

Using Self-Assessment and Remediation to Raise Student Achievement in History

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 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 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. Prakash and Leddo (2025a) built on the findings of Ravi and Leddo (2024) and Nehra and Leddo (2024) by investigating CSA'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. Post-test results revealed that the experimental group significantly outperformed the control group, scoring an average of 85.5% compared to the control group's 58.5%. These findings underscore CSA's potential to improve understanding of abstract mathematical concepts while fostering self-directed learning. This study continues the investigation of CSA in academic concepts

through analyzing its impact in history, particularly that of the Silk Road, a network of Asian trade routes active from the second century BCE until the mid-15th century. Twenty high school students were divided into two groups. Both groups studied a passage about the Silk Road, but only the experimental group used CSA to self-assess their knowledge and remediate gaps. 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%.

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 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. 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%).

This study extends the previous self-assessment plus remediation work to the subject of history, examining the historical significance of the Silk Road, a vast network of trade routes that

facilitated economic, political, and cultural exchanges across Eurasia for over a millennium. By analyzing the geographical, economic, and diplomatic factors that shaped its development, this research investigates how the Silk Road influenced global commerce, the spread of ideas and religions, and the formation of interconnected societies. Additionally, it explores the mechanisms that sustained long-distance trade, including financial innovations, risk management strategies, and imperial policies that fostered stability along the routes. Throughout this study, whether CSA can help students self-assess and remediate their understanding of the Silk Road is studied, thereby determining its role in improving performance on related assessments.

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 Silk Road description passage and 12 comprehension questions is provided below.

https://docs.google.com/forms/d/e/1FAIpQLSfm1LXR2B06xjCd8Lh9IUgbq89w9asCiG7tJHqB_gtp-5n098w/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 guide. It showed an example of a student self-assessing knowledge of a historical concept that included facts, strategies, procedures, and rationales. It was modeled after the self-assessment template previously reported in Ravi and Leddo (2024).

Self-Assessment: History

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 the Declaration of Independence. If I want to check my knowledge of this, I need to assess four types of knowledge. These are facts, strategies, procedures and rationales. Facts are concepts you have that describe objects or elements. For example, for historical knowledge, I need to know the relevant people, dates, locations, the context of the event, etc. Since historical events are typically described in a problem-solution text structure, the strategy knowledge is the problem being faced and the strategy or solution to that problem.

Procedures are specific events that occurred in the strategy, Finally, I need to know rationales which are the reasons why the events happened or any outcomes they produced. Since historical events often describe problems and solutions, I need to know what the problems and solutions were and why those particular solutions were chosen. A rationale could also be how the historical event affects the present or other time periods or how it impacted other parts of the world. 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 Declaration of Independence. For facts, I need to know the key people, dates, locations and content (which could be the problem people were facing). In this case, I know that Thomas Jefferson wrote the Declaration of Independence in 1776. I know that King George III was king of England and that the colonies were under British rule. I know that John Hancock signed the Declaration of Independence bigger than anyone else did. I don’t remember the other names of the signers. I know that, at the time, the colonies didn’t want to remain under British rule. I don’t remember all the reasons listed in the Declaration of Independence, but no taxation without representation was one of them.

For strategies, I know that the general problem was that the colonists didn’t want to be under British rule, so during the Revolutionary War, they signed the Declaration of Independence to get France to side with them.

For procedures, I know that the general flow of events was that the colonies were under British rule and were unhappy about it. There were a series of protests like the Boston Tea Party.

Eventually, war broke out between England and the colonies. The colonists issued the Declaration of Independence to get France to align itself with the colonies, since France was a rival of England. The French did join the war, and the colonies won.

For rationales, I believe the reason why the Declaration of Independence was written was that France needed to believe that the United States was going to be an independent country that could be an ally of France rather than having France believe that it was intervening in a civil war between two parts of Great Britain. That this also led to the first democracy, thereby showing the world that such a form of government is possible.

When I look over what I wrote, I see that I am good with the basics of my facts. I know some of the main players, but I don’t know all the signers of the Declaration of Independence. On my strategy, I think I see the reason for the Declaration as part of the push for independence, but I’m not sure why other strategies weren’t possible. On procedures, I’m not sure about the mechanism that got all the signers to approve it, since this would have been considered an act of treason. For

rationales, I think I'm OK. I don't think I have any incorrect facts, although I mentioned not knowing all the people who signed the Declaration of Independence. For strategy, I think I have the strategy down, but I'm not sure how the colonists knew the strategy would work and that France would help them. It seems like this was a gamble. For procedures, I'm pretty sure I got the key events and I don't think I'm missing anything important. 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.

