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iSTART-E: Reading Comprehension Strategy Training for Spanish Speakers

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Abstract. Interactive Strategy Training for Active Reading and Thinking en Español, or iSTART-E, is a new intelligent tutoring system (ITS) that provides reading comprehension strategy training for Spanish speakers. This paper reports on studies evaluating the efficacy of iSTART-E in real-world classrooms in two different Spanish-speaking countries. In Study 1, Chilean high school students (n = 22) who practiced with iSTART-E showed significant gains on a standardized comprehension assessment (LECTUM) from pretest to posttest. In Study 2 (n = 85), Argentinian middle school students who practiced with iSTART-E showed greater gains on the ECOMPLEC.Sec comprehension test compared to those in control classrooms. Together these results suggest that iSTART-E is an effective means of enhancing Spanish speakers' reading comprehension, with demonstrated transfer of training to standardized reading tests.

Keywords: Intelligent tutoring · Reading comprehension · Spanish

1 Introduction

While there has been an increase in educational technologies for reading and writing [1, 2], most have been developed for English-speaking students. Standardized assessments indicate that students from Spanish-speaking countries also struggle with reading comprehension [3]. Though a few Spanish educational technologies have emerged (e.g., [4–6]), the need remains for further development. This paper describes the development of one such technology, iSTART-E, and initial empirical evidence for the promise of iSTART-E as a reading comprehension tutor for Spanish speakers.

1.1 iSTART-E

The Interactive Strategy Training for Active Reading and Thinking en Español, or iSTART-E, is the Spanish translation of iSTART [7]. iSTART is founded on research showing that explaining a text to yourself as you read, or *self-explaining* enhances

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comprehension [8]. iSTART increases reading comprehension for English speakers across middle, high school, and college students [9, 10].

iSTART-E provides self-explanation training and game-based practice for five comprehension strategies: comprehension monitoring, paraphrasing, prediction, bridging, and elaboration. Students first watch video lessons introducing self-explanation and the strategies and then practice using the strategies in *Práctica Dirigida* (Coached Practice), wherein students read a text and are prompted to write self-explanations for target sentences. A pedagogical agent provides a score (0–3) and actionable feedback to revise and improve the self-explanations. After one round of Práctica Dirigida, students are given access to the practice environment which includes game-based practice designed to enhance engagement and motivation [9]. For example, in the generative game *Conquista del Mapa* (Map Conquest), students try to conquer more squares on the board than their CPU opponents. Higher self-explanation scores earn more flags to place on the board. At the end of each game, students' points are converted to *iFichas*, the in-system currency. iFichas can be used to purchase plays of identification games. In identification games (*Partido de Estrategia, Constructor de Puentes, Estallido del Globo,* and *Escape del Calbozo*), students read a text and view example self-explanations. Correctly identifying the strategy earns points, advancing them in the game. Students can also rewatch the videos and to go through additional rounds of Práctica Dirigida.

Transforming iSTART into iSTART-E was a significant undertaking. First, a Spanish-speaking Psychology expert translated the videos, texts, and example self-explanations from English into Spanish [11]. Then, a new Spanish NLP algorithm was developed to evaluate self-explanations using word-based and deep features of language [12]. This genetic-based (evolutionary) algorithm yielded 69.5% exact accuracy and 94.1% adjacent accuracy with human raters.

1.2 The Current Project

This paper describes evaluations of iSTART-E in two classroom studies in two locations (Chile, Argentina). Two different comprehension measures (LECTUM, ECOMPLEC.Sec) were used to evaluate comprehension, reflecting varying national and international objectives.

2 Study 1

This study employed a small-scale, single classroom pretest/posttest design as an initial evaluation of the effects of iSTART-E comprehension strategy training.

Participants were 22 Chilean Spanish-speaking students (14 female, 8 male, age range: 13–14) enrolled in their first high school course. The comprehension test was LECTUM, a 60-min standardized reading comprehension assessment developed to evaluate students in the Chilean school system. The test evaluates shallow and deep comprehension using textual, pragmatic, and critical items and yields a percentile score [13, 14]. There are two equal forms of the assessment: LECTUM A & B.

Students completed LECTUM B (pretest), nine 45-min sessions (6.75 h) of iSTART-E, and one in-class activity that reiterated the comprehension strategies through a video and examples. In the final session, students completed the LECTUM A (posttest).

Students' comprehension scores increased from pretest (M = 38.39, SD = 22.50), to posttest (M = 72.13, SD = 29.65), $t(22) = 3.88$, $p < .01$, Cohen's $d = 1.28$.

3 Study 2

In Study 1, the increase in score from pretest to posttest could be a practice effect or could reflect learning that occurred outside of iSTART-E. Study 2 included a control condition to more systematically investigate the effect of iSTART-E on these reading comprehension gains.

Participants were 85 8th grade Spanish-speaking students enrolled in six classrooms in Argentina, excluding outliers. The comprehension test was ECOMPLEC.Sec [15], a 68-item, 75-min, multiple-choice test with established validity and reliability [16]. It is modeled after international assessments [3, 17]. Students read three texts (narrative, expository, discontinuous) and answered shallow and deep comprehension questions. Students received half of the items at pretest and half at posttest (counterbalanced across students). Training condition was assigned at the classroom level (iSTART-E = 53, control = 32). Students in the iSTART-E condition received 7 h of training across 7 weeks. Students in the control condition engaged in business-as-usual classroom activities.

A 2(test: pretest, posttest) × 2(training: control, iSTART) mixed analysis of variance (ANOVA)[1] indicated comprehension scores increased from pretest to posttest, $F(1, 83) = 14.38$, $p < .001$, $\eta_p^2 = .15$. Training condition was not significant, $F < 1.00$. However, there was a significant interaction, $F(1, 83) = 6.40$, $p < .02$, $\eta_p^2 = .07$, indicating that iSTART-E resulted in significant comprehension test gains, $t(52) = 5.05$, $p < .001$, whereas the control condition did not, $t(31) = .83$, *ns* (Fig. 1).

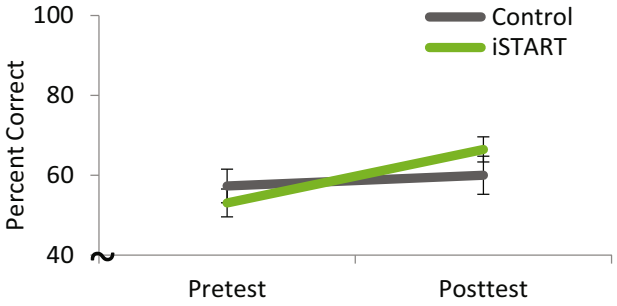

Fig. 1. ECOMPLEC.Sec percent score as a function of test and training condition

[1] Notably, a multi-level analysis yielded the same results; however, because classroom variance is not a factor, the ANOVA is presented here.

4 Discussion

This paper reflects the culmination of developmental work by providing empirical evidence that iSTART-E improves reading comprehension. In both studies, students who received iSTART-E training demonstrated significant gains in reading comprehension. Further research will include classroom and laboratory studies. In addition to increased ecological validity, larger classroom samples will allow us to more precisely represent potential classroom level variance. In turn, laboratory settings afford assignment to conditions at the student level as well as empirical testing of modifications of the system (e.g., new games, more texts, additional feedback).

We anticipate additional testing and modification of the iSTART-E system. We plan to investigate how the system features affect motivation, enjoyment, and comprehension gains. These initial studies are promising indicators of the impacts that iSTART-E may have for Spanish language readers.

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