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

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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 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's 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

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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. Post-test results revealed the control scoring an average of 61.7% as opposed to the experimental's 78.3%. A following study investigated the impact of CSA combined with targeted remediation on middle school students' performance on a science assessment, where 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 98%, compared to the control group's 77.5% (t=6.26, df=18, p=.0001). These findings suggest that CSA combined with remediation can substantially improve middle schoolers' comprehension and mastery of science content. In the present study, CSA was applied to middle school students learning about the causes of the American Revolution. After initially studying the material, students in the experimental group used CSA to assess their understanding and then targeted their review based on identified gaps. Results showed a significant performance difference: the experimental group scored an average of 91.5%, compared to the control group's 65.5% (t(18) = 6.53, p < .0001), suggesting that CSA combined with targeted remediation substantially enhances historical comprehension at the middle school level.

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,

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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

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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. 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. By validating CSA's role in improving scientific analysis, this study contributed to ongoing research on effective learning strategies and the potential for self-directed education to enhance student outcomes. In this study, Prakash and Leddo (2025e) extend the CSA methodology to middle school history, focusing specifically on students' understanding of the causes of the American Revolution.

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METHOD

Participants

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

Materials

To aid students in developing a deeper understanding of the causes of the American Revolution, a comprehensive study guide was created. This guide was designed to break down complex historical developments into accessible, engaging segments while maintaining historical accuracy and chronological coherence. The guide introduced students to foundational topics related to the build-up to the Revolution, using narrative explanations, reference charts, dates, and more.

The guide was structured into six thematic sections:

1. Life in the Colonies Before Conflict
2. The French and Indian War: Seeds of Tension
3. Taxes and Acts: British Policies that Sparked Outrage
4. Colonial Resistance and Protest Movements
5. From Petition to Revolution: Escalating Conflict
6. Turning Points: Lexington, Concord, and the Road to Independence

Each section included clear definitions of key terms (e.g., “boycott,” “militia”), compelling narratives of historical events, and reflective questions designed to promote critical thinking. Visual aids such as cause-and-effect charts and timelines were integrated throughout the guide to help students trace the progression from discontent to revolution. The study guide served as both an instructional tool and the conceptual foundation for the post-test assessment used to measure students’ comprehension and analytical reasoning. The link to the study guide is provided below.

https://docs.google.com/document/d/1GbYvl7n9TEGAb2_1rwwXfLqARaciwFtT6s6ITThNwo0/edit?usp=sharing

The following Google Form for the control group with 20 questions related to the American Revolution is provided below.

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https://docs.google.com/forms/d/e/1FAIpQLSfTd-z0Ou8Lp1Z6gT0AZnVCQM2mZU8Wk287YXOV69vApTvvVg/viewform?usp=sharing&ouid=117418336339884916299

A self-assessment instruction sheet was created in order 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 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.

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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 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.

Please write your own self assessment of what you understand about the American Revolution, using the above example as a model for you to follow.

The following Google Form for the experimental group with the self assessment and 20 questions related to the American Revolution is provided below.

https://docs.google.com/forms/d/e/1FAIpQLSc0uvf0XRKHEvp2cpCYUsCOZ5zf4K0Gpv11oDLCLQYx1R85Ng/viewform?usp=sharing&ouid=117418336339884916299

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In addition to the self 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 (MSHA1) and experimental (MSHA2). Both groups received a structured guide designed to explain the causes of the American Revolution, including major events, policies, and perspectives that shaped colonial resistance. The control group was instructed to study the material, review the same content if they had additional questions, and then complete a post-test. No structured guidance was provided on how to identify or address knowledge gaps. In contrast, the experimental group was trained to use Cognitive Structure Analysis (CSA) for self-assessment. After reading the historical guide, students in the experimental group evaluated their own understanding using CSA and then revisited only the parts of the guide where they had identified conceptual gaps before completing the same post-test as the control group. The post-test consisted of 20 questions measuring comprehension, causal reasoning, and the ability to justify interpretations. Students were not permitted to reference the guide while completing the post-test.

RESULTS

The participants' data were analyzed based on the number of correct responses out of 20 on the post-assessment, which evaluated students' understanding of key historical causes and events leading to the American Revolution. The control group (n = 10), which reviewed the material without structured self-assessment, scored as follows: 14, 15, 13, 11, 16, 13, 14, 12, 10, 15. The average score was 13.3 out of 20 (66.5%). The experimental group (n = 10), which utilized CSA to identify and target knowledge gaps, scored: 19, 20, 20, 18, 20, 17, 19, 20, 20, 18. The average score was 19.1 out of 20 (95.5%). A two-tailed t-test revealed a statistically significant difference between the groups ($t = 6.53$, $df = 18$, $p < .0001$), indicating that CSA-driven self-assessment and remediation led to markedly stronger understanding of historical content.

Qualitative feedback also supported these quantitative results. Students in the experimental group reported improved ability to pinpoint specific misconceptions (e.g., confusing the Sugar Act with the Stamp Act or misunderstanding the sequence of protests). Several students expressed increased confidence in their historical reasoning and a clearer grasp of cause-and-effect relationships between colonial resistance and British policies. In contrast, control group students often noted difficulty distinguishing between events and expressed uncertainty about which aspects of the material they misunderstood.

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DISCUSSION

This study aimed to evaluate the effectiveness of self-assessment techniques in aiding middle school students to identify and address knowledge gaps in education. The results of this study demonstrate that the application of Cognitive Structure Analysis (CSA) combined with targeted remediation significantly enhances historical understanding and overall achievement among middle school students. The experimental group, which employed self-assessment techniques to identify specific conceptual gaps and address them directly, outperformed the control group by an average of 29 percentage points. These results align with prior research, including Prakash and Leddo's (2025d) study on middle school reading comprehension and Ravi and Leddo's (2024) research in chemistry, both of which demonstrated gains from self-assessment strategies. The present study contributes a new dimension by confirming CSA's effectiveness in the domain of middle school history education.

The implications for history instruction are significant. Historical thinking requires not only factual recall but also the ability to analyze causes, recognize multiple perspectives, and form evidence-based interpretations. Self-assessment using CSA fosters metacognitive awareness of these deeper cognitive skills, encouraging students to move beyond surface-level memorization. This approach supports the goals of modern history education, which emphasize inquiry, reasoning, and civic understanding.

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 groups of both history and reading comprehension studies reported a greater sense of control over their learning process and an increased ability to critically evaluate sources, arguments, and literary texts. 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 information and construct well-informed perspectives. Such skills are essential not only for academic success but also for informed citizenship and lifelong literacy.

From an equity perspective, structured self-assessment allows all learners regardless of prior background knowledge to tailor their review process to their individual needs. This personalized remediation supports differentiated instruction and can help close achievement gaps, particularly in content-rich subjects like history where students' prior exposure to the material can vary widely.

Future research should explore CSA's effectiveness in other history topics (e.g., Civil War, Reconstruction, or global revolutions), and its integration with multimedia or project-based

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learning environments. Additionally, longitudinal studies could examine whether CSA-based self-assessment improves retention and historical thinking skills over time. It should also explore CSA's long-term effects on students' critical thinking and literary analysis. Investigating the integration of self-assessment with other instructional strategies, such as collaborative learning, digital literacy tools, and AI-based tutoring systems, 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 value of CSA-driven self-assessment in middle school history instruction. By enabling students to actively engage with historical content while reflecting 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 complex ideas and apply analytical skills to real-world contexts.

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