

No Student Falls Behind: Using Self-Assessment to Improve Academic Performance in Pre-school Children

Advika Keshri¹ and John Leddo^{1,2,3}

¹MyEdMaster, LLC, Virginia, USA

²METY Technology, Inc., Virginia, USA

³METY Foundation, Virginia, USA

DOI: 10.46609/IJSSER.2026.v11i09.047 URL: <https://doi.org/10.46609/IJSSER.2026.v11i09.047>

Received: 14 August 2026 / Accepted: 23 September 2026 / Published: 30 September 2026

ABSTRACT

Early-childhood education can improve school readiness and reduce educational disadvantage, but access, cost, program quality, and the persistence of early gains remain challenges. The present study investigated whether a simple Cognitive Structure Analysis (CSA)-based self-assessment approach, previously shown to improve achievement in older students, could improve academic performance in preschool children. Participants were 56 five- and six-year-old students attending Birla Open Minds Preschools in Hyderabad, India. Students learned a classroom lesson on animal habitats and were assigned to a control condition or one of three self-assessment conditions that varied in template wording and timing. The control group received instruction followed by a 10-item test, whereas the self-assessment groups completed age-appropriate templates emphasizing factual and procedural knowledge. All three self-assessment groups obtained higher mean post-test scores than the control group. Template 1 produced a mean score of 8.00 compared with 6.36 for the control group, a statistically significant 16.4-percentage-point difference, $t(30) = 2.17$, $p = .038$, Hedges' $g = .75$. Template 2 produced the largest effect, with a mean of 8.50, a 21.4-percentage-point advantage over the control group, $t(22) = 2.39$, $p = .026$, Hedges' $g = .96$. Template 3 produced a higher mean than the control group but not a statistically significant difference. Template 2 also significantly outperformed Template 3, $t(22) = 3.40$, $p < .003$, Hedges' $g = 1.36$. Score variability was significantly lower in each self-assessment condition than in the control condition, suggesting that self-assessment may particularly benefit lower-performing students and reduce performance disparities. These findings indicate that CSA-based self-assessment can be adapted successfully for preschoolers, with simple, age-appropriate language appearing important to effectiveness.

The results support further investigation of self-assessment as a low-cost approach for improving and sustaining early academic achievement.

INTRODUCTION

Early-childhood education programs are intended to improve school readiness before children enter elementary school. Major U.S. approaches include the federal Head Start and Early Head Start programs, state- and locally funded prekindergarten, and universal preschool initiatives. Head Start generally serves children ages 3–5 from eligible low-income families, while Early Head Start serves pregnant women and children under age 3; these programs combine early learning with health, family, and developmental supports (Administration for Children and Families [ACF], n.d.).

The research literature indicates that preschool can improve children's early academic skills and reduce educational disadvantage, but the effects are not uniform across programs or outcomes. A systematic review of 26 natural-experiment studies of universal preschool found mixed long-term effects on test scores, while estimates for adequate school progression, years of schooling, highest degree completed, employment, and earnings were generally favorable. The review also found that benefits tended to be larger for children from lower-socioeconomic-status backgrounds (Dietrichson et al., 2020).

One important pattern in the literature is that early academic gains can diminish after children enter elementary school even when longer-term benefits remain. For example, lottery-based research on Boston's public preschool program found increased high-school graduation, SAT-taking, and college attendance, as well as reductions in several disciplinary outcomes, despite finding no detectable effect on later state achievement-test scores (Gray-Lobe et al., 2023). Thus, an absence of persistent test-score effects does not necessarily imply an absence of longer-term educational benefits.

Some high-quality programs have demonstrated persistent academic effects. Research on New Jersey's Abbott preschool program found positive effects through 10th grade in language arts/literacy, mathematics, and science, along with reduced grade retention. Effects were substantially stronger for children who attended for two years beginning at age 3 than for children who attended for only one year at age 4 (National Institute for Early Education Research [NIEER], 2021).

Program quality matters, although the relationship between measured quality and child outcomes is not large in every study. A broad meta-analysis found that higher early-childhood education and care quality was significantly associated with better literacy, mathematics, behavioral skills, and social competence and with fewer behavioral and social-emotional problems; however,

average effect sizes were small. Process-quality indicators, such as the quality of interactions and instruction, were generally more consistently associated with outcomes than structural characteristics alone (Bleses et al., 2023).

