Does it Work for Everyone? The Effect of ELCII on Kindergarteners' Inference Skill Development

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Abstract: We sought to identify the extent to which an innovative educational technology called ELCII (Early Language Comprehension Individualized Instruction) improved inference making for various populations of kindergarten students. Analyses examined student performance based on individual-level demographic characteristics (i.e., gender, race/ethnicity, home language, English Language Learner status, and Free or Reduced Lunch eligibility) to shed light on whether ELCII addresses the needs of learners from marginalized communities. Results showed that all students, on average, improved in their inference making performance over time and that growth in inference making performance did not differ across subgroups. However, the results also highlighted persistent gaps that were present at the onset of the program, and unfortunately continued to persist. To bridge such gaps, the standard of 'working for all' is a necessary first step, but not sufficient. Future research should identify ways to accelerate growth of core skill development among students who need additional support.

Introduction

Our history in the field of education is dominated by the persistent efforts of researchers, policymakers, and educators to improve reading performance of all children across grade levels (e.g., Patton-Terry, 2021). Despite these efforts, yearly reports from the National Assessment of Educational Progress (NAEP) consistently show one in three U.S. students, on average, performing below basic proficiency levels in reading, and persistent achievement gaps across demographic characteristics, such as race/ethnicity, gender, home language, English Language Learner (ELL) status, and Free or Reduced Lunch (FRL) eligibility (NAEP, 2019).

These persistent achievement gaps are due to equally persistent and well-documented opportunity gaps. Poverty, one of the main predictors of reading comprehension (Ransdell, 2011), contributes significantly to racial and ethnic differences in achievement. Census data indicate that Black and Hispanic students, for example, are significantly over-represented in the population in poverty relative to their representation in the overall population (Shrider et al., 2021). Recent data indicate that only 53% of students who qualify for FRL achieved at or above basic reading levels compared with 83% of students who were not eligible (NAEP, 2019). Related opportunity gaps exist for ELLs who are more likely to be enrolled in under-resourced, low-performing schools and are at a greater risk for reading difficulties than non-ELLs (Roberts et al., 2021).

Early instruction in language comprehension skills such as inference making has the potential to prevent long-term negative reading outcomes across diverse groups of students (Silverman et al., 2020). Based on developmental research showing that young children can generate inferences well before the beginning formal reading instruction (Kendeou, 2015), an innovative educational technology called ELCII (Early Language Comprehension Individualized Instruction) has been designed to provide inference making instruction as early as kindergarten. ELCII is implemented via a web-based, interactive application called Inference Galaxy and includes twenty 20-minute learning modules that engage students to: (a) learn academic vocabulary words that are key to ideas in a video they are about to watch; (b) view age-appropriate videos (fiction and nonfiction); (c) respond to inferential questions during viewing of the video at points where inferences are needed for comprehension; and (d) receive scaffolding and specific feedback after each response. For example, after watching a video about how polar bears walk on ice, students will answer a multiple-choice question like, "Why don't polar bears fall into the water while walking?" If answered incorrectly, students receive scaffolding and feedback that guides them to the correct response.

ELCII has a strong theoretical and empirical basis (Kendeou et al., 2019), building on cognitive and developmental work highlighting that (a) early language comprehension skills that are developed in non-reading contexts (e.g., video comprehension) contribute significantly to later reading achievement (Kendeou et al., 2009), (b) language comprehension skills—and specifically inference skills—transfer across different media (Magliano et al., 2013), (c) children's inference skills can be improved using questioning that includes scaffolding and specific feedback (McMaster et al., 2012), and (d) technology provides cost-effective, standardized, individualized delivery of instructional tools in classroom settings (McCarthy et al., 2020). The efficacy of ELCII in improving inference making in kindergarten has been evaluated in quasi-experimental research showing good promise for improving inference making performance and the positive effects of scaffolding (e.g., Butterfuss et al., 2021).

The primary aim in this paper is to identify whether ELCII works for everyone, and specifically whether it addresses the needs of learners from marginalized communities. Thus, in these analyses we examine the efficacy of ELCII based on students' individual-level demographic characteristics (i.e., gender, race/ethnicity, home language, ELL status, and FRL eligibility). Knowledge of how different subgroups of students respond to ELCII is an essential first step in bridging any gaps that may exist. Only after understanding the program's effectiveness

at this level of granularity can steps be taken to develop the program through an equitable lens with each student's unique needs in mind.

