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ARTICLE

# Adolescent English learners' language development in technology-enhanced classrooms

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## Abstract

*Despite their demographic importance in U.S. classrooms, little is known about how the strengths and needs of English learners are engaged through technology, particularly as it is embodied by one-to-one devices such as iPads and Chromebooks. An exploratory study of English learners in technology-enhanced classrooms was undertaken at an urban secondary school with a strong ongoing commitment to student-centered uses of technology. The study used quantitative classroom observations and student surveys to explain variation in English language development among English learners and across classrooms. Findings show that the features of technology-enhanced classrooms that best supported language development were aligned with student-centered and strengths-based teaching; the use of technology in the classroom alone was insufficient. Our findings also bring to light individual characteristics of English learners that shaped their language development in technology-enhanced classrooms. These individual characteristics include academic engagement and language use with friends, as well as student work and being over-age for their grade.*

***Keywords:*** *English Learner, Second Language Acquisition, Computer-Assisted Language Learning, Secondary School*

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

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## Introduction

In response to a globalizing workplace and standards-based school reforms that mandate knowledge of multimodal texts and technology, schools across the United States are rapidly integrating digital technologies (Selwyn, 2013; Warschauer, 2011). At the same time, classrooms have never been so diverse: more than 20 percent of children in the United States speak a language other than English at home (National Center for Educational Statistics [NCES], 2015) and classrooms with English learners[1] are increasingly using digital technologies to teach language and content. The new global reality of people and technology crossing borders in record numbers to create hybrid and interconnected spaces is embodied in our classrooms (Suárez-Orozco & Qin-Hillard, 2004; Vertovec, 2007), providing both an opportunity and a challenge for teachers of English learners. As Ortega (2017) asserts, "The majority of the world is multilingual, but inequitably multilingual, and much of the world is also technologized, but inequitably so" (p. 288).

Currently, 4.4 million students are classified as English learners (NCES, 2015), and despite their demographic importance, little is known about how the use of digital technologies affects their learning. Research is clearly needed to better understand how language learning and digital technologies are intertwined, and whether that interplay provides equitable opportunities for this group. One-to-one devices such as iPads and Chromebooks in particular offer teachers and students numerous possible benefits but also many potential disadvantages: On the one hand, digital technologies and the multimodal literacies they enable can individualize learning and foster independence and creativity; on the other hand, technology can

be a distraction, take time and resources away from tried-and-true learning activities, and present yet another set of hurdles for groups of language learners who are already socially and economically disadvantaged (van Leeuwen, 2015; Peck et al., 2015).

Research is needed to better understand the possibilities and limitations of digital technologies in the classroom for English learners and their teachers. The current study seeks to address this gap in the literature by examining how teaching practices in technology-enhanced classrooms relate to the language learning outcomes of adolescent English learner students. Drawing on quantitative classroom observations and student surveys, we document the role of features of technology-enhanced classrooms and student characteristics in accounting for English learners' language development over the duration of a year.

## Theory and Research

Technology is often invisible in teaching and learning, even as it shapes how language is used and taught in classrooms (Chun et al., 2016). By contrast, when research shines a light on technology in education, it is often showcased as a panacea or a lever of transformation (Liu & Chao, 2018). The reality is somewhere in between. In conceptualizing this study, we drew on an ecological framing (Bronfenbrenner, 1977) of school-based technologies as differentiated both by the classrooms and the individual students engaged in learning with and through technology. Our study was also guided by sociocultural theory (Vygotsky, 1978) and multimodal literacies (Kress, 2003) as the basis for understanding student-centered, multimodal learning. Together these theories suggest teaching with technology should be predicated on recognizing and addressing inequities within and beyond the classroom.

An ecological systems approach allowed us to document both the direct and indirect effects of technology on language learning, an important consideration for policy and practice that is underrepresented in research (Macaro et al., 2012). Our focus, in particular, is on the mesosystem (Bronfenbrenner & Morris, 2006), relating classroom-level practices and individual student characteristics to language development in order to understand how technology-enhanced learning environments contribute to language development (van Lier, 2004). In sociocultural theory, learning is understood to be socially constructed and mediated through interaction (Vygotsky, 1978). Applied to English learners, this theory emphasizes the beneficial role of active engagement with peers (Brooks & Donato, 1994; Swain & Lapkin, 1998) and with more advanced conversation partners, including peer mentors and teachers (Aljaafreh & Lantolf, 1994; Nassaji & Swain, 2000) for English language development. Sociocultural approaches to second-language learning also highlight the utility of technology to explore form-meaning relationships and mediate cognitive activity (Lantolf & Thorne, 2006; Lantolf & Poehner, 2014). Learning in technology-enhanced classrooms can build on these concepts to limit teacher talk and teacher-fronted classrooms in favor of developing more student collaboration and student-directed learning.

Theories of multiliteracy (New London Group, 1996) and multimodality (Kress, 2003) complement a sociocultural orientation to language learning in technology-enhanced classrooms as they ascribe value to all modes of communication. Multimodality—including written, visual, audio, gestural, and spatial communications—is a central feature of technology-enhanced learning environments (Choi & Yi, 2016; LaBanca et al., 2013; Jewitt, 2008). Because digital technologies in the classroom draw on a range of communication tools and strategies commonly used outside of school, school-based technologies risk replicating real-world inequalities if the needs and strengths of immigrant students are not central to their pedagogical use (van Leeuwen, 2015; Peck et al., 2015).