Public access remains incomplete. In the 2024–2025 school year, state-funded preschool enrolled nearly 1.8 million children, representing 37% of U.S. 4-year-olds and 9% of 3-year-olds. When the major public programs are combined—state-funded preschool, preschool special education, and federal Head Start—approximately 46% of 4-year-olds and 17% of 3-year-olds were served (NIEER, 2025). These figures do not mean that all remaining children receive no preschool, because some attend private preschool or other early-care settings; rather, they demonstrate that publicly supported preschool is far from universal.

Funding is substantial but uneven. States spent nearly \$14.4 billion on preschool in 2024–2025; including reported federal and local dollars, total spending was nearly \$17.7 billion. Average state spending was \$8,124 per enrolled child and average spending from all reported sources was \$9,988 per child. At the same time, spending and access varied greatly across states, and six states did not fund a program meeting NIEER's definition of state-funded preschool (NIEER, 2025).

Quality also varies within the publicly funded system. In 2024–2025, only 21% of children enrolled in state-funded preschool were in programs meeting nine or ten of NIEER's ten quality-standard benchmarks, while 46% were enrolled in programs meeting five or fewer benchmarks (NIEER, 2025). Consequently, increasing enrollment alone does not guarantee that children receive an intervention of sufficient quality to produce lasting benefits.

Taken together, the evidence suggests that high-quality preschool can reduce the likelihood that children—particularly disadvantaged children—enter school already behind, and it can produce benefits that extend into later schooling and adulthood. However, preschool by itself should not be viewed as a permanent safeguard against later academic difficulty. Initial achievement gains frequently diminish, access to publicly supported programs remains incomplete, and program quality varies substantially. These findings support a broader prevention model in which strong early-childhood education is followed by continued identification and remediation of learning gaps during elementary and secondary school, rather than relying exclusively on an intervention delivered before kindergarten. The table below summarizes key statistics regarding publicly-funded preschool programs in the United States.

Key National Access and Funding Indicators, 2024–2025

Indicator	National figure
Children enrolled in state-funded preschool	Nearly 1.8 million
4-year-olds in state-funded preschool	37%
3-year-olds in state-funded preschool	9%
4-year-olds served by major public preschool programs combined	46%
3-year-olds served by major public preschool programs combined	17%
State preschool spending	Nearly \$14.4 billion
Total reported state, federal, and local preschool spending	Nearly \$17.7 billion
Average state spending per enrolled child	\$8,124
Average spending per child from all reported sources	\$9,988

Note. Major public programs include state-funded preschool, preschool special education, and federal Head Start. Source: NIEER (2025).

Key takeaways from this research are that preschool can be very beneficial in building knowledge and skills that form the basis of what children learn later in schools, such benefits can degrade if not maintained, these Federally-funded programs are expensive, and not all students are served by them.

In recent years, we have been conducting research and publishing papers showing how a simple self-assessment and remediation method that takes 10 minutes to learn and can be implemented for free greatly boosts student achievement around the world. A major benefit of this method is that it empowers the student and places agency with him/her, thus enabling the student to use this method for a lifetime and both sustain and build on knowledge gains. The present paper explores whether this method will work on preschoolers and if it could be used both to supplement and sustain benefits of early education initiatives.

This method is built on a framework called Cognitive Structure Analysis. 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; Challagulla and Leddo, 2025).

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. 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 self-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 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, 2025h).

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 percentage points higher than those who simply reread the material.

The studies done in the US and other countries all involved a similar format in which the experimenters administered the instructional sessions and/or prepared the instructional materials and post-test to be used. This is appropriate to establish experimental control when exploring a new topic and engaging in systematic replication. However, for the self-assessment and remediation technique to be useful in the classroom, it must also work when incorporated into a classroom's normal mode of operation without the participation of the experimenters. This was addressed by testing whether self-assessment and remediation would raise physics scores of 8th grade students in China (Chen and Leddo, 2025a). In that study, those students using self-assessment and remediation scored 23 percentage points higher than students who did not. Chen and Leddo (2025b) followed up that study with 2nd grade reading students in China and found that those using self-assessment and remediation scored 15 percentage points higher on a post-test than those who did not. Challagulla, Challagulla and Leddo (2025) found that elementary school students in India who used the self-assessment method scored 22 percentage points higher on a reading post-test than those who did not.