A Google Form for the experimental group with the Silk Road description passage, history self-assessment, and 12 comprehension questions is provided below.

https://docs.google.com/forms/d/e/1FAIpQLSfZdCW1nJ6N7wpfFenDemuJb0HdbuSMw_PV-cSqQ87WsAnlrw/viewform?usp=header

In addition to the history assessment, an answer key was created in order 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 (HA1) and experimental (HA2). Both groups received a short passage explaining the significance of the Silk Road, including its origins and applications. 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 12 questions assessing conceptual understanding and rationales. Participants were not permitted to access the Silk Road passage when answering the questions.

RESULTS

The participants' data were analyzed by examining the number of correct responses on the post-test. The results revealed a statistically significant difference in performance between the two groups. The control group (RA1) achieved a mean score of 7.9/12 (65.8%), while the experimental group (RA2) scored an average of 10.5/12 (87.5%). Statistical analysis yielded a t-value of 4.89 (df = 18, $p < .0001$), confirming the significance of the difference. Individual scores further emphasized this disparity, with the lowest score in the control group being 6/12

(50%), whereas the lowest score in the experimental group was 9/12 (75%). The experimental group demonstrated both a higher mean and a higher floor in performance.

Additionally, participants in the experimental group reported a greater ability to identify and correct their own misconceptions after engaging in the self-assessment process. Many expressed increased confidence in their understanding of Silk Road trade dynamics, highlighting the method's effectiveness in reinforcing historical reasoning. In contrast, control group participants largely relied on prior knowledge and struggled to pinpoint specific knowledge gaps, suggesting that traditional study methods may be less effective in encouraging deeper historical comprehension.

DISCUSSION

This study aimed to evaluate the effectiveness of self-assessment techniques in aiding high school students to identify and address knowledge gaps in history education. The findings indicate a significant improvement in the experimental group's performance, with a 21.7% higher mean score compared to the control group. These results are consistent with previous research, such as Nehra and Leddo's (2024) study on Spanish language acquisition, which reported substantial gains through self-assessment methodologies, and Ravi and Leddo's (2024) chemistry research, which observed a 15-point improvement. This study extends the application of self-assessment to history education, a field that benefits from critical thinking and contextual understanding.

The notable 21.7% improvement observed in this study suggests that self-assessment may offer unique advantages in history education. History, with its emphasis on critical analysis and interpretation of events, allows students to engage deeply with content, facilitating the identification and rectification of misconceptions. This process promotes a more nuanced understanding of historical contexts and narratives. The structured nature of self-assessment enables targeted reflection, improving students' ability to connect historical events and themes.

The implications of these findings are significant for educational practices. Traditional history instruction often relies on passive learning methods, which may not effectively address individual learning gaps. Self-assessment empowers students to take an active role in their learning journey, fostering autonomy and self-regulation. This approach aligns with the goals of formative assessment, which emphasizes continuous feedback and adjustment to improve learning outcomes. By integrating self-assessment into history curricula, educators can create a more interactive and personalized learning environment.

Psychologically, the use of self-assessment techniques has been shown to enhance students' self-efficacy and confidence in their academic abilities. Participants in the experimental group

reported a greater sense of control over their learning process and an increased ability to critically evaluate historical sources and arguments. This aligns with Nehra and Leddo's (2024) findings that self-assessment builds self-efficacy, a critical component of long-term academic and professional success. This empowerment is crucial in developing independent learners who can navigate complex historical information and construct well-informed perspectives. Such skills are essential not only for academic success but also for informed citizenship.

From a broader perspective, implementing self-assessment strategies in history education can contribute to educational equity. Students from diverse backgrounds bring varied prior knowledge and experiences to the classroom. Self-assessment allows for differentiation, enabling each student to identify and address their unique learning needs. This personalized approach can help bridge achievement gaps and support all students in reaching their full potential.

Future research should explore CSA's long-term effects on students' historical thinking and retention of knowledge. Investigating the integration of self-assessment with other instructional strategies, such as collaborative learning and technological instruction, could provide insights into creating comprehensive educational approaches. Additionally, examining the impact of self-assessment on diverse populations can inform inclusive teaching and learning practices that address the needs of all learners.

In conclusion, this study reinforces the effectiveness of self-assessment in history education and highlights its potential to transform traditional teaching methods. By enabling students to actively engage with historical content and reflect on their understanding, self-assessment fosters deeper learning and critical thinking. Embracing this approach can lead to more equitable and effective educational experiences, preparing students to thoughtfully engage with the past and its implications for the present and future.

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