### Technology-Enhanced Classrooms

Newly emerging research on English learners in technology-enhanced K-12 classrooms has shown that the integration of computers, iPads, smartboards, and other technologies in all aspects of classroom learning has enormous promise for differentiating instruction and for student appropriation of learning processes (Macaro et al., 2012; Ware & Hellmich, 2014). At a minimum, the purposeful use of technology with English learners is at least as effective as teaching without technology (Grgurovic et al., 2013). However, as recent reviews of literature show, studies that focus on K-12 learning environments with English learners

are severely underrepresented in computer-assisted language learning (CALL) research, especially those that document language learning outcomes (Grgurovic et al., 2013; Macaro et al., 2012; Ware & Hellmich, 2014). Below, we review the most relevant studies, focusing particularly on those that describe technology use in K-12 English learner classrooms as it relates to student learning.

Parks et al. (2003) documented the development of collaborative processes for writing among English learners in a secondary school in Quebec. Based on analysis of classroom observations, interviews, and student work, Parks et al. describe the affordances created by integrated technologies including a more dialogic classroom space and multiliteracies in writing. Similarly, Angay-Crowder et al. (2013) showed that adolescent English learners demonstrated more agency and expressed their ideas more creatively when they used digital technologies than when they did not use technology. Drawing on a multiliteracies framework, the authors documented the emergence of a more critical and more engaged teaching and learning practice through the use of digital storytelling that exploited technologies to build on students' own resources. Students constructed narratives that wove together text, image, and sound. These findings closely parallel Castañeda's (2013) description of digital storytelling in a high school Spanish classroom and Danzak's (2011) study of multimodal storytelling with English learners in an urban middle school.

In one of the few quantitative studies about adolescent English learners, Freeman (2012) used a nested design to show that digital technologies in the classroom increased students' math abilities and math self-efficacy. The study highlights the student-centered and purposeful use of technology to build disciplinary skills and support academic achievement. Lam et al. (2018) found that the writing of secondary English learners in Hong Kong improved with the use of online and classroom-based discussions compared with teacher-led instruction. Research in technology-enhanced classrooms with adolescent English learners has also shown that the use of technologies—including videos and iPad applications—supported better comprehension, retention, and use of key vocabulary (J. Li., 2009; Lwo & Lin, 2012; Smythe & Neufeld, 2010; Tan et al., 2010). Adding nuance to the broad finding that technology supports vocabulary acquisition, J. Li (2009) showed that adolescent English learners used more strategies to understand vocabulary in context within a technology-enhanced reading environment. Additionally, language proficiency level differentiated learning gains for students in such a way that less proficient students were more likely to benefit from multimodal resources than were more proficient students (Lwo & Lin, 2012). Similarly, in their survey of technology use by English learner middle school students, J. Li et al. (2014) found that students with higher levels of perceived English proficiency were more likely to use technologies for blogging, homework, research, and reading than students who reported lower levels of English proficiency.

Despite the many promising outcomes documented in the research reviewed above, it is important to remember that the presence of technology in a classroom does not guarantee more or better opportunities for language learning, nor does it guarantee more student-centered, asset-based teaching practices (Hu et al., 2018; Peck et al., 2015; Phillip & Garcia, 2013). Indeed, some research has shown little impact from ambitious school-wide technology initiatives (Cuban et al., 2001; Q. Li, 2007). In other cases, misuse of technologies, such as remedial computer programs and digital worksheets, have resulted in negative outcomes for students already at risk (Peck et al., 2015; Ware, 2008). When digital technologies have been incorporated into K-12 ESL classrooms, research shows that teachers' approach to teaching remained basically the same, although prior experiences with multimodal texts and school support structures greatly affected the degree to which digital technologies were used (Carhill-Poza, 2017; Choi & Yi, 2016; López, 2010; Rance-Roney, 2010). These and other studies suggest that how technology is used in the classroom is more important than whether technology is present (Bulfin & North, 2007; Chenoweth & Murday, 2003; Neumeier, 2005; Stepp-Greany, 2002). For example, Liu and Chao (2018) showed that teachers' pedagogical goals as well as their perceptions of the affordances of technology resulted in different teaching practices in technology-mediated foreign language classrooms.

## Characteristics of Immigrant Youth Who Are Still Learning English

As digital technologies are increasingly part of classrooms with English learners, it is important to

understand how the experiences of immigrant students who are still learning English contribute to language development in technology-enhanced environments. While many English learners come to school in the United States with significant academic experiences and skills—including advanced math and science—an increasing number of immigrant youth have received inconsistent or interrupted formal education due to poverty or conflict in their country of origin, or from the migration experience itself (Olsen, 2010). Students who are not only learning English and academic content but are also catching up on literacy and schooling concepts are often over-age for their grade (Suárez-Orozco et al., 2010). The indicator over-age—meaning that students are at least one year older than their grade-level peers—is used by schools to identify and provide additional support to students who may be falling behind their peers because of a variety of circumstances including repeating courses, taking remedial coursework, and catching up on academic skills.

Many English learners are also affected by issues such as living apart from family members, poverty, and the related need to work (Suárez-Orozco et al., 2008). Student participation in the paid work force has been used to identify conditions of poverty that affect academic achievement among immigrant youth (Fuligni et al., 1999). These real-world pressures coupled with a lack of resources at school can lead to disengagement, even while students are still physically present (Suárez-Orozco et al., 2008). Given these complexities, academic engagement is a strong predictor of academic achievement (Suárez-Orozco et al., 2010) and has been used in qualitative frameworks for understanding language learning (Carhill-Poza, 2016; Valenzuela, 1999).