These investigations in classrooms included having the teachers explain self-assessment to the students. While this is a reasonable activity for teachers to perform, we wanted to explore whether reducing teacher workload to the simple requirements of handing the students the self-assessment templates and checking to make sure the students filled them in (without actually analyzing the content) would still produce educational gains. Such an investigation was conducted by Gajula and Leddo (2026). In that study, an elementary school math teacher taught a unit on arithmetic operations. Prior to introducing self-assessment, the teacher gave an interim test. After that, half the students were given the self-assessment templates and told to fill them out, including what they learned after remediating their self-identified knowledge gaps, and half were not given self-assessment templates. Instruction continued for three more weeks, with self-assessment students filling out their templates once a week and the teacher checking to make sure they did. At the end of the three-week period, the teacher gave a final exam. Results showed that students in the self-assessment condition scored, on average, 18.5 percentage points higher on the final exam than did the students in the control condition. Moreover, control condition students showed no improvement, on average, over the three-week period. On the

other hand, students in the self-assessment condition improved, on average, by 16.5 percentage points with all but one student raising their scores (the one student who did not show increased performance scored 90% on both the interim and final tests).

The Gajula and Leddo (2026) study was followed up by one involving high school reading (Bajwa, Leddo and Verdu, 2026). In that study, the teacher gave a reading assignment. Afterwards, half the students received the self-assessment for reading and filled it out. Both the self-assessment and no-self-assessment students had an opportunity to review the material before a test was given the next day. Those doing the self-assessment scored on average 96% on the test and improved, on average, by 29 percentage points over their previous averages in that class with each student showing score improvement. The lowest test score in the self-assessment group was 80%, which represented 40 percentage points improvement over the student's previous class average of 40%. That student did not have the largest improvement. Another student who also had a 40% average in the class scored 100% on the test given after the reading assignment. On the other hand, those who did not receive the self-assessment template, scored on average 82% on the test and showed no improvement, on average, compared to their previous averages in the class.

The next series of field trials involved a high school in Nigeria (Ifenatuora et al., 2026). The effectiveness of self-assessment was tested in five subjects: math, chemistry, business, government and grammar. In all cases, students using the self-assessment method showed improved test performance. Average test scores for students using the self-assessment method vs. those who did not were 82% vs 64% for chemistry, 97% vs. 78% for math, 87% vs. 79% for business, 85% vs. 52% for government and 91% vs. 81% for grammar. The lowest test score for any student using the self-assessment method was 70%, which occurred in the government class, the class that had the lowest average test score for students not using the self-assessment method. Moreover, in the government class, the highest test score achieved by a student not using the self-assessment method was 68%, which meant the lowest performing student who used the self-assessment method did better than the highest performing student who did not. Additionally, a Levene's test showed that for the subjects of math, chemistry and business, the variability in scores was lower in the self-assessment group than it was in the no self-assessment group. This suggests that, in some cases, the self-assessment method not only raises student achievement but reduces the difference in performance between high and low performing students, thus helping to close the achievement gap.

Given that our experiments in Africa showed that self-assessment can reduce the variability between high and low-performers, Bajwa, Rutz and Leddo (2026) investigated whether self-assessment could reduce the achievement gap between White/Asian and Black/Hispanic students. Testing in a high school AP Psychology class, Bajwa et al. found that students using

CSA-based assessment and remediation scored nearly 40 percentage points, on average, higher on the teacher's unit test than did those who did not use self-assessment. Moreover, for students not doing self-assessment, White/Asian students scored 38 percentage points higher, on average, than did Black/Hispanic students. However, those students using CSA-based self-assessment and remediation, Black/Hispanic students' test scores were statistically equal to those of White/Asian students and roughly two letter grades higher than the scores of White/Asian students who did not use self-assessment. These results were replicated by Mishra and Leddo (2026b), who found that self-assessment not only improved test performance in 9th grade marketing students, but also resulted in Black/Hispanic students once again scoring statistically equal to White/Asian students (88% vs 89%, respectively).

More recently, Mishra and Leddo (2026a) showed that CSA-based self-assessment and remediation could even improve students' SAT scores. They found that with just a week of practice, students using self-assessment boosted their SAT Math scores by 45 points and SAT Reading by 33 points, on average, while a control group studying SAT without self-assessment showed no improvement in SAT scores.

These cumulative successes led to the creation of a free website, www.metyfoundation.org, in which people can obtain self-assessment templates, created by AI, for any subject, grade/topic, and language. Chandhu and Leddo (2026a) found that the AI-generated self-assessment templates led to increased performance of 19.5 percentage points in 11th grade math, whereas Chandhu et. al (2026b) found that the AI-generated self-assessment templates led to a 74% improvement after a single session in students' ability to solve hard SAT math problems. Chandhu and Leddo (2026c) further found that using the AI-generated self-assessments led to a 16.5 percentage point increase from pre-test to post-test in 8th grade math students.

The previous studies were conducted with elementary school (2nd grade) to college students. We wanted to see if preschoolers could also benefit from self-assessment and remediation. In this way, the hope is that no children have to fall behind and later play catch up.

