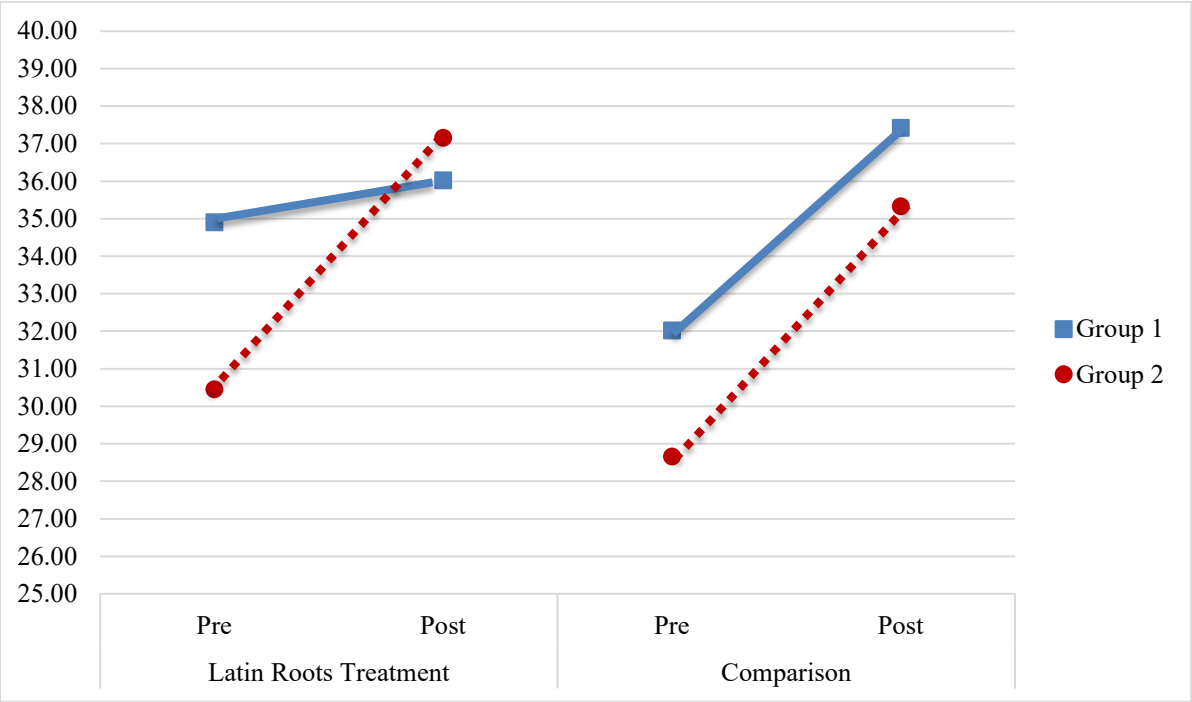

Figure 3. Results on the Morphological Analysis Task from a 2-way mixed general linear model (GLM) analysis for the Latin Roots Treatment and Comparison conditions. (Adjusted mean was calculated with Mean WIDA=385.20.)

Figure 4. Response time results from the Lexical Decision Task scores from a 3-way mixed GLM analysis. Word Type and Condition (Latin Roots Treatment and comparison) were the within-subject factors and Group was the between-subject factor. (Adjusted mean was calculated with Mean WIDA=385.25.)