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# Supporting emergent literacy for English language learners with computer-assisted instruction

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The growing number of students whose primary language does not match the language of their schools and a steadily growing performance gap has prompted widespread attention to support emergent literacy gains for those students. This study randomly assigned schools in a Southwestern U.S. state with English language learners (ELLs) in kindergarten and first grade to an experimental computer-assisted instruction (CAI) condition or a 'business as usual' control. The study tracked ELLs performance over one academic year using a nationally normed standardised reading test. The results demonstrated first-grade students in the experimental condition demonstrated greater gains compared with the control students in the domains of vocabulary, phonics, phonological awareness and text comprehension. Gains for kindergarten were less consistent; however, the lowest language proficient students using CAI experienced greater gains in vocabulary when compared with controls. Results extend prior studies targeting ELL students' reading skill development with targeted CAI interventions.

What is already known about this topic

- English language learners (ELLs) face additional struggles in gaining literacy proficiency in the early grades.
- Computer-assisted instruction (CAI) programs support learning for non-ELLs, provided the instructional materials target specific literacy needs directly.
- Efficacy of CAIs (and any instructional program) is dependent upon the match between learner needs, classroom curriculum and programmatic features.

What this paper adds

- Large randomised control trial testing the effects of a CAI on ELL literacy development in kindergarten and first-grade students.
- Measures of progressive learner development in critical literacy skills using a nationally normed measure of reading achievement.
- Explicit attention to the levels of language proficiency intersecting with the use of the CAI to identify interaction effects

Implications for theory, policy or practice

- Computer-assisted instruction support for second language learners can be effective for targeted literacy gains, provided the program materials support critical literacy needs.

- Use of CAI may be instrumental to support emergent literacy given the ability to capitalise on the proposed pedagogical interventions for second language learners.
- Stress the importance of maintaining attention to the existing language skills of second language learners when examining the efficacy of literacy interventions.

A considerable adjustment that educators have encountered in the recent decades brought about through globalisation has been an increase in the proportion of learners who are not fluent in the language of their schools. In the United States, varying results have been offered to illustrate the increased rate of English language learners (ELLs) served in schools in schools have been offered. One national estimate demonstrated the substantial changes by documenting a 64% increase in ELLs compared with a 4% growth in overall student enrolment (Casteel & Ballantyne, 2010). The prevailing finding is that ELL student representation in the classroom has been on the rise and is projected to continue to grow for the foreseeable future (Kaplan & Leckie, 2009; Nordby & Loertscher, 2009). However, merely documenting the change in percentage of ELLs in schools fails to provide appropriate attention to the true challenge faced by these learners in the educational landscape. The primary concern is and should be the substantial gap in performance that has been documented over the past 15–20 years for second language learners (Alexander, Entwisle & Kabbani, 2001). In the United States, performance trends documented on the National Assessment of Educational Progress demonstrated a significant gap by fourth grade, indicating a 35-point deficit in literacy performance for ELLs compared with non-ELLs – the equivalent to three grade levels of performance difference (Goldenberg, 2011).

This rapid state of change in school composition grows more troubling when combined with the reality that most classroom teachers are underprepared to independently serve the needs of ELLs (Washburn, 2008). Given the challenge, many teachers have to effectively serve a growing number of students in the classroom, a variety of strategies have been proposed to ensure all students receive high-quality instruction that is translated into meaningful learning gains. While considerable effort has been expended to support teachers through professional development experiences to become familiar with needs common among ELLs, our attention in this study is focused on curriculum and pedagogical approaches that are delivered directly to students to support literacy and reading skills for children in the primary grades.

## Classroom interventions supporting ELL reading

Considerable attention has been devoted to designing supportive language and literacy development programs for students who come to school with a home language that differs from the language of the school. Mindful of the needs of teachers, most of this work has occurred with the overarching goal to produce remediation or response to intervention models that focus on common barriers that can be addressed without disrupting the overall instructional model for the classroom. Several best practice interventions for developing early reading proficiency and skills have been gaining traction in both theory and practice including (a) explicit development of vocabulary, (b) development of literacy and language skills in students' primary language to establish a base of home language experiences to that can built upon, (c) individualised pacing and instruction to meet specific deficits or needs and (d) corrective feedback regarding both oral and written language comprehension (e.g., August, McCardle, & Shanahan, 2014).

To set the framework for developing support for ELLs, most quality reading instruction accommodations have focused on adopting the well-established guidelines for reading instruction offered by the National Reading Panel (National Institute of Child Health and Human Development, 2000; Snow, Burns, & Griffin, 1998). Research has demonstrated the importance of systematic instruction in key components of reading comprehension focused on critical aspects of literacy development (i.e., vocabulary, phonemic awareness, phonics, reading fluency and reading comprehension; Hus, 2001; Vaughn et al., 2006).

### *Vocabulary*

For ELLs, limited vocabulary has been shown to interfere with literacy development as the presentation of too many unknown words disrupts students' ability to comprehend written materials (August, Carlo, Dressler & Snow, 2005; Longberg, 2012). Because of this common effect, interventions have been targeted at providing ELLs with explicit vocabulary instruction as a critical addition to support reading instruction (August et al., 2014). Successful strategies for supporting reading with vocabulary training include focused vocabulary training tied to home language transfer (Carlo et al., 2004) as well as heavy use of visual cues (Cheung & Slavin, 2011; Gerber et al., 2004; Silverman & Hines, 2009).

