

Using Self-Assessment and Remediation to Raise Student Achievement in Reading Comprehension

Prathima Prakash and John Leddo

MyEdMaster, LLC

Virginia, USA

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ABSTRACT

*Cognitive Structure Analysis (CSA) is an educational framework designed to help students identify and address knowledge deficits through self-assessment, enabling them to remediate gaps in understanding. Previous studies have demonstrated the effectiveness of CSA in various academic disciplines, including calculus (Cynkin and Leddo, 2023) and chemistry (Dandemraju, Dandemraju, and Leddo, 2024). These studies, however, primarily focused on the identification of knowledge gaps rather than their remediation. As accurate assessment does not inherently address deficiencies, later studies began to investigate CSA's role in addressing the gap. Ravi and Leddo (2024) conducted a study in which students learned an advanced chemistry topic by watching a video. Half of the students rewatched to reinforce their understanding, while the other half were trained to use CSA to self-assess their knowledge and then rewatched the video specifically to remediate assessed knowledge gaps. The CSA-trained group outperformed the control group by 15 points (1.5 letter grades) on a post-test. Similarly, Nehra and Leddo (2024) replicated this approach in Spanish instruction, finding that CSA-trained students scored an average of 25 percentage points (2.5 letter grades) higher than those who simply reread the material without self assessing. This study builds on the findings of Ravi and Leddo (2024) and Nehra and Leddo (2024) by investigating CSA's applicability to reading comprehension, a foundational skill across subjects. 20 high school students participated in the study, focusing on Shirley Jackson's *The Lottery*. Half of the students were trained to use CSA to self-assess their understanding and develop knowledge gaps, while the control group reviewed the material without CSA training. Post-test results displayed that the CSA-trained group scored an average of 93%, outperforming the control group's 69%, suggesting that CSA is effective in developing reading comprehension by enabling students to identify and resolve gaps in understanding. Additionally, it highlights CSA's potential to reduce reliance on teacher intervention by*

promoting self-directed learning. The study further discusses broader educational practices that could potentially incorporate CSA for independent and comparative academic growth.

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 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 an 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 (Chi et al., 1989), 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 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 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 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. This study aims to extend the Ravi and Leddo (2024) and Nehra and Leddo (2024) findings to another subject area: reading comprehension.

METHOD

Participants

20 male and female Loudoun County Public Schools students were selected to participate in this study. All students were high school students, and they were not paid for their participation.

Materials

A Google Form for the control group with the reading passage and 12 comprehension questions is provided below.

<https://docs.google.com/forms/d/e/1FAIpQLScDU482O9tIbbKRTn2s6qpzul0uet6vTIY8b0nY9hqsurgUg/viewform?usp=sharing>

A self-assessment was created in order to help students in the experimental group re-evaluate their understanding of the content provided in the passage. It showed an example of a student self-assessing knowledge of a reading passage that included facts, strategies, procedures, and rationales. It was modeled after the self-assessment template previously reported in Ravi and Leddo (2024).

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 Little Red Riding Hood. 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 the 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 Little Red Riding Hood. For facts, I need to know the characters, setting and time period. The main characters are Little Red Riding Hood (protagonist), the wolf (antagonist), the mother, the grandmother and the woodsman. The story is set long ago in a forest and near the forest for Little Red Riding Hood's home and the Grandmother's home.

For the general plot, a little girl is asked by her mother to give a basket of goodies to her sick grandmother. Even though she's told not to talk to strangers, she does and is almost killed because of it.

For specific events, a mother tells Little Red Riding Hood that her grandmother is sick and to bring the grandmother a basket of goodies. The mother warns Little Red Riding Hood not to talk to strangers. While walking through the woods to get to the grandmother's house, Little Red Riding Hood meets a wolf who asks where she's going. Little Red Riding Hood tells the wolf, who then takes a shortcut to the grandmother's house and impersonates the grandmother. When Little Red Riding Hood arrives, she notices something odd about the grandmother and after a series of questions, the wolf reveals himself and says he'll eat Little Red Riding Hood. Fortunately, a nearby woodsman hears Little Red Riding Hood's screams for help and saves Little Red Riding Hood.

For rationales, I believe the author wrote the story to warn children about the dangers of talking to strangers. The protagonist is a little girl because the story is aimed at children. The wolf has to attack Little Red Riding Hood because the story needs to show the danger of talking to strangers.

Little Red Riding Hood has to be saved in the end because it may be too scary for children to read stories about a little girl who gets eaten by a wolf.

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 long ago and in and near a forest. In my story plot and events, I forget whether the wolf ate the grandmother or just locked her in a closet because Little Red Riding Hood was coming. Also, I'm not sure what happened to the wolf at the end. For rationales, I'm not sure why the setting had to be in a forest or why the antagonist was a wolf as opposed to a person or other animal. I don't think I left anything out.

A Google Form for the experimental group with the reading passage, reading assessment, and 12 comprehension questions is provided below.