METHOD

Participants

Participants were 56 pre-school students who attended Birla Open Minds Preschools in Hyderabad, India. All preschoolers were either five or six years old.

Materials

The educational content for the students was provided by the teacher, based on normal classroom curriculum. The topic covered was animal habitats. There was a single 10-question test created by the teacher.

Previous self-assessment templates that we have used in our research started with a definition of the four different types of knowledge in the INKS framework, gave students a sample self-assessment for the general topic they were studying, asked them to self-assess their own knowledge using the four categories and then list what they learned after they remediated their self-assessed learning needs.

We considered this to be inappropriate for the present age group for two reasons. Most importantly, we expected the reading skills of the present students to be basic and providing them with technical descriptions of categories of knowledge and then a detailed transcript of a self-assessment to be overwhelming. Second, our research with 5th graders (Bekkari and Leddo, 2023) suggests that younger children's scholastic performance depends on their factual and procedural knowledge while strategic and rationale knowledge do not play a statistically significant role.

Accordingly, we chose to modify our self-assessment template by eliminating the extensive text that precedes the areas that students fill in and including only factual and procedural knowledge. Because we were still unsure as to the best way to implement self-assessment in a template form for preschoolers, we created three versions of the template in order to measure which, if any, would lead to improved performance. At the school's request, each template was written in English.

Template 1 contained four fields for students to fill in: Today's Lesson; I know... draw or tell; I want help with... draw or tell; Now I know... draw or tell.

Template 2 was closer to our typical self-assessment template in that was tied to the specific topic the student was learning. Therefore, the template had the header: "Today's Lesson: Animal Homes: Where Do Animals Live?" It contained the following fields for students to fill in: I can name... What animal homes can you name?; I can show... Draw or show where an animal lives; I want help with... What do you still want help learning?; Facts I know now... What do you now know about animal homes?; Things I can do now... What can you do now after learning about animal homes?

Template 3 was similar to template 2 in that the topic was listed at the top using the same wording as in template 2. It was slightly different in that the initial self-assessment used language

that was similar to what one might see in a more INKS-aligned template. It contained the following fields: Facts I know... What facts do I know?; Things I can do... What can I do with what I know about animal homes?; I want help with... What is still hard for me?; Now I can name... What animal homes can I name now?; Now I can show... Draw or show where an animal lives.

In all cases, to compensate for individual differences in writing levels, a student could write or draw his or her answer.

Procedure

Participants were divided into one of the four conditions (control or one of the three assessment conditions). In addition to varying the contents of the self-assessment templates, the procedure was varied as well among the groups to see if that combination of format and template would have a positive effect. For the control condition, Participants received the instruction and then the test. For the Template 1 group, Participants received the instruction, filled out the template and then took the test. For the Template 2 and 3 groups, Participants filled out the existing knowledge parts of the templates and what they still needed to learn, then they received the instruction, then filled out what they learned as a result of the instruction and then took the test. Because of absenteeism, not all Participants took the final test. As a result, the groups had unequal numbers of Participants. The resulting group sizes were control, 14; Template 1, 18; Template 2, 10; Template 3, 14.

RESULTS

The tests were scored out of 10 possible correct by the teacher using her normal grading. Table 1 below shows the mean post-test scores, broken down by condition.

Table 1: Mean Post-test Scores by Condition

Control	Template 1	Template 2	Template 3
6.36	8.00	8.50	7.21

Results showed that all of the self-assessment groups had higher means than the control group (no self-assessment). The biggest difference (8.50 vs. 6.36 or 21.4 percentage points) was shown by the Participants who used Template 2, which was tailored to the specific topic, used simpler language to describe the terms and had Participants fill out the template before and after the instruction. This difference was statistically significant, $t(22) = 2.39$, $p = .026$, Hedges' $g = .96$.

The next biggest difference (8.00 vs. 6.36 or 16.4 percentage points) was shown by the Participants who used Template 1, a generic template not tied to a specific topic, used simpler language to describe the terms and had Participants fill out the template after instruction. This difference was statistically significant, $t(30) = 2.17$, $p = .038$, Hedges' $g = .75$. The Template 3 condition, which had a template that was similar to Template 2, except that it had language closer to terminology described in the INKS framework, and followed the same procedure as the Template 2 condition did not have results that were statistically significantly different than the control condition.