### *Phonological awareness, decoding and phonics*

A clear foundation to effective reading is the ability to identify the component sounds and their corresponding letter combinations, encompassing the skills of phonological awareness and decoding (Ehri et al., 2001). Explicit instruction in these practices is a cornerstone of all reading instruction recommendations (e.g., Snow, Lawrence & White, 2009), and the evidence is clear that the efficacy of this training approach transfers well to supporting second language learners (August et al., 2014). To that point, the National Literacy Panel on Language Minority Children and Youth (August & Shanahan, 2006) advocated for promoting oral language development as a key starting point for interventions designed to improve reading skills among ELLs. The extension of this attempt to teach foundational prereading and reading skills to learners with limited English proficiency has further demonstrated that highlighting differences between the home language and English accelerates development of phonological awareness and decoding for ELLs (Giambo & McKinney, 2004). There is also evidence that consistent exposure to English text and sight words upon entering the school setting supports recognition of the conventions of decoding skills (Elley, 1991; Macaruso & Rodman, 2011). Macaruso and Rodman (2011) demonstrated that these skills can be promoted through computer-assisted instruction (CAI) that focuses on sight word recognition as well as practice with phonological detection and manipulation, for both low-performing and high-performing readers. Finally, as with all emergent readers, promoting decoding and phonological awareness skills for ELLs is optimised with high levels of teacher modelling, frequent repetition of basic skills and consistent feedback on performance (Gunn, Biglan, Smolkowski & Ary, 2000; Kamps et al., 2007).

### *Individualised instructional goals*

The acquisition of reading abilities is a highly individualised process where readers acquire skills at different rates due in large part to diverse needs (Stuart & Coltheart, 1988). Given the variability that has been observed in reading development, it is no surprise that

intervention programs that provide personalised instruction have been shown to be highly beneficial to ELL students (August et al., 2014; Block & Mangieri, 2009; Shamir & Johnson, 2012). That is, intervention programs that track students' progress and present instructional materials that are tailored to fit the educational needs of the learner appear to be particularly effective in supporting literacy development among ELLs (Gersten et al., 2007; Mioduser, Tur-Kaspa & Leitner, 2000; Shamir & Johnson, 2012). One such general approach showing promise is the 3-tier response to intervention model, where individual needs are explicitly identified and addressed as part of the classroom curriculum with small group or individual support (Kamps et al., 2007). Similarly, considerable support for scaffolding reading instruction has been forwarded as a general strategy to help reading teachers target the students' optimal skill focus in reading, capitalising on the common thread of developing students' language growth within a zone of proximal development and differentiated instruction practices (August et al., 2014).

An additional consideration that comes from this important practice to provide student-specific instructional interventions that is particularly relevant for a discussion of meeting the needs for emergent readers with limited English proficiency is the need to identify language proficiency for the population under investigation. Much of the research in the United States has been limited in identifying level of English language proficiency when examining impact of instructional interventions for reading development with ELLs (Richards-Tutor, Baker, Gersten, Baker, & Smith, 2016). Conclusions from this developing line of research support the projection that specific components of literacy skill development may be more sensitive to level of language proficiency – with more complex skills (e.g., reading comprehension) being more sensitive to limitations in proficiency in the assessed language.

### *Primary language support*

Clearly, the vast majority of recommendations in the literature are simply good reading practice, validating the importance of ensuring that teachers of reading maintain best practices in reaching the needs of students who are simultaneously learning English and to read (August et al., 2014). However, one strategy that is specific to ELLs that shows promise in helping to close the observed reading performance gaps as compared with their non-ELL counterparts has endured. Providing ELL students with first language support has proven to be vital in the successful development of early literacy skills (Francis, Lesaux & August, 2006). When teachers possess knowledge of the structure and conventions of a learner's first language, it is possible to build literacy skills by noting similarities between the languages (i.e., sounds common to both languages; Gersten et al., 2007; Giambo & McKinney, 2004). In addition to supporting basic skill development for literacy, this process has the added benefit of enabling the teacher to build more positive connections with the student by demonstrating the value of the learners' home language, culture and individuality.

The most comprehensive approach to examining the impact of primary language support for developing ELLs reading skills has been undertaken by Sharon Vaughn and colleagues (e.g., Vaughn et al., 2006). The unique contribution of this line of inquiry has been the explicit use of primary language training and testing as well as English instruction. The broad implications of this line of research have demonstrated that ELL students involved in targeted literacy development interventions in their primary language show gains in literacy skills that are not similarly met when tested in English. Conclusions regarding their work illustrate the importance of providing specific support in revealing the underlying structure of language and reading, building upon the base of their home language experiences. While

it is unlikely that all schools can match the quality of teacher preparation afforded by their carefully recruited and supported intervention studies (with simultaneous bilingual support and expertise in reading for their teachers), the implications of connecting the structure of the primary language (Spanish) and English provide further support for interventions that draw explicit connections between the oral and written features of the two languages (Chamberlain, 2005).

## Computer-assisted instruction and reading development

Classroom learning technologies are becoming increasingly prevalent and offer several possible advantages to support teaching and learning in schools. There is little doubt that access to high-quality learning resources afforded by technology has a general positive influence on the educational landscape, and teachers have generally positive attitudes towards the inclusion of educational technologies (Yurt & Cevher-Kalburan, 2011). However, the empirical findings from studies examining the efficacy of classroom-based technology resources have been mixed, particularly when examining the impact of structured computer-assisted learning materials on student performance (e.g., Cheung & Slavin, 2011). There are several interested stakeholders in these studies, as dedicated educators are unwilling to sacrifice classroom time to activities that are unproven and budget restrictions preclude the purchase of materials that have not been vetted through 'gold standard' research methodologies.

Our interest is focused on studies that systematically explore the efficacy of CAI, also termed integrated learning systems, on reading development for early elementary school students. In these studies, the goal has generally been to explore the efficacy of these pre-packaged standard-aligned software packages that are intended to augment classroom instruction through providing research-supported literacy instruction strategies directly to learners (Cassady & Smith, 2004; 2005; Longberg, 2012; Macaruso & Rodman, 2011; Macaruso & Walker, 2008).

