

## **Using Self-Assessment and Remediation to Raise College Student Achievement in Psychology**

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DOI: 10.46609/IJSSER.2025.v10i05.029 URL: <https://doi.org/10.46609/IJSSER.2025.v10i05.029>

Received: 6 May 2025 / Accepted: 28 May 2025 / Published: 10 June 2025

### **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 reliability of teaching students to use CSA to assess their own knowledge 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 high school students learned an advanced chemistry topic by watching a video. Half relearned the material while the other half self-assessed using CSA and relearned the material with an eye to filling in assessed knowledge gaps. Students performing self-assessment prior to relearning material scored 15 points or 1.5 letter grades higher 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. Prakash and Leddo (2025a) built on the findings of Ravi and Leddo (2024) and Nehra and Leddo (2024) by investigating CSA plus remediation's applicability to reading comprehension; post-test results displayed that the CSA-trained group scored an average of 93%, outperforming the control group's 69%. Prakash and Leddo (2025b) built on prior research by investigating the applicability of CSA in learning Bayes' Theorem, a foundational concept in probability theory and statistics. The investigation of CSA was continued through analyzing its impact in history, where post-test results revealed the significant statistical difference between the control and experimental groups, the control scoring an average of 65.8% compared to the experimental group's 87.5% (Prakash and Leddo,*

2025c). Leddo, Clark and Clark (2025) extended the previous work on high school students with middle school students and found that self-assessment using CSA plus remediation improved math scores by 18 percentage points compared to remediation without self-assessment. This investigation of CSA plus remediation was continued in the context of middle school students' ability to comprehend a reading passage. (Prakash and Leddo, 2025d). Post-test results revealed the control scoring an average of 61.7% as opposed to the experimental's 78.3%. Prakash and Leddo (2025e) reported similar effects in middle school science. This present study investigates the impact of CSA combined with targeted remediation on college students' performance on a topic in psychology: signal detection theory.. Twenty-six college students were randomly assigned to either a control or experimental group. Both groups read a lesson The control group re-engaged with the material without guidance, while the experimental group used CSA to self-assess and target their remediation efforts. Results revealed a significant performance difference, with the experimental group scoring an average of 92%, compared to the control group's 79% ( $t= 2.3,$   $df=24,$   $p=.03$ ). These findings suggest that CSA combined with remediation can substantially improve college students' comprehension and mastery psychology content.

## **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, 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 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. 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. 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. Statistical analysis yielded a t-value of 4.38 ( $df = 18$ ,  $p = 0.0004$ ), confirming the significance of the difference. 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 post test 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 showed that students in the self-assessment group scored 16 points higher on a post-test than those who re-read the material without self-assessment. This was followed up with a study on middle school science (Prakash and Leddo, 2025e), in which students learned about topics in ecology. Results showed that students who used the self-assessment technique plus remediation scored on average 98% on a post-test, while those who simply reread the material without self-assessment scored on average 77.5%.

Building upon these results, this present study examines CSA's impact on college students' understanding of psychology concepts. Students in the experimental group were taught to self-assess their understanding of a key psychology concept 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. This study seeks to explore the extent to which CSA paired with remediation can improve conceptual understanding and performance in college students and whether the results hold up in a country other than the United States (in this case, Scotland), where the previous research on CSA plus remediation had been conducted.

## **METHOD**

### *Participants*

16 male and female college students in the United Kingdom were selected to participate in the control group and 10 of the same were selected in the experimental group for this study. All the students were college students, and they were not paid for their participation.

### *Materials*

To aid students in developing a deeper understanding of a psychological theory, Signal Detection Theory, a comprehensive study guide was created to serve as a resource to break down the theory concepts into accessible, engaging segments while maintaining scientific accuracy. The guide introduced the students to the foundation of said theory and its working model.

The study guide served as both a learning tool and a conceptual foundation for the assessment component of the project, in which student comprehension and application of the material were evaluated. The link is provided below.

<https://www.cns.nyu.edu/~david/handouts/sdt/sdt.html>

The following Google Form for the control group with 10 questions related to Signal Detection Theory is provided below.