Finally, within the self-assessment template conditions, Participants using Template 2 scored higher on the post-test than those using Template 3 (8.50 vs. 7.21), $t(22) = 3.40$, $p < .003$, Hedges' $g = 1.36$. Participants using Template 1 also scored higher than those using Template 3 (8.00 vs 7.21), but this difference only approached statistical significance, $t(30) = 1.70$, $p < .10$, Hedges' $g = .59$. Finally, the difference in performance by Participants in Template groups 1 and 2 were not statistically different from each other. Collectively, the results suggest that self-assessment can work on younger students. The key variable seems to be using simple language. The Template 2 condition included the categories of knowledge and also a pre- and post-instruction self-assessment. These produced a higher, but not statistically significant, post-test average score. Further research can be done to explore whether these additional variables can influence self-assessment effectiveness.

Another question that could be asked is whether self-assessment reduced the variability in the different groups' test scores. As we noted in our previous research, e.g., Ifenatuora et al. (2026), groups of students using self-assessment may show less variability in their test scores than students not using self-assessment. The reason for this is that improvement offered by self-assessment often eliminates lower scores, and those using self-assessment show greater improvement because they have more room for improvement, thus bringing their scores more in line with those of high scoring students. We see evidence of this as the ranges of scores in the four groups were: Control, 3-10; Template 1, 5 to 10; Template 2, 7 to 9.5; Template 3, 5 to 8. Table 2 shows the standard deviation associated with each of the conditions.

Table 2: Standard Deviation of Post-test Scores by Condition

Control	Template 1	Template 2	Template 3
2.73	1.50	.82	.97

To test whether these differences in standard deviations were statistically significant, we performed a Brown-Forsythe version of Levene's test. This test was chosen due to the relatively small sample size per group and the limited score range of 0-10. The overall result was $F(3,52) =$

7.40, $p = .0003$, suggesting differences in variability among the groups. Further analysis showed that, consistent with our previous findings, e.g, Ifenatuora et al. (2026), the control group showed greater variability than each of the self-assessment groups: control vs. Template 1, variance ratio is 3.35, $p = .004$; control vs. Template 2, variance ratio is 11.22, $p = .003$; control vs. Template 3, variance ratio is 7.97, $p = .001$. While there was some variability among the standard deviations in scores in the three self-assessment groups, none of the pairwise comparisons yielded statistically significant differences.

DISCUSSION

This study aimed to evaluate the effectiveness of self-assessment and remediation using Cognitive Structure Analysis (CSA) in helping preschoolers improve academic performance. Three different self-assessment templates were used. Based on prior research (Bekkri and Leddo, 2023), all templates included factual and procedural knowledge only. Two of the templates, Template 1 (16.4 percentage points) and Template 2 (21.4 percentage points) produced statistically significant improvements in performance compared to the control group. Template 3 produced higher performance as well, but the difference was not statistically significant. The key factor in producing the effects seemed to be incorporating simple language to describe the types of knowledge for the students to self-assess. Both Template 1 and Template 2 used the simpler language whereas Template 3 used language that was closer to terms used in the INKS framework. Consequently, Participants using Template 2 scored significantly higher on the post-test than did those using Template 3 and the higher performance of those using Template 1 approached statistical significance compared to those using Template 3.

The other key finding was that the variability in performance of all groups of self-assessment Participants was lower than the variability in performance in the control group. This is noteworthy in that self-assessment appears, as in our prior research (Ifenatuora et al., 2026), to reduce variability in student performance by raising the scores of lowest performing students the most, thus reducing the gap between low and high performers. This is relevant for those interested in equity in education and reducing disparities in performance between low and high performing students.

The present study, along with others cited in the Introduction of this paper, demonstrates that a simple and free self-assessment technique that takes 10 minutes for students to learn and that can be done for homework, without changing how teachers teach and test their students, dramatically raises student achievement. What the government and educational community has failed to achieve in the past 50 years can now be achieved, for free, in 10 minutes.

What makes this study noteworthy is that the present study shows that a CSA-based self-assessment method can boost performance by as much as two full letter grades in preschoolers, a result consistent with findings for other grade levels. Collectively, we have now shown that our self-assessment method greatly improves performance in students from preschool all the way up to college. If we examine some of the challenges faced with publicly funded preschool programs designed to serve underserved communities, we see that issues that need to be address include universal access (not all eligible children are served), the high cost of delivering service, and preserving throughout the years the gains achieved in preschool. Self-assessment using CSA can be a valuable tool. It is available to all students and is free to implement. Moreover, since we have documented that it produces gains at any age, students can build on their early gains by sustaining self-assessment as they progress in school.

There is no apparent downside to implementing this self-assessment method. It produces large educational gains across the board, it takes only 10 minutes to implement, is completely free, incurs virtually no burden to teacher workload, requires no additional teacher training or change to curriculum/testing, and is politically non-controversial. Furthermore, should a teacher choose, s/he could read the students' self-assessments to see where their learning needs are and use that to inform daily teaching, and administrators could use the aggregated student self-assessment data to make data-driven decisions about curriculum design and selection of instructional materials.