While specific studies vary in the observed efficacy of various programs (Hammond, 2012; Huffstetter, Schneider, Onwuegbuzie, King & Powell-Smith, 2010; Longberg, 2012), the broad conclusions we draw from the established research are that highly structured, curriculum-based CAI software packages can be anticipated to generate positive effects when implemented under the direction of an engaged teacher. Stetter and Hughes (2010) summarised this literature with the conclusion that struggling readers can be assisted in their reading skills provided the implemented instructional package is bolstered with significant teacher training and engagement. This is, consistent with our own work in the field, we suggest that teacher 'intentionality' is the critical element in determining the successful implementation of the CAI product (Putman, Smith, & Cassady, 2009). By this, we mean that when teachers are intentional in effectively aligning the classroom curriculum with the CAI materials and aligning those instructional materials to the individual children's needs, gains are noted (Cassady & Smith, 2004; 2005). Unfortunately, it is common that CAI programs are ineffectively integrated into the classroom reading curriculum, leading to the implementation of parallel – perhaps competing – reading instruction processes in one classroom (i.e., the 'teacher curriculum' and the 'computer curriculum'). When that is the case and the implementation of the computer application is not intentionally tied to the day-to-day operations of the literacy instruction, the utility and efficacy of the program are hampered significantly (Putman, Cassady, Smith, & Heller, 2014).

The variations in quality materials, issues with integrity and intensity of deployment of CAIs and questionable outcome measures in many of these studies have further hampered the ability to generate clear consensus on the impact of technology in reading development. However, some exemplar studies provide reasonable explanation of the general findings in the field. Research examining the implementation of one commonly used structured integrated learning system led to higher gains in kindergarten and first-grade students' phonological awareness skills when supported with significant professional development and teacher coaching (Cassady & Smith, 2004; 2005). Shamir and Johnson (2012) demonstrated similar gains in phonological processing skills when the program was utilised to support literacy skills for students in Israel learning English as a foreign language in early grades as well. Tracey and Young (2007) expanded evidence in this field by demonstrating student gains on the established Test of Early Reading Achievement (second edition), which measures several dimensions of early reading skill development. However, the same program was found to be ineffective in a widely cited well-controlled study (Paterson, Henry, O'Quin, & Ceprano, 2003), with suggestions that the failure of teachers to effectively implement the program may explain the ineffective outcomes. This brief summary of studies on one program is unusual in the field, because most studies of CAI tend to focus on less widely used applications that are not comprehensive literacy programs, testing a specific potential for impact (e.g., phonological awareness; Macaruso & Walker, 2008), rather than testing actual implementation efficacy (e.g., Kyle, Kujala, Richardson, Lyytinen & Goswami, 2013; Saine, Lerkkanen, Ahonen, Tolvanen & Lyytinen, 2011). However, this collection of disparate findings related to both full-scale literacy curriculum programs and small-scale targeted intervention applications illustrates that technology-based reading program success varies dramatically across contexts and conditions.

In 2009, the Institute for Educational Sciences commissioned a report examining the efficacy of four reading software products implemented within first-grade classrooms. The results of the analyses for two cohorts demonstrated the reading software products failed to generate positive effects on literacy learning for the first-grade students and suggested that in the second year of implementation, the effects of the products were actually negative (Campuzano, Dynarski, Agodini & Rall, 2009). The findings of that large-scale study across multiple schools and contexts raise concern for implementing technology products to support student reading development. However, it is important to identify that the implementation of those products in the various schools was not closely observed, calling into question factors such as treatment fidelity and appropriate use of the content. These complexities are more comprehensively articulated in the meta-analysis of Cheung and Slavin (2011) on implemented educational technology applications on reading performance. The conclusion of their work illustrated generally weak effect sizes associated with the implementation of computer applications to support reading performance. The effect sizes were smaller for experimental studies (as compared with quasi-experimental) as well as for larger studies. Their results also illustrated that merely increasing the level or intensity of technology use did not translate into similarly higher levels of performance (Cheung & Slavin, 2011).

However, one interesting finding from the meta-analysis that is particularly relevant to this line of research was the conclusion that reading-focused CAI proved promising for low-ability students and ELLs (Cheung & Slavin, 2011). The rationale for this differential benefit rests primarily in the potential for well-implemented CAI to provide direct, targeted reading support for struggling learners who are behind their same-age peers. Consistent with the extant literature on supporting English learners' reading development, the elements of CAI most likely to support emergent reading development include vivid visual

representations to support vocabulary development, individualised practice and support for reading skills, personalised pace for working through content and corrective feedback to guide learning (Cheung & Slavin, 2011).

One recent study demonstrating this effect was conducted by Macaruso and Rodman (2011), which demonstrated a specific CAI application focused explicitly on phonological awareness and used in a kindergarten classroom with ELLs, and was successful in promoting sight word reading skills and phonological processing skills. Several key features of that study included the high level of control in implementing the targeted intervention as prescribed, providing teachers with considerable professional development, classroom support, alignment with classroom reading goals and explicit treatment intervention parameters (e.g., use of materials 2–3 times per week). Consistent with our own conclusions with CAI and reading instruction (e.g., Putman et al., 2014) that argues efficacy is most likely to be impactful when the CAI is (a) consistent with the classroom curriculum, (b) reaching the child's current reading development needs and (c) provides educationally relevant learning experiences (rather than merely entertaining content masquerading as educational content; see also Clark, 1994).

## Current investigation: Imagine Learning for English language learners

As reviewed, there is considerable research examining the challenges facing schools and children given the growing rate of students who come to school speaking a different language in the home. Further, there is a reasonable body of literature demonstrating that CAIs may be effective in supporting early literacy development for learners (particularly those with learning challenges). However, there has been very little research examining the use of CAIs to support ELLs (for English-speaking schools) in learning to read in the primary grades.