[https://docs.google.com/forms/d/e/1FAIpQLSdA\\_YDJqg56RzENKpxgssWUo-FKAjkOTY1r7fsrD6O8q7Nu1w/viewform?usp=header](https://docs.google.com/forms/d/e/1FAIpQLSdA_YDJqg56RzENKpxgssWUo-FKAjkOTY1r7fsrD6O8q7Nu1w/viewform?usp=header)

A self-assessment instruction sheet was created to help students in the experimental group self-assess their understanding of the content provided in the guide. It showed an example of a student self-assessing knowledge of a concept that included facts, strategies, procedures, and rationales. Below is the self-assessment set of instructions.

### **Self-Assessment**

I want to teach you how to assess your own knowledge that you have about a subject area. Let's do this by taking an example that you already know. Suppose you wanted to assess your own knowledge about solving 2-step equations of the form  $ax + b = c$ . An example of this type of problem is  $2x + 3 = 15$ . If I want to be able to solve problems like these, 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, for two step equations, I need to know what variables, constants, coefficients, equations, and expressions are. Strategies are general processes I would use to solve a problem. For two step equations, this would be reverse order of

operations. Procedures are the specific steps that I would use in a strategy. So, if I am using reverse order of operations, I need to know additive and multiplicative inverses. Finally, I need to know rationale which are the reasons why the strategies or the procedures work the way they do. For example, this could include things like the subtraction or the division property of equality that says that when you do the same operation to both sides of an equation, you preserve the value of the equation. 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 solving two step equations.

For facts, I need to know what variables, constants, coefficients, equations and expressions are. A variable is an unknown quantity, usually represented by a letter. A constant is a specific number. A coefficient is a number that you multiply a variable by like  $2x$ . An equation is an expression that is equal to another expression and the two expressions are joined by an equal sign. An expression is one or more terms that are combined by mathematical operations like addition, subtraction, multiplication and division.

For strategies, I need to know the reverse order of operations which is SADMEP. This stands for subtraction, addition, division, multiplication, exponents and parentheses. I know that I’m supposed to do these in order, but I don’t remember whether I’m supposed to do subtraction always before addition or just which one goes first. The same is true for division and multiplication.

For procedures, I need to know additive inverse and multiplicative inverse. The additive inverse is taking the number with the opposite sign as the constant and adding it to both sides of the equation. The multiplicative inverse is taking the inverse of the coefficient of the variable and multiplying both sides of the equation by it. However, if the coefficient is negative, I’m not sure if the multiplicative inverse is supposed to be negative as well.

For rationales, I believe the two rationales I need are the subtraction property of equality and the division property of equality. The subtraction property of equality says that if I subtract the same number from both sides, which is what I’m doing with the additive inverse, I preserve equality. Similarly, the division property of equality says that if I divide both sides of the equation by the same number, which is what I’m doing with the multiplicative inverse, I preserve equality.

When I look over what I wrote, I see that I am good with my facts. On my strategy, I’m not sure about the order of steps in reverse order of operations when it comes to subtraction and addition or multiplication and division, so I need to learn those. On procedures, I’m not sure what to do with multiplicative inverses when the coefficient is negative, so I need to learn that as well. For rationales, I think I’m OK. I don’t think I have any missing facts/concepts that I left out that I

should know or I didn't list any facts/concepts where I didn't know what they were. For the strategy, I believe I listed the correct strategy and parts of the strategy, but I wasn't sure about some of the ordering of steps in the strategy. For procedures, I was good on the additive inverse but had a question on carrying out the multiplicative inverse when the coefficient was negative. For rationales, I think I had all the rationales that were important and that I understood them as well. I don't think I left anything out.

Please write your own self-assessment on this topic using the model above as an example.

The following Google Form for the experimental group with self-assessment and 10 questions related to Signal Detection Theory is provided below.

<https://docs.google.com/forms/d/e/1FAIpQLSeWYIB7INyBSIhTXlmhqJLKn4xHHTDTBGQ-0jWY1-cTqPzSgA/viewform?usp=header>

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

### ***Procedure***

Participants were randomly assigned to one of two groups: control (MSSA1) and experimental (MSSA2). Both groups received a brief guide that explained Signal Detection Theory and provided examples to develop a conceptual idea of the topic. The control group was instructed to study the material, review the same material if there were any additional inquiries, and complete a post-test, with no structured guidance on how to address knowledge gaps. The experimental group was trained to use CSA for self-assessment. After studying the document, participants in the experimental group evaluated their understanding using CSA and revisited the material to address knowledge gaps before taking the same post-test as the control group. The post-test included 20 questions assessing conceptual understanding and rationales. Participants were not permitted to access the excerpt when answering the questions.