When George W. Bush became president of the United States in 2001, he established an educational initiative called "No Child Left Behind." The implication in the initiative's name is that children can fall behind but then would be "rescued" through educational initiatives. Unfortunately, today, there are still millions of children who are still left behind. Our CSA-based assessment method suggests that since it works on preschoolers to college-aged students, children do not have to fall behind to begin with. In the present study, for those using Template 2, the lowest score was 70%, which is considered a C by United States educational standards. With our self-assessment method, the new motto can be "No Child Falls Behind."

There is one area of further research that would be most interesting. Currently, after self-assessing, students perform their own remediation, which means that they have to review their instructional materials and find the relevant information to fill in their knowledge gaps. Our body of research in self-assessment shows that students can do this very well. However, in recent years, we have seen a proliferation of large language models (LLMs) and their use by students for their schoolwork. While LLMs are very powerful, they are inherently language models that provide answers to the questions they are asked. If 100 people ask the same question, it is still the same question and therefore, these people will get the same answer. However, people do not talk to each other the same way. We do not talk to children the same way we talk to adults. We

do not talk to people with little knowledge of a subject area the way we talk to people who know a lot about it. LLMs do not make these distinctions.

Recently, we have been conducting experiments in which we incorporate self-assessment into LLM-based chatbots. Students perform an initial self-assessment on the topic they wish to learn about, and that information is fed to the chatbot with the instructions to tailor answers to students' questions to focus on filling self-assessed knowledge gaps. We have tested this approach on a variety of subject areas (Ganne and Leddo, 2026; Rapolu and Leddo, 2026a; Maviti and Leddo, 2025; Maviti, Leddo and Prakash, 2025; Wang and Leddo, 2025). In these tests, students learn a new subject by using either our self-assessment chatbot or a standard LLM like ChatGPT or Gemini. The instruction is followed by a post-test. We find that those using the self-assessment chatbot score, on average, the equivalent of one to four letter grades (roughly 10 to 40 percentage points) higher on the post-test than those who use a standard LLM. Rapolu and Leddo (2026b) found that while students who used self-assessment showed improvement in performance, those who used a self-assessment chatbot showed an additional 10 percentage points improvement. This suggests that AI can enhance the effectiveness of CSA-based self-assessment and remediation by assisting the remediation process. By creating a simpler interface, perhaps using voice, we can test whether a self-assessment chatbot can enhance learning in preschoolers.

We have established a non-profit called METY Foundation in order to disseminate the self-assessment method free of charge to all who want to use it (www.metyfoundation.org). Students and teachers are able to access self-assessment templates in any subject, grade and language. They can print templates and students can fill out templates online and then email self-assessment reports to parents and teachers. We are implementing a capability for teachers to register their classrooms and receive analytics on students' knowledge strengths and learning needs to support teaching. Ultimately, the self-assessment chatbot technology will be included as well to provide personalized remedial instruction.

REFERENCES

- Administration for Children and Families. (n.d.). Head Start and Early Head Start. Childcare.gov. <https://childcare.acf.gov/consumer-education/what-are-my-child-care-options/head-start-and-early-head-start>
- Ahmad, M. and Leddo, J. (2023). The Effectiveness of Cognitive Structure Analysis in Assessing Students' Knowledge of the Scientific Method. *International Journal of Social Science and Economic Research*, 8(8), 2397-2410.

Bajwa, J., Leddo, J. and Verdu, M. (2026). Incorporating Student Self-assessment and Remediation into Classroom Instruction Greatly Improves Educational Performance in High School Reading Students. *International Journal of Social Science and Economic Research*, 11(3), 1073-1084.

Bekkari, V. and Leddo J. (2023). Cognitive Structure Analysis: Assessing Elementary School Students in Math to Determine the Types of Knowledge They Have. *International Journal of Social Science and Economic Research*, 8(10), 3260-3269.

Bleses, D., et al. (2023). Early childhood education and care quality and associations with child outcomes: A meta-analysis. *PLOS ONE*, 18, e0285985. <https://doi.org/10.1371/journal.pone.0285985>

Challagulla, M. and Leddo, J. (2025). Assessing and Remediating Knowledge Improves Problem-solving Performance in Middle School Math Compared to Remediating Problem-solving Steps. *International Journal of Social Science and Economic Research*, 10(8), 3574-3586.