This study was focused on the implementation of one particular CAI – the Imagine Learning (IL) software application. Unpublished studies examining the efficacy of IL have demonstrated divergent results with respect to learner gains in measures of reading development (e.g., Longberg, 2012; SEG Measurement, 2013; Sorenson, 2015). As with the prior studies examining CAI efficacy, we propose variations in outcomes observed in the studies may be driven in part by methodological differences. That is, the chosen outcome measures, methods of teacher professional development and technical support are all meaningful factors in determining the success of any educational intervention and are likely factors in the success of implementing CAI effectively in classrooms.

Empirical validation of this particular program is warranted given the growing availability of the IL program in schools. Unlike several of the computer-assisted programs outlined in the literature, the IL program is designed for school-wide adoption and promoted as a comprehensive language and literacy program intended to be used 4–5 times per week for up to 20 min per session (Longberg, 2012). Given the ambitious implementation goals, consistent with what Cheung and Slavin (2011) would characterise as 'intense', the efficacy of implementing in classroom contexts is of both theoretical and practical significance to educational researchers. Furthermore, this specific application has a heavy theoretical emphasis on promoting access to students in various languages and is purported to be optimal for use with ELLs due to high levels of visual engagement, interactive activities, ability to have repeated practice with reading skills and frequent feedback guiding performance gains within the program (August et al., 2014; Kamps et al., 2007). As such, testing the efficacy of this particular product to support ELLs was of considerable interest.

## Method

This study was designed to provide a direct test of the impact of the IL software program when implemented in a randomised control trial design. To accomplish this process, five school districts in the Southwestern United States in the state of Arizona were approached with the opportunity to participate. To encourage districts to participate in the study, they were offered reduced-price program licenses for the IL software in return for participation. To participate in the project, the district identified pairs of schools with similar demographic profiles on overall level of socioeconomic status (as identified by percentage of students eligible for free or reduced lunch), minority student representation and patterns of school success. In addition, both schools were required to included large percentages of English learners (most districts identified their schools with the highest proportion of ELLs).

Those paired schools were subsequently randomly assigned (random draw) to either the treatment (IL) or control condition, resulting in 14 control schools and 14 treatment schools. All participants (treatment and control) were required to complete the Scantron Reading Foundations test during the three prescribed testing windows during the 2014–2015 academic year. All data collection and analyses reported in this study were conducted by researchers external to the IL organisation.

### *Participants*

Six school districts with a total of 28 (large city/urban = 17 and small town/rural = 11) schools participated in the study conducted during the 2014–2015 academic year. While the schools participating in this study served grades kindergarten through Grades 5 or 6, this investigation is focused solely on the performance of children identified as ELLs in kindergarten and first grade. Overall, complete data were available for 1,490 ELL students in kindergarten and first grade at the experimental ($n$ = 813) and control ($n$ = 677) schools. The absence of balance was driven primarily by a disproportionate rate of missing data from control group schools that failed to fully implement the standardised testing protocol by missing one of the testing windows for individual students. Examination of score differences for children with and without complete data demonstrated no significant performance patterns. While this serves as the sampling frame for the study, each analysis has varied numbers of participants because of individual student missing data for the three time points on specific subtests involved in the analyses.

Participant data revealed a relatively even distribution based on gender (46% female) and current identified level of English proficiency as determined by the state-mandated and administered language proficiency measure. The measure used to validate student's language proficiency is the Arizona English Language Learner Assessment, which is administered by school officials for all students who have been identified as second language learners by the state. Students are assessed yearly, and the data used in this study to identify language status were the most recent assessments for each learner. The student profiles identified learners were distributed as follows (with descriptors for the proficiency ratings provided): 23% emergent/pre-emergent (lack English skills required to communicate or use mainstream curricula), 44% basic (limited understanding of basic social English and beginning to identify letter sounds and alphabet) and 33% intermediate/proficient (moderate understanding of spoken social English, able to decode CVC words and beginning to demonstrate written conventions).

Student grade level was tracked because of the different curricular and programmatic focuses for the grade levels. In our sample, there were 767 kindergarten and 723 first-grade students. Preliminary analyses demonstrated no significant effect of gender in growth or overall performance on the measures of interest in the grade levels. As such, for simplicity in analyses, gender was not included as a factor. Finally, examination of the free and reduced lunch eligibility for the participating students demonstrated that 90% (school range 79–99%) were eligible for subsidised lunch programs (indicative of low-income family status).

Examining overall school educational quality for the participating locations, we were able to identify general proficiency estimates using the state-mandated school rating system. These values are based on an algorithmic combination of proficiency and growth for the school as a whole based on the annual state proficiency exams. The schools in this study had an average school performance value of 109.52 (standard deviation [*SD*] = 17.19) as compared with the state average 128.46 (*SD* = 20.9). This translates into a modal school rating of 'C' for participating schools, which is identified by the Arizona Department of Education as demonstrating that 50% of the students in the school meet grade-level performance standards, and the school demonstrates typical academic compared with the state norming sample (Arizona Department of Education, 2012). Examining overall school ratings for experimental (109.42) and control (109.62) demonstrated there were no differences between the randomly assigned schools on this broad indicator of school functioning.

While the standard level of support offered by the IL corporate software team had was provided and schools were regularly visited by IL staff to troubleshoot and provide technical support, there were no regular on-site observations of teacher performance used in this study. While this limits the ability to examine specific integration with prescribed preferences in instructional style from teacher to teacher, our study is focused on the broad efficacy of using the IL program for ELLs across a variety of educational settings. In order to conduct a broad study across multiple districts, the research design was limited in the specificity and contextual information available. As such, this study is more aligned with the 'large-cale' studies reviewed by Cheung and Slavin (2011) and consistent with the implementation strategies reported in Campazuno et al. (2009).