Relating students' experiences both in and out of school, language use with friends has been shown to powerfully predict language development (Carhill et al., 2008; Jia & Aaronson, 2003). Not only do measures of peer talk highlight the types of peer interactions we expect to find in student-centered classrooms, but research has shown that immigrant students may have limited interactions with school adults including teachers, and parents may have limited experience and linguistic skills to support immigrant youth in school (Carhill-Poza, 2015). Peers constitute an essential context for second-language acquisition during adolescence, providing the kinds of conversations that offer English learners multiple turns to negotiate meaning with their partner(s) (Gass, 2003; Swain, 1993).

## The Current Study

This exploratory study examines how teaching practices in technology-enhanced classrooms relate to the language learning outcomes of diverse adolescent English learners. The study is the first to document the features of technology-enhanced classrooms and student characteristics in accounting for English learners' language development. The study aims to address the following research questions:

1. What features of technology-enhanced classrooms support language development for adolescent English learners?
2. What characteristics of adolescent English learners are related to language development in technology-enhanced classrooms?

### Research Design

This study employed a nonexperimental design and analyzed data using descriptive statistics and hierarchical linear modeling (Raudenbush & Bryk, 2002) to help to identify factors that supported the language development of adolescent English learners in technology-enhanced classrooms at the classroom and individual levels.

### Study Setting and Participants

Patriot High School[2] (PHS) is demographically typical of the secondary schools adolescent English learners encounter in urban environments (see Table 1); it is also the site of an initiative to improve the educational outcomes of its diverse students through the use of technology in student-centered classrooms. More than half of the 1,850 students speak a language other than English at home (60%) and many students are classified as economically disadvantaged (38%; Massachusetts Department of Elementary and Secondary

Education, 2016). During the first year of technology-enhanced instruction in 2013-14, we entered into a partnership with PHS to explore the affordances of their approach to teaching and learning for English learners and we continued our investigation over three years. All students at PHS were issued iPads, and later Chromebooks, free of charge, and teachers received professional development in the pedagogical and technical use of these one-to-one devices. In Massachusetts, a program of sheltered instruction as well as some newcomer and ESL coursework is provided for students classified as English learners. Owing to the limited training about teaching English learners that teachers who are not ESL teachers receive, English learners are often included in school-wide initiatives with little differentiation for their unique needs and strengths at the level of policy or practice.

Table 1. *School Characteristics, 2016*

| | **Patriot HS** | **Greater Boston Schools** | **MA Schools** |
|---|---|---|---|
| Total Enrollment (students) | 1,837 | 54,312 | 953,748 |
| Economically Disadvantaged | 38.4% | 80.6% | 30.2% |
| Ethnicity**:** | | | |
| African American | 4.7% | 33.6% | 8.9% |
| Asian | 5.7% | 8.5% | 6.3% |
| Hispanic | 54.1% | 40.9% | 19.4% |
| White | 32.7% | 13.8% | 61.3% |
| First Language not English | 60.4% | 47.4% | 20.1% |
| English Learner**s** | 14.3% | 29.8% | 9.5% |
| Attendance Rate | 95.3% | 92.1% | 94.9% |
| **Graduation Rate:** | | | |
| All Students (4 year) | 90.3% | 66.7% | 86.1% |
| EL Students (4 year) | 67.3% | 61.4% | 63.9% |
| EL Students (5 year) | 87.5% | 68.5% | 70.9% |
| EL attending 2 or 4 year college | 59.1% | 66% | 81% |
| Classrooms on Internet | 100.0% | 100.0% | 100.0% |

*Note: Data from the Massachusetts Department of Elementary and Secondary Education, 2016.*

Ten classrooms were observed. These included two beginning, two intermediate, and two advanced ESL classes; a sheltered biology class; a sheltered history class with mixed levels of English learners; a newcomer science class; and a newcomer ESL class. Class size ranged from 12 to 24 students. Among 31 classrooms where English learners were concentrated, 10 classrooms were selected using a stratified purposeful sampling procedure to include two of each type of classroom (newcomer, beginning ESL, intermediate ESL, advanced ESL, and sheltered content). The classrooms in our study used digital technologies to a high degree[3] including smartboards, iPhones, iPads, Chromebooks, computers, and many applications within those operating systems. Classes were thematically organized with a sustained focus on academic language development and academic subject-area content. All of the teachers in our study were highly qualified—holding appropriate professional licenses in ESL and often another subject area as well—and all teachers had been teaching for at least 3 years (3 to 26 years, M = 7.2) and had received training in technology-enhanced instruction. (For a fuller description of teacher expertise, please refer to Carhill-Poza, 2018).

Students in each of the classrooms we observed were asked to take a survey about their experience in that class and about their use of language and technology. A total of 110 unique students nested in 10 classrooms participated in the survey. Survey participants were representative of the diversity within the English learner

population of the school: The sample consisted of a majority of Spanish-speakers (85.5%), as well as those students whose first language was Arabic (4.5%), Portuguese (9.1%), and French (0.9%); students ranged from beginning to advanced levels of English proficiency, as shown in Table 2 and Table 3. Nearly half of participants were female (52.7%) and the average age was approximately 17 (SD = 1.37). The majority of participants had immigrated to the US within the previous three years (56%).