Challagulla, R., Challagulla, L. and Leddo, J. (2025). Improving Reading Comprehension in Elementary School Students in India by Teaching Them to Self-Assess and Remediate Their Own Learning Needs. *International Journal of Social Science and Economic Research*, 10(10), 5586-5596.

Chandhu, H. and Leddo, J. (2026a). AI-Generated Self-Assessment Templates Greatly Improve Math Performance in 11th Graders: A Test of the METYFoundation.org Free Self-Assessment Website. *International Journal of Social Science and Economic Research*, 11(8), 4378-4393.

Chandhu, H. and Leddo, J. (2026b). Improving SAT Test Performance by Having Students Engage in Self-Directed Learning Using Self-assessment and Remediation With METYFoundation.org-Generated Templates. *International Journal of Social Science and Economic Research*, 11(9), 4793-4809.

Chandhu, H. and Leddo, J. (2026c). AI-Generated Self-Assessment Templates Greatly Improve Math Performance in 8th Graders: A Test of the METYFoundation.org Free Self-Assessment Website. *International Journal of Social Science and Economic Research*, 11(9), in press.

Chen, Y. and Leddo, J. (2025a). Using Self-Assessment and Remediation to Raise Chinese Middle School Achievement in Physics. *International Journal of Social Science and Economic Research*, 10(9), 4473-4482.

Chen, Y. and Leddo, J. (2025b). Using Self-Assessment and Remediation to Raise Chinese Primary School Achievement in Reading. *International Journal of Social Science and Economic Research*, 10(10), 5576-5585.

Cynkin, C. and Leddo, J. (2023). Teaching students to self-assess using Cognitive Structure Analysis: Helpingr students determine what they do and do not know. *International Journal of Social Science and Economic Research*, 08(09), 3009-3020.

Dandemraju, A., Dandemraju, R., and Leddo, J. (2024). Teaching students to self-assess their knowledge of chemistry using cognitive structure analysis. *International Journal of Social Science and Economic Research*, 09(02), 541–549.

de Kleer, J. and Brown, J.S. (1981). Mental models of physical mechanisms and their acquisition. In J.R. Anderson (Ed.), *Cognitive skills and their acquisition*. Hillsdale, NJ: Erlbaum.

Dietrichson, J., Kristiansen, I. L., & Viinholt, B. A. (2020). Universal preschool programs and long-term child outcomes: A systematic review. *Journal of Economic Surveys*, 34(5), 1007–1043. <https://doi.org/10.1111/joes.12382>

Gagula, A. and Leddo, J. (2026). Incorporating Student Self-assessment and Remediation into Classroom Instruction Greatly Improves Educational Performance in Elementary School Math Students. *International Journal of Social Science and Economic Research*, 11(2), 803-814.

Ganne, Y. and Leddo, J. (2026). Evaluating the Impact of Personalized Adaptive AI vs. Standardized ChatGPT on the Short-Term Academic Performance in Adolescents. *International Journal of Social Science and Economic Research*, 11(3), 1059-1072.

Gray-Lobe, G., Pathak, P. A., & Walters, C. R. (2023). The long-term effects of universal preschool in Boston. *The Quarterly Journal of Economics*, 138(1), 363–411. <https://doi.org/10.1093/qje/qjac036>

Ifenatuora, G. P., Leddo, J., Sobayo, A. J., Ogude, O. F., Demian, G. C., & Emodi, U. S. (2026). Incorporating student self-assessment and remediation into classroom instruction greatly improves educational performance in senior secondary students in Nigeria. *International Journal of Social Science and Economic Research*, 11(4), 1622–1636.

Leddo, J. and Ahmad, M. (2024). Do You Want to Raise Student Achievement? Then, Assess and Remediate Knowledge, Not Problem-solving Performance. *International Journal of Social Science and Economic Research*, 9(1), 249-261.

Leddo, J., Clark, E. and Clark, A. (2025). Using self-assessment and remediation to raise middle school student achievement in math. *International Journal of Social Science and Economic Research*, 10(3), 1083-1092.

Leddo, J., Cohen, M.S., O'Connor, M.F., Bresnick, T.A., and Marvin, F.F. (1990). Integrated knowledge elicitation and representation framework (Technical Report 90-3). Reston, VA: Decision Science Consortium, Inc.

Leddo, J., Li, S. and Zhang, Y. (2022). Cognitive Structure Analysis: A technique for assessing what students know, not just how they perform. *International Journal of Social Science and Economic Research*, 7(11), 3716-3726.

Maviti, A. and Leddo, J. (2025). A Self-assessment Chatbot Greatly Outperforms Chat GPT in Teaching High School Students Calculus. *International Journal of Social Science and Economic Research*, 10(10), 5519-5531.