### *Materials*

The computer-assisted instructional device used in this study was the IL literacy package. The IL program is a comprehensive curriculum support system designed to improve language and literacy skills among struggling readers. IL provides students with direct individualised instruction in five domains that are considered key for the development of high-level reading ability including (a) phonological awareness, (b) phonics, (c) fluency, (d) vocabulary and (e) comprehension. In addition to adopting these five key elements of reading skill, the IL software is designed to provide supportive educational elements designed to help teachers guide students through their literacy skill development. Key elements promoted by the publisher include differentiated instruction strategies; and primary language support; frequent practice, assessment and re-teaching as needed (Imagine Learning, 2015).

The kindergarten and first-grade curriculum program for IL was utilised in this study, with attention to students in the participating schools who were ELLs with Spanish as their home language. The teachers in the experimental schools were provided with the standard introductory training by IL software professional development

team and given access for all students in their classrooms. However, only students who were ELL are included in this study because of limitations in data collection for the non-ELL students in control group schools. The program guideline is to provide students with 20 min on the IL program at least four times per week. Implementation was delayed in most schools because of technical issues at the school locations as well as testing requirements for the participating schools and did not become standard until November of the fall semester in question, with more consistent engagement in the spring semester.

### *Measures*

*Program usage.* To validate student participation in the program materials, IL software usage data were made available to our research team. This rough estimation of treatment fidelity was used to ensure that students in the experimental schools were using the software at reasonable levels. If a student in an experimental school did not use the program for at least 2 h, they were removed from the analyses based on the presumption that they did not have access to the program. Less than 10% of the experimental group used the IL software less than 15 total hours. Collectively, schools included in this study demonstrated sufficient engagement with the materials to be maintained in the study through the entire academic year ($\underline{M}$ = 42.06 h, $\underline{SD}$ = 16.23). This was ensured partly by monthly monitoring of usage levels to ensure consistent and regular usage. We also made comparisons of individual users based on usage levels (i.e., intensity); however, the results demonstrated no significant differences on the outcome variables based on level of usage. That is, we observed no differences between the 'high usage' and 'typical usage' groups in preliminary analyses. As such, for simplicity and consistency with standard implementation in school settings, the main findings are focused on comparisons of experimental and comparison schools.

In addition to the objective measure of minutes and sessions used in the program, teachers completed an exit interview to discuss their use of the program. The variations in program implementation were predictable based on technology access. These variations in usage patterns were driven by the school technology plans for the most part. That is, classrooms with 1:1 access with tablets adopted daily usage procedures, while those with only computer labs scheduled 2–3 sessions per week for classroom implementations. Comparisons across schools provided no meaningful pattern to suggest that mode of program usage (i.e., lab-based vs classroom implementation) was influential in either overall usage level or individual student growth.

*Reading performance.* The primary measure of interest in this study of the ELL students in kindergarten and first grade was the Scantron Performance Series Reading Foundations test (English version). This is a computer-adaptive measure given in three testing windows during the academic year to assess initial ability, midyear progress (collected in this study in the last 2 weeks of the fall semester or the first 2 weeks after the semester break) and end of year performance (April–May data collection). The short form of the Scantron Reading Foundations was completed by the students during the regular school day, and completion of the measure generally took less than 1 h per assessment period, with the option to take breaks at the discretion of the classroom teachers.

The Scantron Reading Foundations measure assesses student performance phonological awareness, phonics, text comprehension and vocabulary, with a reported 25% of assessment attention to each of the domains (Scantron Corporation, 2016). The key skills identified for the four domains include

- Phonological awareness: identify, blend and substitute phonemes; count and blend syllables.
- Phonics: decode and spell words; identify letters, letter and sound correspondence.
- Vocabulary: understand and use grade-appropriate words; interpret words in context.
- Text comprehension: concepts about print (initial skills) to basic word comprehension.

Although there is very little published information on the technical merits of the test available, the publisher reports that the test has been validated with 27 different statewide tests of reading proficiency and published validation evidence is available, establishing both concurrent and predictive validity with the more established Scantron Reading Performance Series measure (with predictive validity correlations ranging from .69 to .73; Scantron Corporation, 2016). Scores generated in the three nationally determined testing windows lead to scaled scores that are normalised against national norming comparisons for growth and proficiency benchmarks. The scores available for analysis from the Reading Foundations test include subscores for each of the four domains (phonological awareness, phonics, text comprehension and vocabulary) and a total scaled score for reading.

All testing with the Scantron program is conducted online with a computer-adaptive testing protocol, and scores are posted within 24 h to a district-specific database, enabling immediate reporting on student progress. All data used in this study were captured directly from these Scantron databases to ensure maximal accuracy in data management.

## Results

### *Growth on Reading Foundations total score*

To evaluate the effect of IL use for ELLs in the two school conditions, a split-plot analysis of variance (ANOVA) with three assessment points (fall, winter and spring) was used to compare Reading Foundations scores for students in the experimental (IL usage) and control schools. These analyses were further disaggregated by grade.

*Kindergarten.* Results of the analysis revealed a main effect of growth over time across the fall, winter and spring measurement periods for kindergarten students, $F(2, 690) = 171.40$, $p < .001$, $\eta_p^2 = .33$. Simple effect analyses revealed the mean Reading Foundations scaled score observed during the spring measurement period ($M = 1600.71$, $SD = 204.53$) was significantly greater than the Reading Foundations scaled score observed within the winter and fall measurement periods ($M$s = 1473.05, 1378.16, $SD$s = 161.83, 117.61, respectively; Figure 1). However, the analysis failed to produce a significant interaction effect indicating ELL students in the experimental and control conditions did not experience differential rates of growth in reading ability, as assessed by the Reading Foundations measure, $F(2, 690) = 1.90$, $p > .05$, $\eta_p^2 = .005$.

