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Improving Reading Comprehension in Elementary School Students in India by Teaching Them to Self-Assess and Remediate Their Own Learning Needs

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ABSTRACT

Cognitive Structure Analysis (CSA) is an educational framework that helps students identify and address knowledge gaps through self-assessment and targeted remediation. Prior studies have shown its effectiveness in improving test scores across disciplines (math, reading, science, history and foreign language) and grade levels (elementary, middle, high school and college students), typically producing 1.5 to nearly 3 letter grade improvements in performance on average. Recent investigations (Sathiyamoorthy and Leddo, 2025; Chen and Leddo, 2025) have shown that self-assessment and remediation boosts performance in international students with both college students in Scotland and middle school students in China showing large increases in test score performance after learning to self-assess and remediate their own learning needs. The present study extended this international research to India, specifically, to elementary school students learning to read English. 15 students participated in the study. Both groups read the story "Little Red Riding Hood." Eight students were taught to self-assess their own learning needs and were told to self-assess what their knowledge of "Little Red Riding Hood." Both groups were told to reread the story. After the second reading, both groups were given a 12-item reading comprehension post-test. Students who were taught to self-assess scored, on average, 87.5% on the post-test, while those who were not scored on average 65.5%, a statistically significant difference. Results suggest that CSA-based self-assessment and remediation continues to be a powerful method for improving educational performance, even among international students.

INTRODUCTION

Throughout history, assessment has served as a measure of students' learning. Traditionally, "learning" has been defined by the number of correct answers on tests, as per classical test

ISSN: 2455-8834

Volume:10, Issue:10 "October 2025"

theory, which assumes that a student's total correct responses reflect their knowledge level (de Ayala, 2009).

Assessment methods typically fall into two categories: selecting correct answers from choices or constructing answers independently. Multiple-choice tests, widely used for their efficiency in grading, allow for guessing, which can inflate scores (Chaoui, 2011; Elbrink and Waits, 1970; O'Neil and Brown, 1997). Constructive response tests require students to provide their own answers, encouraging logical reasoning and offering a more accurate measure of knowledge (Herman et al., 1944; Frary, 1985). However, both methods rely on the assumption that correct answers signify learning. This assumption is problematic, as incorrect answers may point to underlying knowledge gaps, while correct answers might result from memorization or guessing, not true understanding.

Cognitive Structure Analysis (CSA) is a query-based assessment method designed to uncover the underlying knowledge concepts a student possesses, identifying the source of errors for targeted remediation (Leddo et al., 2022; Ahmad and Leddo, 2023; Zhou and Leddo, 2023; Dandemraju, Dandemraju, and Leddo, 2024). CSA is rooted in cognitive psychology research, which identifies various knowledge types, such as semantic nets (Quillian, 1966), production rules (Newell and Simon, 1972), scripts (Schank and Abelson, 1977) and mental models (de Kleer and Brown, 1981). Together, these form the INKS framework (Integrated Knowledge Structure), developed by John Leddo (Leddo et al., 1990). This framework suggests that expert knowledge is organized around scripts and principles that enable predictions and explanations.

CSA, which integrates INKS principles, has shown strong correlations with problem-solving performance: 0.966 in Algebra 1 (Leddo et al., 2022), 0.63 in scientific method problem-solving (Ahmad and Leddo, 2023), and 0.80 in precalculus (Zhou and Leddo, 2023). By assessing students' conceptual understanding, CSA enables educators to address knowledge gaps effectively, leading to significant improvements in student performance (Leddo and Ahmad, 2024).

Although CSA has proven effective, the responsibility for diagnosing and remediating students' knowledge gaps lies primarily with teachers, who often manage large numbers of students. Teaching students to self-assess their knowledge could alleviate this burden. Unlike self-explanation, which involves generating explanations for learned material, self-assessment involves evaluating one's knowledge after learning.