Methods

The final analytic sample used in this analysis consisted of 191 students (*M*age = 5.66, *SD* = 0.32) recruited from a mid-sized suburban school district in the United States Midwest. There were no exclusion criteria. Demographic characteristics of the sample were analyzed by gender (47.6% female, 52.4% male), race/ethnicity (34.0% white, 64.4% non-white, 1.6% missing), home language (62.8% English, 35.6% non-English, 1.6% missing), FRL eligibility (52.4% eligible, 46.0% not eligible, 1.6% missing), and ELL status (29.3% ELLs, 69.1% non-ELLs, 1.6% missing).

The efficacy of ELCII was examined using a quasi-experimental pretest-posttest design. Fidelity of implementation was confirmed based on students' high engagement during the intervention across the observation measures developed by the research team. ELCII was implemented in classrooms with diverse groups of students with no significant clustering as a function of demographic characteristics.

Mixed-effects models were used to assess students' inference making performance over time and whether trajectories varied across subgroups. The unit of analysis was one time-period, equivalent to two weeks. In each time-period, students completed four ELCII modules (two fiction and two non-fiction). Scores assessing inference making were aggregated for a total score out of 20. Plotting mean trajectories of students' inference making ability over time suggested that a linear function could be used to explain student trajectories. Thus, a linear model was fit to the data using the lme4 package in R. The model included a fixed intercept and a time predictor. Students' demographic variable characteristics were included as additional covariates. Demographic variables serving as covariates were race/ethnicity (White vs non-White), gender (male vs female), home language (English vs non-English), ELL status (ELL vs non-ELL), and FRL eligibility (eligible for FRL vs not eligible for FRL). One demographic variable was included at a time in separate models to facilitate interpretation and to reduce multicollinearity issues for interaction terms.

Results

Figure 1 shows the estimated ELCII mean score trajectories for all students and by race/ethnicity, gender, home language, ELL status, and FRL eligibility. Parameter estimates for each model are shown in Table 1. Highlighted in bold are the main effects of each covariate.

The base model without covariates showed a main effect of time for all students, with all students, on average, showing improved inference making performance across 4 timepoints (Figure 1a).

The model with race/ethnicity as a covariate showed a significant main effect of race/ethnicity but no significant interaction with time (Figure 1b). White students performed significantly better than non-White students across all ELCII modules. However, the learning trajectories for the groups did not differ over time.

The model with gender as a covariate showed no significant main effect of gender and no significant interaction with time (Figure 1c). However, the learning trajectories for the groups did not differ over time.

The model with home language as a covariate showed a significant main effect of home language but no significant interaction with time (Figure 1d). Students who spoke English at home performed significantly better than students who did not speak English at home across all ELCII modules. However, the learning trajectories for the groups did not differ over time.

The model with ELL status as a covariate showed a significant main effect of ELL status but no significant interaction with time (Figure 1e). Students who were not ELLs performed significantly better than students who were ELLs across all ELCII modules. However, the learning trajectories for the groups did not differ over time.

Finally, the model with FRL eligibility as a covariate showed a significant main effect of FRL eligibility but no significant interaction with time (Figure 1f). Students not eligible for FRL performed significantly better than students who were eligible for FRL across all ELCII modules. However, the learning trajectories for the groups did not differ over time.

Table 1

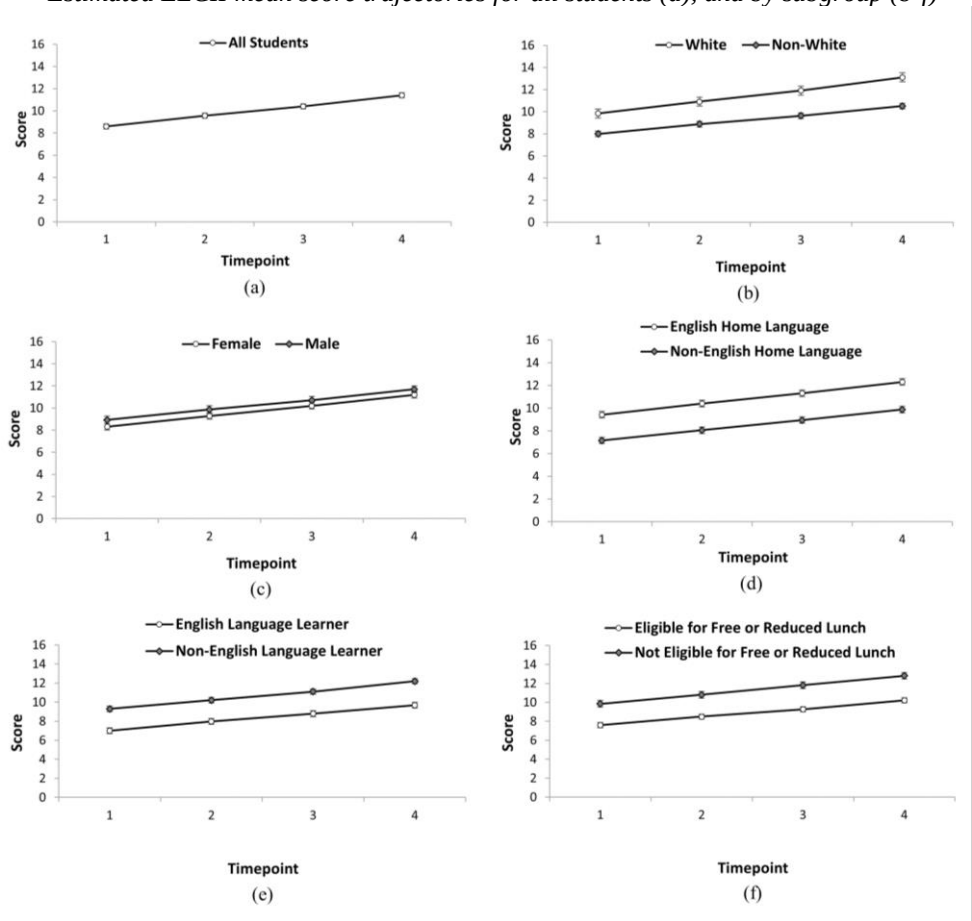
Parameter estimates for ELCII trajectory model by covariate