Table 2. *Summary statistics of student characteristics (n=110)*

| Variables | M / % | SD / No. | Min | Max | Median |
|---|---|---|---|---|---|
| Age in Years | 16.97 | 1.37 | 14 | 20 | 17 |
| Years in the US | 1.81 | 1.46 | 0 | 8 | 1.5 |
| Family Poverty | 58.18% | 64.0 | 0 | 1 | 1 |
| Gender (Male) | 47.3% | 52.0 | 0 | 1 | 0 |
| Over-age for Grade | 52.7% | 64.0 | 0 | 1 | 1 |
| Student Work | 42.7% | 47.0 | 0 | 1 | 0 |
| SIFE | 5.5% | 6.0 | 0 | 1 | 0 |
| English Proficiency Level | 358.64 | 133.67 | 150 | 600 | 350.00 |

Table 3. *Comparison of group differences for Growth in English Proficiency (n=110).*

| | Mean | SD | Average Diff | t/F | (P-v) |
|---|---|---|---|---|---|
| Over-age for Grade | | | 58.68 | 2.60 | 0.01 |
| Over-age for grade | 35.01 | 103.40 | | | |
| At or below age for grade | 93.70 | 132.72 | | | |
| Gender | | | 21.39 | 0.92 | 0.36 |
| Male | 51.48 | 100.72 | | | |
| Female | 72.87 | 137.15 | | | |
| Family Poverty | | | 17.77 | 0.76 | 0.45 |
| Free lunch | 55.32 | 110.91 | | | |
| Paid lunch | 73.10 | 134.89 | | | |
| Language use with Friends | | | | 2.95 | 0.06 |
| - 25% (n = 54) | 36.16 | 119.17 | | | |
| 50% (n = 33) | 78.03 | 106.73 | | | |
| 75% + (n = 23) | 103.28 | 135.08 | | | |
| Student Work | | | 57.15 | 2.50 | 0.01 |
| Work after school | 95.49 | 116.72 | | | |
| No Work | 38.34 | 119.65 | | | |
| SIFE | | | 6.89 | 0.14 | 0.89 |
| Yes | 69.27 | 125.23 | | | |
| No | 62.38 | 121.62 | | | |

*Note: Independent samples t-Test is used for the comparison of two groups and One-Way ANOVA (F–test) is used for the comparison of more than two groups.*

## Research Methods

### *Data collection*

In academic year 2015-16, we recruited teachers from 10 classrooms (including in the newcomer academy, beginning, intermediate, and advanced ESL classrooms, and sheltered content classrooms) to participate in the study. A series of 2 to 3 classroom observations (4 to 6 hours) during what teachers considered typical instruction were video-recorded for quantitative coding of classroom teaching and learning activities. The Classroom Learning Assessment Scoring System—Secondary (CLASS-S; Pianta et al., 2011)[4], a widely used quantitative classroom observation tool, was used to code 20 hours of classroom video (the first 2 hours from each class) broken down into four 20-minute cycles. Two trained observers independently watched the videos while taking detailed notes about student and teacher behaviors; then, they rated each segment on a scale of 1 to 7 for each dimension. Certification for observers consisted of a two-day workshop to learn the CLASS-S system and passing a reliability test within two weeks of beginning coding for this project. All observations were independently double-coded, and differences greater than 1 point were resolved through discussion. Scores for each class were averaged across four cycles to produce the final score.

Students were recruited from the 10 classrooms we observed for survey participation. The semi-structured survey, administered online via students' iPads, asked students to describe their academic engagement, technology use, language use, and demographic information. A bilingual and bicultural researcher was present during survey completion to answer questions and help navigate technical bugs. She also met individually with students who needed additional literacy support to complete the survey. Document collection was used to gather student outcome data including English proficiency scores and attendance records and to verify demographic data with report cards.

### *Measures*

*Growth in English Proficiency* was measured by comparing student scores on the standardized English proficiency test, the WIDA Assessing Comprehension and Communication in English State-to-State for English Language Learners (ACCESS; Board of Regents of the University of Wisconsin System [BRUWS], 2016), administered by the school in April 2015 and April 2016. The WIDA ACCESS analyzes English proficiency across four language domains (listening, reading, writing, and speaking) using three performance criteria measuring language-specific knowledge: (a) complexity, the amount and quality of the speech; (b) vocabulary usage, the specificity of words or phrases; and (c) language control, control over mechanics, syntax, and semantics. Scaled scores range from 100 to 600 and proficiency levels range from 1 (Entering) to 6 (Reaching) with each proficiency level spanning approximately 100 scale score points. Our variable calculated the difference between scores in 2015 and 2016 and used a 500-point scale in keeping with WIDA proficiency levels.

The WIDA ACCESS is the most widely used test of academic English proficiency in U.S. schools today and has been normed for all groups and ages present in our sample such that scores scale across grade levels (BRUWS, 2016). Reliability for the internal consistency of the four ACCESS subtests is reported at alpha levels of .82 to .97 (Kenyon, 2006). Missing data for this variable (less than 9%) was imputed using a matched propensity score based on demographic variables including Time in the US, Age, and Parents' English Proficiency.

*Academic Engagement* was measured using a five-item self-report scale that focused on students' behaviors adapted from Suárez-Orozco et al. (2008) (Appendix A). Participants were also asked how many hours they spent on homework after school, how many times they had been late to class, and how many times they had skipped class in the last week. All nine items were measured in 1–3 point scales and were summed to create a composite score with a range of 12 to 27 (Cronbach's $\alpha$ =.60).

*Language Use with Friends* was measured using a self-report scale that asked students to estimate the percentage of time that they spoke each language with friends (75% or more, about 50% of the time, or

25% of the time or less), generating a 1 to 3 point scale (Carhill-Poza, 2008) (Appendix A).

*Demographic data* including Age, Age of Arrival, Time in the US, Grade-level, Over-age for Grade, and Gender were collected from student surveys and verified on student transcripts. Students with interrupted formal education (SIFE) was dummy-coded such that students who had missed more than three months of school were assigned a value of 1 and students who had missed three months or less were coded as 0. Student Work was dummy-coded such that a working student was assigned a value of 1 and a non-working student, 0.