Cynkin and Leddo (2023) demonstrated that high school calculus students could accurately self-assess their knowledge using CSA, while Dandemraju, Dandemraju, and Leddo (2024) extended this finding to chemistry. These studies, however, addressed only the identification of knowledge

ISSN: 2455-8834

Volume:10, Issue:10 "October 2025"

gaps, not their remediation. Accurate assessment does not equate to addressing deficiencies, just as diagnosing a medical issue does not equate to treating it.

To address this issue, Ravi and Leddo (2024) conducted a study in which high school students learned an advanced topic in chemistry by watching a video. Half the students were told to rewatch the video to fill in any knowledge gaps, while the other half were taught to self-assess their knowledge using CSA and then told to rewatch the video to fill in any assessed knowledge gaps. The group that was taught to self-assess scored 15 points or 1.5 letter grades higher on a post-test than students who simply rewatched the video without self-assessment. Nehra and Leddo (2024) replicated the Ravi and Leddo study to the learning of Spanish. They found that high school students performing self-assessment plus remediation scored, on average, 25 percentage points or 2.5 letter grades higher than those re-reading the material without performing a self-assessment. Prakash and Leddo (2025a) extended the Ravi and Leddo (2024) and Nehra and Leddo (2024) findings to another subject area: reading comprehension. The results revealed a mean post-test score of 8.3 out of 12 (69.17%) for the control group and 11.2 out of 12 (93.33%) for the experimental group. Notably, individual scores further illustrated the disparity: the lowest score in the control group was 41.67%, whereas the lowest in the experimental group was 83.33%. This is the difference between an F letter grade and B letter grade. Following this, another study conducted by Prakash and Leddo (2025b) examined CSA's effectiveness in teaching math, specifically, the topic of Bayes' Theorem, and found a 27-point improvement. Individual scores also highlighted the disparity. The control group's lowest score was 6/20 (30%), whereas the experimental group's lowest score was 15/20 (75%). Following this, a history assessment revealed that students who utilized CSA for self-assessment and remediation significantly outperformed their peers in the control group (Prakash and Leddo, 2025c). Post-test results demonstrated that the experimental group achieved an average score of 87.5%, whereas the control group scored 65.8%, indicating a substantial difference in comprehension and retention of historical concepts.

These results on high school students were further extended by Leddo, Clark and Clark (2025) in their investigation of middle school math. Leddo, Clark and Clark found that middle school students who self-assessed using CSA and then remediated their knowledge gaps scored 18 percentage points higher on a posttest than those who relearned material without first performing a self-assessment.

Following this, Prakash and Leddo (2025d) conducted a study on middle school students' reading comprehension, specifically through an analysis of To Kill a Mockingbird, a novel that explores complex themes of ethics and social structure. Students in the experimental group were trained to evaluate their own knowledge gaps and use targeted remediation strategies, while those in the control group engaged with the text without structured self-assessment. Results

ISSN: 2455-8834

Volume:10, Issue:10 "October 2025"

showed that students in the self-assessment group scored 16 points higher on a posttest than those who re-read the material without self-assessment. Building upon these results, another study examined CSA's impact on middle school students' understanding of science concepts. Students in the experimental group were taught to self-assess their understanding of key science concepts using CSA and then engage in focused review based on their assessed gaps. In contrast, students in the control group reviewed the material without guidance or structured self-assessment. Students using self-assessment scored, on average 20 percentage points or two letter grades higher on a posttest than those who did not (Prakash and Leddo, 2025e). Then, Prakash and Leddo (2025f) extended the CSA methodology to middle school history, focusing specifically on students' understanding of the causes of the American Revolution. Again, those students using self-assessment scored higher on a posttest than those who did not, this time by 29 percentage points.

Following this, Prakash and Leddo (2025g) tested whether self-assessment and remediation would work with elementary school students. This research showed that elementary school students using self-assessment and remediation for math scored an average of 83% on a posttest while those who simply reread the material scored an average of 70%. They also showed that using self-assessment and remediation raised elementary students' reading scores by an average of 20.5 percentage points (Prakash and Leddo, 2025 in press).