Maviti, A., Leddo, J. and Prakash, P. (2025). A Self-assessment Chatbot Greatly Outperforms Gemini in Teaching High School Students Calculus. *International Journal of Social Science and Economic Research*, 10(11), 6073-6085.

Mishra, G. and Leddo, J. (2026a). Improving SAT Test Performance by Having Students Engage in Self-assessment and Remediation. *International Journal of Social Science and Economic Research*, 11(8), 4345-4360.

Mishra, G. and Leddo, J. (2026b). Self-Assessment and Remediation Using Cognitive Structure Analysis Greatly Improve Test Performance in 9th Grade Marketing Students. *International Journal of Social Science and Economic Research*, 11(9), in press.

National Institute for Early Education Research. (2021, May 6). Positive effects of universal high-quality preschool persist through 10th grade. <https://nieer.org/research-library/positive-effects-universal-high-quality-preschool-persist-through-10th-grade>

National Institute for Early Education Research. (2025). The State of Preschool 2025: Executive summary. Rutgers Graduate School of Education. <https://nieer.org/yearbook/2025/executive-summary>

Nehra, P. and Leddo, J. (2024). The effects of Cognitive Structure Analysis in self-assessing and remediating knowledge gaps in introductory Spanish. *International Journal of Social Science and Economic Research*, 9(12), 5956-5964.

Newell, A. and Simon, H. (1972). Human Problem Solving. Prentice-Hall.

Quillian, M. R. (1966). Semantic memory. In M. Minsky (Ed.), *Semantic Information Processing* (pp. 227-270). MIT Press.

Prakash, P. and Leddo, J. (2025a). Using Self-Assessment and Remediation to Raise Student Achievement in Reading Comprehension. *International Journal of Social Science and Economic Research*, 10(1), 277-286.

Prakash, P. and Leddo, J. (2025b). Using Self-Assessment and Remediation to Raise Student Achievement in Mathematics. *International Journal of Social Science and Economic Research*, 10(1), 447-456.

Prakash, P. and Leddo, J. (2025c). Using Self-Assessment and Remediation to Raise Student Achievement in History. *International Journal of Social Science and Economic Research*, 10(3), 650-659.

Prakash, P. and Leddo, J. (2025d). Using Self-Assessment and Remediation to Raise Middle School Student Achievement in Reading Comprehension. *International Journal of Social Science and Economic Research*, 10(3), 1130-1140.

Prakash, P. and Leddo, J. (2025e). Using Self-Assessment and Remediation to Raise Middle School Student Achievement in Science. *International Journal of Social Science and Economic Research*, 10(4), 1471-1482.

Prakash, P. and Leddo, J. (2025f). Using Self-Assessment and Remediation to Raise Middle School Student Achievement in History. *International Journal of Social Science and Economic Research*, 10(6), 2429-2440.

Prakash, P. and Leddo, J. (2025g). Using Self-Assessment and Remediation to Raise Elementary School Student Achievement in Mathematics. *International Journal of Social Science and Economic Research*, 10(9), 4058-4068.

Prakash, P. and Leddo, J. (2025h). Using Self-Assessment and Remediation to Raise Elementary School Student Achievement in Reading. *International Journal of Social Science and Economic Research*, 10(10), 5532-5541.

Rapolu, S. and Leddo, J. (2026a). The Impact of a Self-Evaluation Chatbot on High School Students' Learning of Cell Communication. *International Journal of Social Science and Economic Research*, 11(1), 320-333.

Rapolu, S. and Leddo, J. (2026b). A Comparison of the Relative Effectiveness of Student Self-Assessment/Remediation vs. Using a Self-Assessment Chatbot on Raising Student Performance. *International Journal of Social Science and Economic Research*, 11(7), 3613-3629.

Ravi, D. and Leddo, J. (2024). Improving Student Performance by Having Students: Assess and Remediate Their Own Knowledge Deficiencies. *International Journal of Social Science and Economic Research*, 9(10), 4717-4724.

Sathiyamoorthy, S.S. and Leddo, J. (2025). Using Self-Assessment and Remediation to Raise College Student Achievement in Psychology. *International Journal of Social Science and Economic Research*, 10(5), 1859-1869.

Schank, R. C. and Abelson, R. P. (1977). *Scripts, plans, goals, and understanding*. Lawrence Erlbaum.

Zhou, L.N. and Leddo, J. (2023). Cognitive Structure Analysis: Assessing Students' Knowledge of Precalculus. *International Journal of Social Science and Economic Research*, 8(9), 2826-2836.