*Quantitative Classroom Observations*. CLASS-S (Pianta et al., 2011) was developed for secondary schools as a measure of classroom instruction and interaction. The CLASS-S was chosen because it captures the degree to which classrooms use strengths-based, student-centered instructional approaches that result in student engagement and learning across a wide range of teaching strategies and styles. We considered this focus essential to understanding how technologies were employed in classrooms with English learners given the many ways teachers and students engaged with and through technology.

The CLASS-S consists of a set of global 7-point rating scales with behaviorally anchored scale points providing detailed descriptions of each dimension[5], including the five dimensions that make up the Instructional Support domain. Instructional Support—the most closely aligned with our research questions as it focuses on teaching and learning activities that directly draw on technology—is composited from subscales for Content Understanding (reflecting teacher presentation of content within a broader intellectual framework); Analysis and Inquiry (focusing on the degree that the teacher engages students in higher-level thinking skills); Quality of Feedback (assessing the provision of feedback designed to challenge students and expand their understanding of concepts); Instructional Dialogue (capturing the distribution and use of questions and dialogue to build student understanding of content and language); and Instructional Learning Formats (quantifying the variety of modes of presentation and activities). Of the five dimensions, only Instructional Learning Formats specifically measures technology used in instruction; each of the other dimensions documents instructional activities and interactions in which technology may play a role.

*Quantitative data analysis*. Quantitative data analyses were used to describe how instructional features of technology-enhanced classrooms relate to language learning outcomes as well as how student characteristics mediated the relationship between classroom features and outcomes for diverse English learner students. Descriptive and correlational analyses were conducted initially to describe variables. Two-level hierarchical linear models (HLM) were specified using maximum-likelihood estimation to ascertain the effects of student- and classroom-level variables on English learners' Growth in Language Proficiency; intra-cluster correlations were 29.1%. These analyses allowed researchers to examine the roles of classroom-level features of technology-enhanced classrooms (Instructional Support) and student characteristics (Academic Engagement, Language Use with Friends) relative to other predictors in the models in accounting for student outcomes (Growth in English Proficiency). In effect, individuals were nested within classrooms (Raudenbush & Bryk, 2002).

Due to the relatively small sample size, we used Bayesian statistics (Raudenbush & Bryk, 2002; Schoot et al., 2014; Zhang et al., 2007). With a large sample size, all parameters are normally distributed and the results between Maximum Likelihood estimation and Bayesian estimation are not likely to produce numerically different outcomes. However, with the relatively small sample size of 110 and 10 level 2 units, there could be slight difference in parameter estimation. Therefore, in addition to the two-level Hierarchical Linear Model using SAS 9.4, we also employed Bayesian Hierarchical Model using WinBUGS 1.4.

## Findings

### Factors Affecting Growth in English Proficiency

English learners who participated in this study varied considerably in their Growth in English Proficiency over the school year. The mean score for Growth in English Proficiency for the entire sample was 62.75

points over the year with a standard deviation (SD) of 121.24. Student characteristics and classroom features were related to the language development outcome in technology-enhanced classrooms.

### Classroom Instruction

Instructional Support measured the degree to which classrooms were student-centered by looking for concrete, behavioral evidence of the types of interactions taking place in a classroom during a few typical lessons. On the seven-point amalgam scale, classrooms varied immensely, from 2.50 to 5.50 (M = 3.65 SD = 0.86), as shown in Table 4. Classrooms scoring as low as a 2.5 were far more teacher-centered and rote in their approaches to engaging English learner students in learning language and content. Classrooms that were as high as 5.5 on the scale scaffolded learning by using more interaction between students, teachers, and peers to achieve deeper and more inclusive learning with technology.

Table 4. *Descriptive statistics and correlation coefficients among Instructional Support (n = 10, Cronbach's Alpha = .805).*

| Variables | Mean | St. Dev. | 1 | 2 | 3 | 4 | IS |
|---|---|---|---|---|---|---|---|
| 1. Instructional Learning Formats | 4.375 | 0.702 | 1 | | | | |
| 2. Content Understanding | 3.484 | 0.889 | 0.422 | 1 | | | |
| 3. Analysis and Inquiry | 1.934 | 0.538 | 0.611 | 0.314 | 1 | | |
| 4. Quality of Feedback | 3.867 | 0.998 | 0.855** | 0.620 | 0.448 | 1 | |
| 5. Instructional Dialogue | 3.950 | 0.880 | 0.528 | 0.092 | 0.745* | 0.270 | |
| *Instructional Support* | 3.651 | 0.860 | 0.902** | 0.339 | 0.723* | 0.801** | 1 |
| *Growth in Eng Prof* | 62.754 | 121.240 | 0.236 | -0.012 | 0.565 | 0.260 | 0.304** |
| *Growth in Eng Prof [a] n = 110* | | | 0.127 | 0.031 | 0.302** | 0.204* | 0.305** |

*Note: Growth in English Proficiency is aggregated as the average values in classroom level.*
*a: Correlations are evaluated at student level with n = 110; * p < .05. ** p < .01. *** p < .001.*

Instructional Support in the classroom was positively related to Growth in English Proficiency over the year ($\rho = .233$, $p < .05$). Three indicators of this dimension of the CLASS-S observation protocol were also significant: the level of Analysis and Inquiry, indexing the facilitation of higher-order thinking, opportunities for novel application of skills and concepts, and metacognition ($\rho = .302$, $p < .01$); Quality of Feedback, referencing teacher use of feedback loops, scaffolding, building on student responses, and affirmation ($\rho = .204$, $p < .05$); and Instructional Dialogue, including the cumulative content-driven exchanges, distributed talk, and use of facilitation strategies in the classroom ($\rho = .259$, $p < .01$). Findings from our quantitative classroom observation tool captured the importance of depth of student engagement with academic concepts through teacher and peer support for language development.