All of the above results were conducted with American students and students in K-12. Sathiyamoorthy and Leddo (2025) investigated whether self-CSA plus remediation would boost performance in college students in Scotland. Here, the testbed was college psychology. Students using self-assessment scored 15 percentages points higher than those who simply reread the material. This study was followed up by one testing whether self-assessment and remediation would raise physics scores of 8th grade students in China (Chen and Leddo, 2025). In that study, those students using self-assessment and remediation scored 23 percentage points higher than students who did not.

The goal of the present study is to test the effectiveness of CSA-based assessment and remediation in another country. In this case, we choose elementary school students in India who are learning to read in English.

METHOD

Participants

15 male students from the Nightingale Home for Boys, an elementary school in Hyderabad, India were selected to participate in this study. All students were elementary schoolers in grades three

ISSN: 2455-8834

Volume:10, Issue:10 "October 2025"

through six who spoke Telugu as their native language and were learning to speak and read English.

Materials

All materials were created in English. Two versions of the materials were created. In the control condition, the materials contained the story "Little Red Riding Hood", followed by instructions that the students should re-read the story to make sure they understood it. The story was then presented a second time. A 12-question post-test was presented at the end.

In the experimental condition, the materials were the same, except that after the first instance of the story, students were given instructions to perform a self-assessment to measure what they understood and did not understand about the story. These instructions included a sample assessment for the story "The Velveteen Rabbit", which the students had previously read, followed by space for them to write their own self-assessment. The next part of the form told students to re-read Little Red Riding Hood in order to fill in any self-assessed gaps they discovered. This was followed by the same 12-question post-test that the control condition had. Instructions for the self-assessment are shown below.

Self-Assessment: Reading

I want to teach you to assess your own knowledge that you have about something you read. Let's do this by taking an example that you already know. Suppose you wanted to assess your own knowledge about the story The Velveteen Rabbit. If I want to be able to understand stories, I need four types of knowledge. These are facts, strategies, procedures and rationales. Facts are concepts you have that describe objects or elements. For example, in reading, facts can be characters or elements of the setting such as location or time period. Strategies are the general plot sequences of events that authors use to make the points or express the themes or conflicts they write about. Procedures are the specific events in the story that are part of the overall strategy or plot. Finally, I need to know rationales which are the reasons behind the plot elements or events. Rationales could include things like author's purpose, the character's goals (why the characters act the way they do) and how elements of the story reinforce the points the author is trying to make. You can think of facts as telling you "what", strategies and procedures as telling you "how" and rationales as telling you "why".

With this in mind, this is how I might assess my own knowledge of the story The Velveteen Rabbit. For facts, I need to know the characters, setting and time period. The main characters are The Velveteen Rabbit (protagonist), The Boy (protagonist), The Skin Horse (supporting protagonist), the Nursery Toys and Fairy. The Velveteen Rabbit is mainly set in a child's nursery

ISSN: 2455-8834

Volume:10, Issue:10 "October 2025"

in a house, with minor scenes in the garden and the Fairy's magical place. The story takes place in the early 20th century, around the time it was published (1922).

For the general plot, a little boy receives a Velveteen Rabbit as a toy. Even though he is told by the other toys that he isn't real, he dreams of becoming real through the love of the boy.

For specific events, the boy receives the Velveteen Rabbit as a Christmas gift. The Skin Horse tells the Rabbit about becoming real through love. The Rabbit becomes the boy's favorite toy and is loved deeply, but when the boy gets sick, the Rabbit is put aside. The Rabbit fears he may never become real. Later, a magical fairy transforms the Velveteen Rabbit into a real rabbit, fulfilling his wish to live and play freely in the garden.

For rationales, I believe the author wrote the story to show children that love makes things real and to teach about the value of inner growth rather than appearances. The protagonist is the Velveteen Rabbit because the story focuses on his journey of becoming real. The challenges he faces being a toy, almost forgotten, and not real are necessary to show his emotional growth. The Rabbit has to become real in the end because the story emphasizes the reward of love and loyalty.