	All Students	Race/ Ethnicity: White	Gender: Female	Home Language: Non-English	ELL Status: ELL	FRL Eligibility: Eligible
Fixed effects						
Intercept	7.69 (0.31) ***	7.16 (0.38) ***	8.01 (0.45) ***	8.49 (0.38) ***	8.36 (0.36) ***	8.87 (0.45) ***
Time	0.91 (0.07) ***	0.83 (0.09) ***	0.92 (0.10) ***	0.93 (0.09) ***	0.93 (0.09) ***	0.97 (0.10) ***
Covariate	-	**1.62 (0.65) ***	**-0.61 (0.62)**	**-2.22 (0.64) ***	**-2.23 (0.67) ***	**-2.13 (0.61) ***
Covariate*Time	-	0.23 (0.15)	-0.01 (0.14)	-0.05 (0.15)	-0.07 (0.16)	-0.12 (0.14)

Note. Covariate and reference group in each column. Standard errors in brackets. *p<.05, **p<.01, ***p<.001.

Figure 1

Estimated ELCII mean score trajectories for all students (a), and by subgroup (b-f)



Discussion

Computer-based learning environments aimed at improving literacy skills help adapt instruction to an increasingly diverse student population (McCarthy et al., 2020) and have the potential to bridge persistent opportunity gaps that manifest as achievement gaps (Patton-Terry, 2021). We investigated whether the effect of such a program, called ELCII, differed based on students' demographic characteristics to identify how well the program works for all students in kindergarten. Results indicated that all students, on average, showed improved inference making performance over time and that growth in inference making performance did not differ across gender, race/ethnicity, home language, ELL status, or FRL eligibility. However, the results also highlighted persistent gaps that were present at the onset of the program, and unfortunately continued to persist. Specific factors relevant to initial gaps in inference making performance were race/ethnicity, home language, ELL status and FRL eligibility.

Promisingly, ELCII works equally well for all students, which is a necessary first step in the eventual bridging of opportunity gaps. However, for gaps to be bridged, future research must identify ways to accelerate growth of core skill development among students who need additional support. In the context of ELCII, such acceleration may be possible by, for example, increasing dosage. This would allow students who struggle initially to receive additional opportunities for developing inference skills (e.g., four modules per week instead of two). The use of language supports should also be examined (Roberts et al., 2021), which may serve to tailor the program more adequately to students learning English or to students who do not speak English at home. Since pre-existing background knowledge has been found to influence socioeconomic differences in children's learning and comprehension (Kaefer et al., 2014), future research should also determine how to minimize prior knowledge demands in educational interventions. Considering the complex relationship between socioeconomic differences and race/ethnicity (Shrider et al., 2021), future analyses must first improve on the rudimentary race/ethnicity categorization used in the present study before more precise interventions can be developed. Without question, each learner's identity is represented across each of the groups defined in the present study.

With the ideal in mind of an intervention that is responsive to every component of a learner's identity, we hope for this study to serve as an initial step. Importantly, the findings from this study not only identify the benefits of ELCII for developing inference making skills generally, but also identify groups of students who may need additional support. We believe that this identification is critical in the evolution of such interventions from equal to equitable.

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