### Student Factors

The educational experiences of immigrant youth classified at school as English learners in this sample included two indicators of diversity: Over-age for their Grade and Student Work. Educational experiences varied significantly depending on the age at which students had come to the US and the resources available to them in their home country. Only a small percentage (6.4%) had missed significant amounts of schooling prior to coming to PHS, but fully 53% of English learners in this sample were over-age for their grade, a condition associated with lower rates of growth in English proficiency. Over-age students had an average of 35.01 points (SD = 103.40) of Growth in English Proficiency, significantly lower than other students whose average of Growth in English Proficiency was 93.70 points (SD = 132.73) based on independent samples t-Test, $t_{(108)} = 2.601$, $p = .011$.

Work was an important dimension of the life of many English learners in this sample. Paid employment

was intertwined with education in the daily lives of more than a third of students who participated in our study (43%). For these students, the average value of Growth in English Proficiency was 95.49 points (SD = 116.72), significantly higher compared to students who did not work (average 38.34 points (SD = 119.65), $t_{(108)} = 2.504$, $p = .014$.

Language Use with Friends was an important indicator of the opportunities English learners had to learn their new language and was positively related to Growth in English Proficiency ($\rho = .226$, $p < .05$). Overall, about half of students used mostly their first language when they were spending time with friends (49.1%) while nearly a third used both English and their home language about equally (30.5%), and 20.4 percent used English most of the time. In contrast, at school in class, the majority of students spoke mostly English (56.4%) and nearly all (83%) reported using mostly English on their iPads and Chromebooks.

Academic engagement is a well-known predictor of academic achievement; in this study, it is also positively related to Growth in English Proficiency. Students in our sample who reported high levels of Academic Engagement tended to have higher levels of Growth in English Proficiency than those who were less academically engaged ($\rho = .205$, $p < .05$). Attendance, a related student-level indicator recorded by the school, was strongly correlated with our measure of academic engagement ($\rho = .730$, $p < .001$). Students who scored low on the academic engagement scale found that they were often bored in class, did just enough homework to get by, and arrived late or cut class frequently; those who were highly engaged spent more time on homework, reported always finishing the work they started, and paid close attention in class.

## Modeling the Impact of Student Characteristics and Classroom Teaching with Technology on Growth in English Proficiency

Exploratory analysis demonstrated that a large number of individual variables were related to Growth in English Proficiency. To avoid multicollinearity and confounding factors, not all variables that were significantly related to outcome measures could be included in the final models; researchers removed closely-related individual-level variables until the condition number was less than 30 and only variables that predicted Growth in Language Proficiency at $p < .05$ at level one were retained. Table 5 displays bivariate correlations among level 1 and level 2 variables used in the final model.

Table 5. *Descriptive statistics and correlations for the variables in two-level HLM for Growth English Proficiency*

| Variables | Mean | St. Dev. | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|---|
| 1. Growth in English Proficiency | 62.75 | 121.24 | 1 | | | | |
| 2. Over-age | 0.527 | 0.502 | -0.243* | 1 | | | |
| 3. Student Work | 0.427 | 0.497 | 0.234* | 0.118 | 1 | | |
| 4. Language Use with Friends | 1.718 | 0.791 | 0.226* | 0.193* | -0.018 | 1 | |
| 5. Academic Engagement | 20.779 | 3.037 | 0.205* | -0.284** | -0.143 | -0.077 | 1 |
| 6. Instructional Support | 3.651 | 0.860 | 0.305** | 0.056 | 0.150 | 0.225** | -0.103 |

* $p < .05$. ** $p < .01$. *** $p < .001$.

Since individual students are nested within classrooms and the estimated inter-class correlation coefficient of .291 indicates that approximately 29.1% of the variance in Growth in English Proficiency was due to classrooms, a two-level hierarchical linear regression model (HLM) was used. Let $i = 1, 2, \ldots, 10$, the number of classrooms, and $j = 1, 2, \ldots, n_i$, the number of students in each classroom, and $Y_{ij}$ be the response variable of *Growth in English Proficiency* for student $j$ in classroom $i$, then the Level 1 equation is:

$$Y_{ij} = \beta_{0i} + \beta_1 X_{1ij} + \beta_2 X_{2ij} + \beta_3 X_{3ij} + \beta_4 X_{4ij} + \varepsilon_{ij} \quad (1)$$

where X1, X2, X3, and X4 are the student-level independent variables Over-age, Student Work, Language

Use with Friends, and Academic Engagement, and $\beta_{0i}$ is the random intercept that may be dependent on the classroom variable as the following:

$$\beta_{0i} = \gamma_0 + \beta_5 X_{5i} + \eta_i \qquad (2)$$

where X5 is the classroom variable of Instructional Support. Combining equations (1) and (2) results in the following joint equation:

$$Y_{ij} = \gamma_0 + \beta_1 X_{1ij} + \beta_2 X_{2ij} + \beta_3 X_{3ij} + \beta_4 X_{4ij} + \beta_5 X_{5i} + \eta_i + \varepsilon_{ij} \qquad (3)$$

SAS PROC MIXED (SAS 9.4) was used to estimate equation (3) using a maximum-likelihood approach. The estimated beta coefficients are listed in Table 6. Compared to the null model, predictors in the final model in the equation (3) explained 9.3% of Level-1 variance, and 62.7% of Level-2 variance. Continuous independent variables are all centered at the average values. This means that on average, students gained 62.75 points over the year (SD = 121.24). The relationship between Growth in English Proficiency and Instructional Support was significant and positive based on a 95% Bayesian credibility interval.