When I look over what I wrote, I see that I am good with my facts. I know who the characters are, and I know that the story is set mainly in a nursery and later in a garden. On my story plot and events, I'm not completely sure how the Rabbit was transformed, whether it was only the fairy or the boy's love that caused it. For rationales, I'm not sure why the author chose toys and a nursery as the main setting instead of another location, or why the main challenge had to be about being real rather than something else. I don't think I left anything out.

Please complete this self-assessment for the story Little Red Riding Hood that you just wrote using the self-assessment for the Velveteen Rabbit as an example.

Procedure

Participants were assigned to each condition with seven in the control group and eight in the experimental group. Instructions to each group were contingent on their condition. The control group was told to read both passages, and if they had any issues understanding the content, they could read over it again. After that, they took the post-test. They were not permitted to refer to the passage when taking the post-test. The experimental group was also instructed to read the story. However, after reading the story, participants in the experimental group were given the self-assessment script and then were asked to self-assess their knowledge of Little Red Riding Hood. After the self-assessment, experimental group participants were told to go back to the instructional document to remediate any knowledge deficiencies their self-assessments had

ISSN: 2455-8834

Volume:10, Issue:10 "October 2025"

identified. After they reviewed the material again, they took the same test as did the control group.

RESULTS

The participants' data were analyzed by examining the number of correct responses on the 12-item post-test. The control group achieved a mean score of 7.86 out of 12 (65.5%), while the experimental group, who engaged in CSA-based self-assessment with remediation, achieved a mean score of 10.5 out of 12 (87.5%). This 22-percentage point difference in performance was statistically significant ($t = 4.48$, $df = 13$, $p = .0006$), indicating that CSA plus remediation produced substantially higher reading comprehension outcomes, equivalent to improving performance by two full letter grades. Individual results reinforced this finding: the lowest score in the control group was 6 out of 12 (50%), compared to 9 out of 12 (75%) in the experimental group.

DISCUSSION

This study aimed to evaluate the effectiveness of Cognitive Structure Analysis (CSA) in helping elementary school students in India self-assess and remediate knowledge gaps in reading comprehension. The findings demonstrate that CSA-trained students significantly outperformed their peers, with the experimental group scoring an average of 22 percentage points higher than the control group. These results align with earlier research, such as Prakash and Leddo (2025, in press), who reported a 20.5 percentage point improvement in elementary school reading in United States students using CSA to self-assess. Importantly, this study builds on prior findings using international students (Chen and Leddo, 2025; Sathiyamoorthy and Leddo, 2025) to further demonstrate that the present methodology works with a third international student population and produces results there that are comparable to those produced in United States students.

On a societal level, the results underscore the value of self-assessment frameworks in education. Students often struggle to meet grade-level expectations, placing a heavy burden on teachers to identify and address learning gaps (Frary, 1985). With many educators managing large classes, individual remediation becomes more and more challenging. CSA offers a scalable solution by empowering. This method could alleviate systemic pressures by enabling students to address their deficiencies independently (O'Neil & Brown, 1997).

From an individual perspective, CSA provides learners with the method to overcome frustration and self-doubt associated with academic struggles. As observed by Nehra and Leddo (2024), students often internalize negative beliefs about their abilities, which can hinder their long-term educational success. Teaching self-assessment both enhances academic performance and builds confidence, helping students reframe challenges as opportunities for growth.

ISSN: 2455-8834

Volume:10, Issue:10 "October 2025"

In an era of growing self-directed learning facilitated by online resources, effective self-assessment methods are becoming vital to educational growth and development. Previous research (Leddo, Clark, & Clark, 2021) has shown that learners often overestimate their comprehension of new material. The CSA framework addresses this issue by providing a structured approach to evaluate understanding, thus enhancing the outcomes of self-directed study (Chi et al., 1989).

Ultimately, this study reaffirms CSA's utility as an educational intervention, particularly in elementary school reading comprehension. While further research is needed to explore its applicability across geographic regions, the findings suggest that teaching students to self-assess can lead to significant improvements in both academic performance and self-efficacy.

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Volume:10, Issue:10 "October 2025"

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Volume:10, Issue:10 "October 2025"

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Volume:10, Issue:10 "October 2025"

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