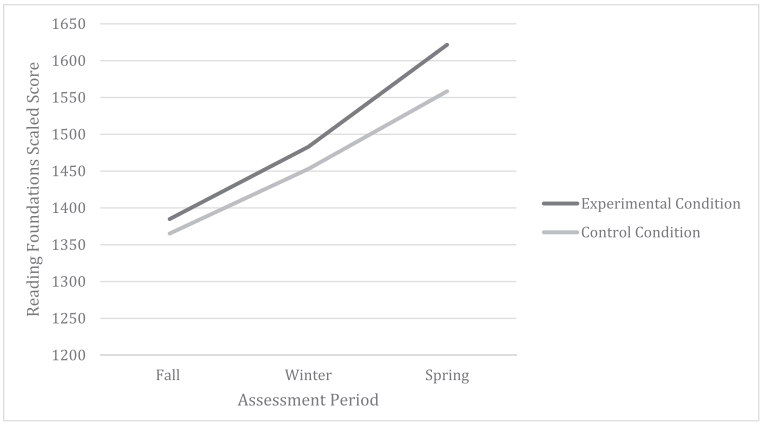


**Figure 1.** Kindergarten student performance trends on Scantron Reading Foundations.

*First grade.* Results of the split-plot ANOVA once again revealed a main effect of growth over time across the fall, winter and spring measurement periods for all students, $F(2, 722) = 218.29$, $p < .001$, $\eta_p^2 = .37$, indicating that collectively scores improved on Scantron Reading Foundations measure (as expected). Follow-up analyses revealed the mean Reading Foundations scaled score observed during the spring measurement period ($M = 1813.00$, $SD = 228.48$) was significantly greater than the Reading Foundations scaled score observed within the winter ($M = 1669.58$, $SD = 220.42$) and fall ($M = 1542.84$, $SD = 184.81$) measurement periods (Figure 2).

Of greater relevance to the primary research question was the significant interaction effect observed between growth over time and condition, $F(2, 722) = 4.94$, $p < .01$, $\eta_p^2 = .014$, indicating differential gains in reading ability over time for the two groups. Examination of the group effects illustrates that the control group had a slight initial advantage in the fall assessment, but by the spring assessment, the experimental group had overcome the deficit

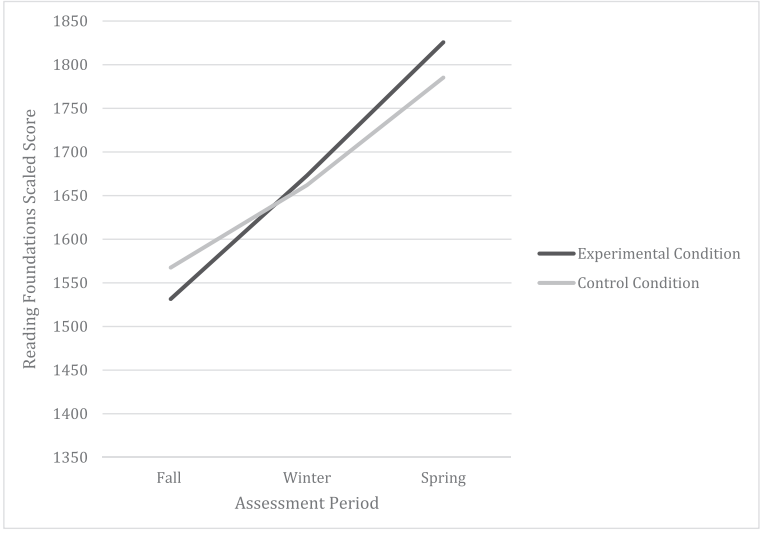


**Figure 2.** First-grade student performance trends on Scantron Reading Foundations.

and performed at a significantly higher level of competence. As such, first-grade ELL students using the IL program demonstrated higher rates of growth in basic reading skills than their control school counterparts. Observation of the growth patterns illustrate the difference was evident primarily during the spring semester, when higher rates of usage occurred because of the late implementation.

### *Specific language and literacy performance gains*

In addition to the Reading Foundations total score offered in the Scantron report, data were available for the four specific reading skills measured by the Scantron materials (e.g., phonological awareness, phonics, reading comprehension and vocabulary). Given the predictable development of reading skills across learners, as well as the identification in the literature of the key importance of vocabulary development while students are learning English and reading, specific analyses of those subdomains of reading were deemed relevant to this investigation. For this set of analyses, in addition to reviewing IL program use as a factor, we further examined if there were differences among learners at differing levels of English language proficiency.

We performed grade-specific multivariate analyses of variance (MANOVAs) examining gains from fall to spring on the four Reading Foundations subtests, with level of language proficiency and IL usage as independent variables. Therefore, for each grade level, comparisons for three levels of ELL status (pre-emergent/emergent, basic and proficient/full) and two levels of IL usage (control vs experimental) were conducted. These analyses examine the main effect of ELL, which determines if there are differences in performance gains based on ELL status (without respect to IL usage); the main effect of IL, which determines if there is a differential gain on the measures based on effect for using IL (without attention to level of language proficiency); and the interaction, which examines if there is a differential level of growth that is sensitive to both factors (e.g., higher gains for emergent English learners who use IL).