<https://forms.gle/ZBqPyQkQseCCHX1P7>

In addition to the reading assessment, an answer key was created in order to evaluate each participant's response. There was no partial credit, with 1 point for each correct response and 0 for each incorrect response.

Answer Key:

1. The main characters in The Lottery are:

Tessie Hutchinson: The chosen victim who protests the fairness of the process.

Bill Hutchinson: Tessie's husband, who participates without resistance.

Mr. Summers: The official who conducts the lottery.

Old Man Warner: A staunch defender of the tradition.

The villagers: Collective participants who uphold the ritual.

2. The setting of the story is a small, unnamed village on June 27th, during the morning hours.
3. The black box symbolizes tradition and the villagers' resistance to change. Its deteriorating condition represents how rituals lose meaning over time but are still followed blindly.
4. Jackson builds suspense through details like the gathering stones, nervous conversations, and the slow, formal lottery process.

5. Casual conversations (e.g., Mrs. Hutchinson's tardiness or talk about other towns abandoning the lottery) foreshadow the violent conclusion by juxtaposing normalcy with ominous hints.
6. The tone transitions gradually from light and ordinary to tense and shocking through descriptions of the villagers' nervousness and the climactic moment of Tessie's stoning.
7. Preparations for the lottery include making lists of households and families, preparing slips of paper, and locking the black box overnight. These steps show the villagers' adherence to the ritual's formalities.
8. The drawing process involves the head of each household selecting a slip of paper, followed by individual family members drawing to determine the final "winner."
9. Tessie Hutchinson initially laughs casually, protests the process as unfair when her family is chosen, and panics as the villagers, including her family, turn against her.
10. Jackson leaves the purpose of the lottery ambiguous to emphasize the absurdity and horror of blindly following traditions without questioning their purpose.
11. Old Man Warner's characterization reinforces blind tradition by showing his disdain for change and insistence on the lottery's necessity.
12. The calm, matter-of-fact tone contrasts with the violent ending, heightening the shock and critique of desensitization to violence.

Procedure

Participants were randomly assigned to each condition with 10 per group. Instructions to each group were contingent on their condition. The Google Forms contained all the questions, while instructions were provided verbally. The control group was told to read the passage, *The Lottery* by Shirley Jackson, and if they had any issues understanding the content, they could read over it again. After that, they took the post-test on the Google Form itself. They were not permitted to reference the passage when taking the post-test. The experimental group was also instructed to read over the guide. However, after reading the guide, participants in the experimental group were given the self assessment script and then were asked to self-assess their knowledge. 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 identified. After they reviewed the material again, they took the same test as did the control group. The post test contained questions that were direct recall, situation based, and assessed their knowledge of concepts rather than picking a correct answer.

RESULTS

The participants' data were analyzed by examining the number of correct responses on the post-test. 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. This difference in averages was statistically significant ($t = 3.75$, $df = 11.07$, $p < .01$). 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.

Additionally, 8 out of 10 participants in the experimental group, when asked, voted in favor of hypothetically implementing the self-assessment system into schools, to improve reading comprehension. This suggests that the approach is both effective and appealing for learners. In contrast, participants in the control group reported no benefits from rereading the guide, as they lacked structured tools to identify and address their knowledge gaps effectively.

DISCUSSION

This study aimed to evaluate the effectiveness of Cognitive Structure Analysis (CSA) in helping high school students 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 24 percentage points higher than the control group. These results align with earlier research, such as Ravi and Leddo (2024), who reported a 15-point improvement in chemistry performance using CSA, and Nehra and Leddo (2024), who demonstrated a 25-point improvement in Spanish. Importantly, this study builds on prior findings by extending CSA's applicability to reading comprehension, a foundational skill across academic disciplines (Leddo, Ahmad, & Zhou, 2022).

Interestingly, the improvement in this study (24 points) exceeds that of Ravi and Leddo's chemistry study, following a similar trend found in Nehra and Leddo's (2024) research on an introductory Spanish self-assessment. Their work highlighted that CSA tends to yield stronger effects in simpler subject areas, such as language learning, compared to more complex topics like advanced chemistry. This pattern suggests that CSA might be especially impactful in foundational subjects where knowledge is more readily compartmentalized and assessed as opposed to advanced concepts building upon foundational ones (Nehra & Leddo, 2024).

On a societal level, the results underscore the value of self-assessment frameworks in education. U.S. students often struggle to meet grade-level expectations, placing a heavy burden on teachers to identify and address learning gaps (Frery, 1985). With many educators managing large classes, individual remediation becomes more and more challenging. CSA offers a scalable

solution by empowering students to take ownership of their learning, thereby reducing reliance on teacher intervention. For example, while participants in the control group struggled to recall key details from *The Lottery* and often left questions unanswered, the CSA-trained group identified their knowledge gaps, revisited the material, and demonstrated mastery (Jackson, 1948). 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.

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 reading comprehension. While further research is needed to explore its applicability across other domains and age groups, 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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