Table 6. *Model estimates for two-level analysis of Growth in English Proficiency*

| | **Null Model** | | **2-Level HLM** | | **Bayesian HLM** | | |
|---|---|---|---|---|---|---|---|
| | *Beta* | *SE* | *Beta* | *SE* | *Mean* | *2.5% CI* | *97.5% CI* |
| Fixed effects | | | | | | | |
| Intercept | 66.25* | 23.65 | 75.31** | 21.05 | 73.14 | 35.22 | 114.20 |
| Over-age | | | -59.97** | 20.69 | -63.98 | -106.60 | -22.40 |
| Student Work | | | 49.97* | 20.82 | 58.07 | 13.71 | 101.00 |
| Language Use w Friends | | | 26.68* | 13.91 | 31.87 | 2.46 | 61.12 |
| Academic Engagement | | | 6.96* | 3.39 | 7.16 | .35 | 13.99 |
| Instructional Support | | | 37.39 | 20.95 | 36.07 | .21 | 74.54 |
| Random effects | | | | | | | |
| Student level (τ00) | 10884.00** | 1539.91 | 9869.66** | 1433.37 | 10570.0 | 7933.00 | 14240.00 |
| Classroom level (τ1) | 4462.65* | 2653.91 | 1664.28 | 1475.23 | 1030.00 | .00 | 5993.00 |

*Note: Both null model and 2-Level HLM are estimated using SAS PROC MIXED and Bayesian HLM are estimated using WinBUGS 1.4.3; * p < .05 ** p < .01. *** p < .001.*

Several student-level variables were powerful predictors of Growth in English Proficiency in this model. Controlling for all other variables in the model, a 1-point increase in Language Use with Friends (on a 3-point scale) corresponds to a 26.68-point increase in Growth in English Proficiency. Academic Engagement has a range from 12 to 27; for each unit increase in Academic Engagement, Growth in English Proficiency is expected to increase 6.96 points. Similarly, holding all factors constant, a student who worked after school tended to be 49.97 points higher in Growth in English Proficiency, and over-age students tend to be 59.97 points lower. The results indicate that the average Growth in English Proficiency for a reference student—a student who is average in Language Use with Friends, and Academic Engagement, is not over-age for their grade, does not work, and who received average amount of Instructional Support in their classroom—was about 75.31 points (intercept of the estimated model).

The practical significance of our results was assessed by estimating the change in proportion of variance explained at each level between the null model to the final model (Raudenbush & Bryk, 2002). At Level 1, the final model explained just 9.3% of variance in Growth in English Proficiency, suggesting the need to identify additional student-level variables and highlighting the power of classroom effects. At Level 2, more

than half of between-class variation in average Growth in English Proficiency was explained. However, chi-square statistics associated with the coefficient's variance indicate that a substantial amount of variance remained unexplained and may be attributed to classroom variables not measured here, including those from other classrooms that students participated in throughout their day.

### A Closer Look: Teaching and Learning English with Technology

Quantitative observations of Instructional Support captured the degree to which classrooms used student-centered instructional approaches that resulted in student engagement and learning. Observations captured students using their iPads and cell phones to make videos and presentations, play cloud-based interactive games, find multimodal resources to demonstrate academic concepts, collaboratively edit documents on Google Drive, access texts and assignments on Schoology, and take notes from a Smartboard on their Chromebooks during routine teaching and learning activities. In the following section, we share a qualitative analysis of Quality of Feedback—one of the dimensions of Instructional Support—to illustrate the quantitative metric.

Teachers often used technology to facilitate interaction in the classroom. Most teachers regularly used their Smartboards in combination with students' networked Chromebooks or iPads to provide multimodal explanations of new concepts and vocabulary, scaffold student participation, and provide feedback during discussion. For example, in a sheltered history class, we saw the teacher lead a Do Now activity in which students posted responses to a document-based question about the most important function of Louis and Clark's expedition using the Facebook-like learning management system (LMS) Schoology. Because the responses appeared in real time on the Smartboard, the teacher and students were able to respond to each other and build the discussion collectively in a way that would have been cumbersome using pencil and paper. When a student posted the following answer, "Draw maps so they could make routes," both the teacher and several students provided feedback including "liking" the response and asking the student to expand on his idea. Another student built on this statement orally and finally in writing as follows: "I think the most important job for them was to draw a map because they had no idea where they were going and at the same time they had other jobs to take care of. And there were only three people and a lot of land to cover." This example showed several feedback loops, ample scaffolding for language and content development, an abundance of visual and verbal affirmation, and (often intense) student and teacher participation that built on student responses, all aided by the use of technology. This classroom received an above-average rating of 6.2 on the Quality of Feedback scale.

We also documented instances where, despite the potential of the technologies in use in the classroom to deepen interaction, teachers and students moved quickly through materials without taking the time to develop their ideas. Less effective teaching with technology often centered around completing worksheets or reading texts on iPads and laptops without scaffolding rich communication between students and with the teacher. A sheltered Biology classroom that rated below average on the Quality of Feedback scale (2.1 points) began with the teacher setting an internet timer for 40 minutes on her Smartboard. She explained that students would be preparing for an exam at the end of the week by reviewing specific points listed on a worksheet that was available on the LMS. The worksheet was not interactive and students formed groups themselves to begin the review. The teacher circulated through the room as students referred to their notes and textbooks to answer the review questions. Although technology was in use in this example, student and teacher interactions did not use it to scaffold multi-turn interactions that deepened their understanding of content or language, nor did the structure of the lesson overall provide multiple opportunities for students to give and receive feedback.