*Kindergarten.* For the kindergarten participants ($n$ = 466), results of the MANOVA revealed there was no significant main effect of language proficiency, Pillai's trace = .03, $F(8, 916) = 1.79$, $p > .05$, $\eta_p^2 = .01$, or IL program use, Pillai's trace = .003, $F(4, 457) = 0.39$, $p > .05$, $\eta_p^2 = .003$. Furthermore, results revealed the overall interaction effect between language proficiency and IL program use was not significant, Pillai's trace = .25, $F(8, 916) = 1.42$, $p > .05$, $\eta_p^2 = .01$.

Given the interest in specific domains of linguistic development for ELL student growth, we conducted a series of follow-up ANOVAs examining group differences on the four specific curriculum areas independently. These analyses revealed a significant interaction effect between ELL status and experimental condition on the vocabulary subtest of the Scantron Reading Foundations measure, $F(2,460) = 3.78$, $p < .05$, $\eta_p^2 = .016$. This weak but significant effect illustrated that while there were no meaningful differences in vocabulary growth for students identified as 'basic' or 'intermediate and full English proficient' based on IL usage, there was a significant difference among those students classified as 'pre-emergent and emergent' (Figure 3). Observation of the values for vocabulary growth also illustrates a difference within control group students determined by the level of English proficiency. Control group students at the pre-emergent and emergent status

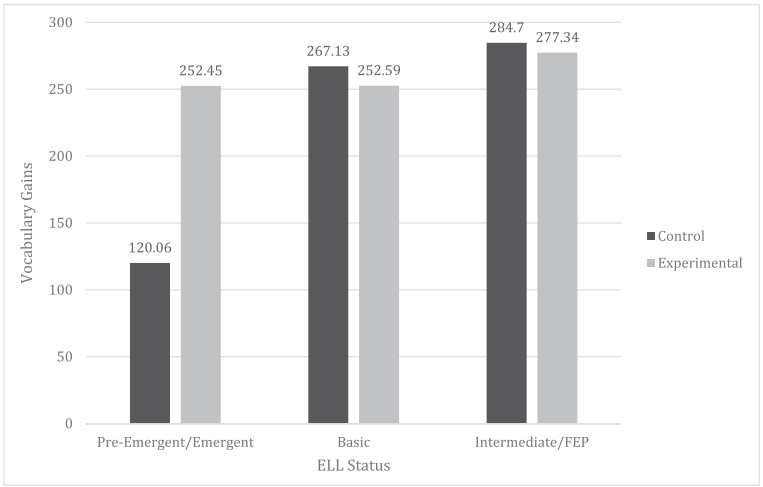


**Figure 3.** Kindergarten student gains on vocabulary subtest (fall to spring): effects of language proficiency and treatment condition.

demonstrated significantly lower gains in vocabulary than their more linguistically proficient peers attending the same schools.

*First grade.* For first-grade students ($n$ = 387), the MANOVA analysis revealed a main effect of IL usage, $F(4, 378) = 3.56$, $p < .01$, $\eta_p^2 = .036$, but the main effect of language proficiency and the interaction effects was not significant. As with the kindergarten sample, we explored the individual domains of literacy development directly as well.

Direct analyses targeting the individual literacy domains revealed statistically significant differences in all four, with students using the IL program showed significantly greater gains in phonological awareness ($F(1, 381) = 7.03$, $p < .01$, $\eta_p^2 = .018$), phonics ($F(1, 381) = 4.51$, $p < .05$, $\eta_p^2 = .012$), text comprehension ($F(1, 381) = 8.13$, $p < .01$, $\eta_p^2 = .021$) and vocabulary ($F(1, 381) = 8.12$, $p < .01$, $\eta_p^2 = .021$) over the academic year (Figure 4). These effects were consistent across the three levels of language proficiency for the ELLs in the first grade.

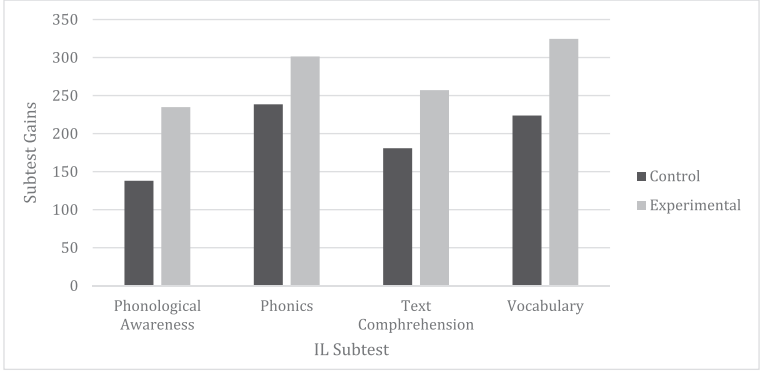


**Figure 4.** First-grade Scantron subtest gains (fall to spring) for control and experimental students.

## Discussion

The results of this randomised control trial study conducted in multiple school districts in the Southwestern United States provide a first empirical test of the efficacy of the IL software application for ELLs. The results demonstrated a small but statistically significant benefit to ELLs in kindergarten and first-grade classrooms, as compared with similar students in 'business as usual' curriculum programs. The results provide information on three key issues related to use of CAI to support English Language Leaners' emergent reading skills.

First, the data demonstrated a consistent advantage in reading performance gains for students using the CAI in first grade, as compared with the control condition students. The data further indicated that the greatest gains were noted during the second half of the school year, which was when more consistent and continued use of the program was documented. Second, a benefit for gains in vocabulary proficiency was detected for kindergarten students with low levels of English proficiency using the CAI program. Third, there was a noted difference in performance in vocabulary score gains in the control group students when comparing students with 'pre-emergent and emergent' language proficiency to other control group students with 'basic' or 'proficient' skills. This illustrates once again the need to review ELLs as a heterogenous population, considering the variations in linguistic proficiency as a critical variable in studies examining learning gains.