### **RESULTS**

The participants' data were analyzed by examining the number of correct responses on the post-assessment, which consisted of 10 questions covering a key college psychology concept. The control group (n=16), which reviewed the material without structured self-assessment, had an average score of 7.9 out of 10 (79%). The experimental group (n=10), which utilized CSA to identify and target knowledge gaps before reviewing, scored an average score of 9.2 out of 10 (92%). A two-tailed t-test revealed a statistically significant difference between the groups

( $t=2.3$ ,  $df=24$ ,  $p=0.03$ ), indicating that the CSA self-assessment plus remediation approach significantly improved student achievement in science compared to standard review practices.

## **DISCUSSION**

The study's findings show how well Cognitive Structure Analysis (CSA) works as a self-assessment and rehabilitation technique for enhancing conceptual understanding in psychology at the college level. On a post-test, students who received training on how to assess their knowledge using CSA performed noticeably better than those who merely went over the content without engaging in organized self-assessment. These results are in line with earlier studies in a number of subjects, such as chemistry, Spanish, reading comprehension, and mathematics, which show that CSA not only helps to identify knowledge gaps but also significantly improves academic performance when combined with focused review (Ravi & Leddo, 2024; Nehra & Leddo, 2024; Prakash & Leddo, 2025a–e; Leddo, Clark & Clark, 2025). The present study contributes to our previous work by showing that self-CSA plus remediation not only works with college level students (as compared with the previous studies that focused on middle and high school students), but also shows that this technique is effective when used in another country (Scotland) than the United States.

By demonstrating that the advantages of CSA are not just for high school or middle school kids but also apply to college students, this study adds to the body of previous research. A deeper, more structured kind of metacognition is fostered by CSA, as seen by the experimental group's post-test scores, which improved significantly, average 13 percentage points higher. Students were urged to consider the four main components of knowledge—facts ("what"), methods and techniques ("how"), and justifications ("why")—instead of depending solely on passive review. According to this, which is consistent with the INKS framework, this kind of systematic reflection encourages expert-like knowledge organization, which helps students reason more successfully about abstract scientific ideas like Signal Detection Theory.

Notably, CSA fills a significant gap in conventional assessment techniques, which frequently mistake accurate responses for genuine comprehension. The present study supports the notion that self-awareness of one's ignorance is just as important as knowledge itself. According to Cynkin and Leddo (2023), the cornerstone of successful learning interventions is accurate self-assessment. This study goes one step further, though, by demonstrating that self-evaluation by itself is inadequate unless combined with knowledgeable repair. It would be like diagnosing a medical condition without seeking treatment to diagnose a learning disability without doing something about it. The diagnostic, reflection, and repair phases of the learning cycle are all supported by the CSA technique.

The results have broad ramifications. Strategies that promote student autonomy become increasingly important as educators deal with growing demands and greater class numbers. Students are empowered to take charge of their education and are less dependent on teacher-driven remediation when they are taught how to identify and fill in their own knowledge gaps. This is in line with more general educational objectives of encouraging self-regulated learning and lifelong learning abilities, especially in STEM professions where problem-solving and conceptual accuracy are critical.

In order to scale its utilization, future studies should investigate longitudinal uses of CSA across grade levels and disciplines, incorporating it into online learning environments. Furthermore, CSA's instructional usefulness could be further refined by examining how it interacts with various learning styles, cognitive capacities, or prior knowledge levels. By incorporating CSA into online learning environments, formative assessment systems, and peer learning settings, it may become a common educational practice rather than an experimental one.

In summary, this study demonstrates that CSA considerably improves learning outcomes in college scientific education when utilized as a self-assessment and remediation tool. CSA promotes deeper learning, increased autonomy, and better academic performance by promoting focused review and structured reflection—a goal that is both necessary and timely in today's educational environment.

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