## Discussion

Our study asked how features of technology-enhanced classrooms affect adolescent English learners, taking into account the immense variability among English learners and across classrooms. To develop this inquiry we used quantitative classroom observations and surveys to examine a diverse group of English learners in

technology-enhanced classrooms in an urban secondary school. Our ecological conceptualization of technology-enhanced classrooms emphasized the integral role of technology in routine instructional activities, rather than focusing on a technology as a tool or controlled intervention, a critique of CALL research (Macaro et al., 2012; Ortega, 2017; Ware & Hellmich, 2014).

At the classroom level, findings show that the use of digital technologies alone did not ensure high levels of Instructional Support for English learners. The final model showed that nearly a third of variation in English language development was due to classrooms. Classrooms varied enormously in the types of interactions taking place despite all having a high level of technology use. Instructional Support was positively related to Growth in English Proficiency, although once the influence of other crucial factors that are often ignored (e.g., student work, language use with friends) was removed, the shared variance for Instructional Support did not reach significance in the final model. Quantitative analysis of classroom interactions showed that the features of technology-enhanced classrooms that best supported language development were aspects of instruction that align with notions of student-centered teaching, including multi-turn interactions between peers and with the teacher, and collaborative experiential learning (Lantolf & Thorne, 2006). Findings closely parallel existing research with adolescent English learners by showing that the power of technology in the classroom derives from its responsiveness to students' needs and strengths and can be used to build deep conceptual understanding as well as language skills (Angay-Crowder et al., 2013; Freeman, 2012).

Our findings also document that not all English learners derived the same benefits for language development from technology in their classroom and underscore the importance of CALL research with K-12 English learners. Individual factors include working after school, being over-age for their grade, academic engagement, and language use with friends. Controlling for all other variables, students who were over-age for their grade tended to be a half of a WIDA level lower than students who were of age with their peers. Those who used English more frequently with their friends on average gained about a third of a WIDA level more than students who spoke with their friends mainly in their native language. Our findings align with existing literature in that individual variables enable some students to take greater advantage of technology-enhanced learning (J. Li et al., 2014; Lwo & Lin, 2012). In our sample, students with particularly favorable characteristics derived greater benefit from high levels of Instructional Support in technology-enhanced classrooms while students with less favorable individual characteristics were particularly penalized by low levels of Instructional Support, including less optimal uses of technology. These findings suggest that teachers need to carefully assess students' skills with technology as well as how their experiences outside of school contribute to their engagement in technology-enhanced classrooms. Variables such as Student Work and Language Use with Friends highlight stark issues of equity that English learners encounter within and outside of the classroom that merit far greater scrutiny than they have received to date in CALL research (Carhill-Poza & Williams, 2020; Ortega, 2017).

## Conclusion

Our study has made an important contribution to the CALL literature by beginning to map the variety of student and classroom factors that affect language development in technology-enhanced classrooms for adolescent English learners. Interpretation of results is limited by a small sample size and our focus on a single school community. We also note that use of a global measure of language proficiency is at odds with much of the CALL literature while it is in keeping with an integrated view of technologies in classrooms.

Inquiry about how technologies can be thoughtfully implemented in K-12 classrooms with English learners is necessary to offer concrete recommendations to teachers and policy makers, recommendations that are urgently needed in a rapidly evolving technological landscape. We strongly recommend that research on this topic utilize ecological models and mixed methods so that appropriate foci on patterns of student, classroom, and school factors, as well as the processes and experiences that differentiate such patterns, are apparent. Technology is no panacea, and future research needs to account for the inequities outside of the classroom as well as those that technologies can create when used inequitably in classrooms (Ortega, 2017).

## Notes

1. English learner is a school classification of immigrant children and youth who are learning English as a second language in a country where English is the majority language. We will use this term throughout to identify such students in U.S. schooling contexts.
2. Pseudonyms are used for the school and all participants to protect their identities.
3. A rating of 6 or 7 on the Instructional Learning Formats indicator of the CLASS-S, as described in more detail in the Measures section following.
4. See Measures section for full description.
5. For a full description of the 12 dimensions in the CLASS-S, please refer to Pianta et al. (2011). The CLASS-S does not produce a composite score based on all 12 dimensions.

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## Appendix A. Survey Questions

### Academic Engagement:

For the following statements, pick the answer that is most true of you in school:

1. Some students always finish the work they start. [really true for me, sort of true for me, not true for me]
2. Some students turn in most of their homework on time. [really true for me, sort of true for me, not true for me]
3. Some students pay close attention in class. [really true for me, sort of true for me, not true for me]
4. Some students just try to get by in school. [really true for me, sort of true for me, not true for me]
5. Some students get bored easily with school work. [really true for me, sort of true for me, not true for me]
6. How many hours do you generally spend on homework after school? [0, 1-2, 3 or more]
7. How many times have you been late to class in the last week? [0, 1-2, 3 or more]
8. How many times have you missed class in the last week? [0, 1-2, 3 or more]
9. How many days in the last week have you felt prepared for class? [0, 1-2, 3 or more]

### Language Use with Friends:

1. How much of the time do you speak English when you are with friends? [75% or more, about 50% of the time, 25% of the time or less]

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