### *First grade reading gains*

The primary finding related to the impact of the CAI on emergent reading skills for ELLs illustrated that for both the total Reading Foundations score on the Scantron assessment and related the subtests (vocabulary, phonics, phonological awareness and text comprehension), the students who used IL as a regular part of their classroom-based reading instruction showed greater gains in reading development. The positive impact noted in first grade but not in kindergarten could be explained by (a) more direct alignment of the first grade materials to the Reading Foundations measure, (b) superior levels of integration of IL materials in the first-grade classrooms or (c) mere readiness for using the computerised learning materials. Exit interviews with teachers did indicate a higher level of technical issue frustrations for the kindergarten students, which may have precluded optimal usage. All three of these potential differences can be accounted for by a simple intentional teaching framework (Putman et al., 2014), where instructional interventions are only effective in contexts where the teachers identify specific avenues for implementing the intervention within the current learning context to support learner change. As such, our conclusion on the utility and efficacy of using IL in primary grades that serve second language learners is that it shows promise provided the teachers have the necessary resources to support the learners and that the content aligns with their classroom level curriculum needs.

### *Kindergarten vocabulary gains*

Furthermore, kindergarten students who were at the pre-emergent or emergent English proficiency levels were shown to have greater gains on the Scantron vocabulary measure when using the IL software than students with similar proficiency levels at the control schools. These results provide initial evidence that the CAI program, which had a heavy level of vocabulary training consistent with the guidelines offered by prior research with emphasis on

visual cues and repetition (Cheung & Slavin, 2011; Gerber et al., 2004). In particular, the results demonstrating benefits of using IL for kindergarten pre-emergent and emergent English learners appear to illustrate that IL provided a remediation support in vocabulary for the learners with the greatest linguistic needs. That is, no significant differences were observed in Scantron Reading Foundations performance gains between the experimental and control group students except for the vocabulary effect illustrated in Figure 3. This pattern of results may illustrate that pre-emergent and emergent learners received the necessary additional visual and auditory materials needed to develop vocabulary skills in their first year of formal schooling.

An additional programmatic and pedagogical consideration is important for discussion with this sample. The prevailing research on supporting ELL literacy development for skills such as phonics and phonological awareness points to support for the primary language as a positive strategy in supporting learning gains (e.g., August et al., 2014; Gersten et al., 2007; Giambo & McKinney, 2004). However, in the current setting, teachers were restricted to using only English in the classroom (as dictated by state legislation). This included the implementation of the CAI software, which can be configured to provide support in additional languages. It is quite possible that more effective gains in emergent literacy skills such as phonics and phonological awareness would be achieved in a kindergarten setting where the child's primary language is used to support the learning as recommending by the extant literature.

### *Heterogeneity of samples*

Finally, the results of this study support repeated calls from researchers examining academic outcomes for ELLs (or any minority group) to identify the heterogeneity of the group in question (Richards-Tutor et al., 2016). In our study, we observed a pattern of difference in learning vocabulary based on the level of language proficiency in our control group sample. Attention to linguistic readiness is critical to identify contexts under which academic interventions may be replicated to achieve similar success.

## Conclusions, limitations and future directions

Most prior studies with CAI were conducted in small, school-specific studies with measures of reading that were focused on distinct skills (e.g., Cassady & Smith, 2005; Huffstetter, et al., 2010; Kyle et al., 2013). In this study, the use of a nationally normed and validated standardised measure of reading performance (Scantron Corporation, 2016) provides insight to the potential outcomes in large-scale implementation of this or related reading software materials for ELLs. Furthermore, the use of a random assignment to condition provides a higher degree of confidence that the observed differences between the experimental and control groups may be attributed to the intervention. This was validated broadly with clear initial equivalence on external measures of school performance and initial performance indicators made available by the repeated testing over the course of the intervention year.

Our results are consistent with a broad body of research that identifies CAI applications have potential value – but only so far as they are implemented by well trained and supported teachers who make clear and active decisions regarding the use of the programs to support their learners' current literacy development needs (e.g., Cassady & Smith, 2004; 2005; Stetter & Hughes, 2010). Our observation of the use of this program in classrooms serving

high percentages of ELLs suggests that it can provide a supportive resource to teachers who are active in overseeing the selected learning activities of all learners. However, we also advance the perspective that the restriction imposed upon these teachers to not support the primary language of the learners in the classroom likely suppressed literacy gains in both the experimental and control conditions. That is, if teachers had the potential to implement the program using the primary language support, it is anticipated that students would be able to see greater gains (particularly for those in the lowest levels of identified English proficiency).

While we believe this study has utility due to the aforementioned contributions, there were several limitations that are inherent to large-scale studies such as this that bear consideration. Although all reported effects in this study were statistically significant, it should be stressed that several of these findings are classified as 'weak'. That is, while the effects observed were statistically significant and reliable, the overall effect sizes were not strong – consistent with the findings of Cheung and Slavin (2011). As such, caution needs to be taken when generalising these findings to additional contexts and learning situations. Additionally, observed rate of attrition in the current study was high. This was due to missing data in the three time points for the primary assessments due to primarily student mobility and site-specific failures to collect data at all three time points for students in the sample. This limitation in control over the sample was a consequence of the decentralised nature of data collection (handled at the school level) and was a consistent barrier to the study given that the testing duties were handled at the individual school level. We also noted inconsistencies in IL usage levels, suggesting differential teacher implementation. While our analyses did not detect differences in the impact of these variations on student performance, the reality is that our data confirm that teachers' implementation of the CAI program was not universal and optimal use requires significant oversight and support. As such, a logical next step in research with this program and population would be a smaller scale study involving direct observation of teacher engagement with the materials. This would provide a more direct-link connection between the curriculum implementation and individual student gains.

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