

# Impact of Student Learning Strategies on Academic Development and Psychological Well-Being among Children with Autism Spectrum Disorder

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## ABSTRACT:

This cluster-randomised controlled trial examined whether explicitly taught, neurodiversity-affirming learning strategies could simultaneously advance academic development and psychological well-being among children with Autism Spectrum Disorder (ASD). Employing a mixed-methods longitudinal design (N = 360; ages 7–12), participants were allocated to Integrated Strategy Instruction (ISI), Standard Strategy Support, or an active control condition. Multilevel modelling revealed that ISI yielded statistically significant and educationally meaningful gains in both domains: academic outcomes (Hedges'  $g = 0.33–0.42$ ) and psychological well-being ( $g = 0.58–0.71$ ), with effects sustained across four assessment waves. Structural equation modelling confirmed partial

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mediation via strategy internalisation and academic self-efficacy, while moderation analyses indicated heightened benefit for learners with elevated baseline anxiety or executive function challenges. Latent growth curves demonstrated compensatory trajectories, with initially lower-performing students exhibiting steeper improvement under ISI. High implementation fidelity (>90%) and qualitative narratives underscored autonomy, sensory affirmation, and generalisation as active ingredients. These findings validate an integrated theoretical framework, uniting Cognitive Load Theory, Self-Determination Theory, and the Neurodiversity Paradigm, and offer a scalable, evidence-based pathway toward equitable, holistic education for autistic learners..

**Keywords:** Autism Spectrum Disorder; neurodiversity-affirming education; learning strategies; academic development; psychological well-being; self-regulation; cluster-randomised controlled trial.

**Introduction:**

Autism Spectrum Disorder (ASD) represents a neurodevelopmental condition characterized by heterogeneous profiles in social communication, sensory processing, and executive functioning. With global prevalence estimates now exceeding 1 in 36 children [1], educational systems worldwide face the pressing challenge of designing instructional environments that honor neurocognitive diversity while fostering meaningful academic growth. Historically, educational interventions for learners with ASD have emphasized external behavior management and highly structured adult-directed instruction [2]. While these approaches have yielded measurable skill acquisition, they often overlook the internal cognitive and affective processes that sustain long-term learning. Contemporary educational neuroscience underscores the necessity of aligning pedagogical practices with the intrinsic information-processing preferences of autistic learners, particularly in contexts that demand self-initiated problem-solving and knowledge transfer [3], [4]. The paradigm shift toward neurodiversity-affirming education has catalyzed renewed interest in student-centered learning strategies [5]. Rather than viewing autism through a deficit lens, current frameworks recognize autistic cognition as possessing distinct strengths in pattern recognition, systematic thinking, and deep focus [6]. When instructional practices are adapted to leverage these cognitive profiles, students demonstrate enhanced

engagement and reduced reliance on compensatory masking behaviors [5]. Learning strategies such as visual scheduling, explicit metacognitive training, peer-mediated collaboration, and technology-supported scaffolding are increasingly embedded into inclusive classrooms [7], [8]. These approaches aim not only to improve content mastery but also to cultivate learner autonomy, self-efficacy, and adaptive coping mechanisms [9], [10]. Student learning strategies encompass a spectrum of cognitive, metacognitive, behavioral, and affective techniques that learners deploy to encode, organize, and retrieve information [11]. For children with ASD, strategy instruction must account for differences in working memory capacity, sensory sensitivity, and social information processing [12], [13]. Explicit teaching of planning, self-monitoring, and strategy selection has been shown to reduce cognitive overload and promote generalized skill application across academic domains [3]. Importantly, strategy use is not static; it evolves through repeated practice, feedback, and reflective adjustment, making it a critical target for longitudinal educational research [11]. Academic development in autistic children extends beyond standardized achievement metrics to encompass functional literacy, numeracy fluency, executive function maturation, and cross-contextual generalization [14]. Many learners with ASD demonstrate uneven academic profiles, excelling in rule-based or visually structured tasks while struggling with open-ended or socially embedded

assignments [8], [13]. Learning strategies that incorporate multimodal representation, chunked instruction, and predictable routines have consistently mitigated these disparities [3], [8]. However, the sustainability of academic gains depends heavily on whether students internalize these strategies as self-regulatory tools rather than externally imposed compliance mechanisms [7].

Concurrently, psychological well-being has emerged as a pivotal yet under-prioritized outcome in ASD educational research [10], [15]. Autistic children exhibit elevated rates of anxiety, depressive symptoms, somatic stress, and diminished self-concept, particularly in mainstream school settings where masking demands are high [9], [10]. Psychological well-being in this population is closely tied to perceived competence, social belonging, and the degree to which learning environments accommodate neurocognitive differences [5], [10]. When instructional practices ignore affective dimensions, academic progress often plateaus or reverses due to chronic stress, avoidance behaviors, and diminished motivation [15], [16].

The interplay between academic development and psychological well-being is fundamentally bidirectional [16]. Effective learning strategies that reduce cognitive friction and enhance predictability can lower autonomic arousal, thereby improving attentional control and emotional regulation [3], [4]. Conversely, students with stronger psychological resilience are more likely to persist through academic challenges, experiment with novel strategies, and recover from setbacks [17]. Emerging longitudinal data suggest that interventions targeting both domains simultaneously yield more durable outcomes than siloed approaches [16]. Nevertheless, the mechanisms underlying this synergy remain inadequately mapped in empirical literature.

Current research exhibits several critical limitations. Many studies isolate academic or psychological outcomes, employ short-term designs, or rely on adult-reported measures that fail to capture student-perceived strategy utility [7], [18]. Furthermore, strategy instruction is frequently

delivered in a prescriptive manner, neglecting individual preference profiles, cultural contexts, and the developmental trajectory of self-advocacy skills [5]. The field lacks integrative models that explicitly link strategy type, implementation fidelity, neurocognitive profile, and dual-domain outcomes [16], [19]. Without such frameworks, educators are left to navigate intervention selection through trial and error rather than evidence-based decision-making [19].

This study addresses these gaps by examining how systematically implemented student learning strategies influence both academic development and psychological well-being among children with ASD. Grounded in contemporary neurodiversity-affirming principles and cognitive-educational theory, the investigation seeks to identify which strategy clusters yield optimal dual-domain benefits, how individual differences moderate these effects, and what implementation conditions maximize sustainable outcomes [5], [3]. The findings aim to inform scalable, student-centered pedagogical frameworks that align with the priorities of modern inclusive education and developmental psychology [8], [19].

Despite substantial advancements in special education and clinical intervention, children with Autism Spectrum Disorder continue to experience disproportionate academic underachievement and elevated psychological distress within mainstream and specialized learning environments [2], [5]. Traditional pedagogical models often prioritize compliance, rote skill acquisition, and externally regulated behavior management, inadvertently marginalizing student agency and internal self-regulation capacities [12]. This misalignment between instructional design and neurocognitive processing preferences results in fragmented learning experiences, heightened cognitive load, and chronic stress that undermine long-term educational trajectories [3], [20].

Empirical literature remains inconsistent regarding the differential efficacy of specific learning strategies for autistic learners, particularly in their capacity to simultaneously support academic progress and mental health [7], [15]. Many studies

isolate outcome domains, employ homogeneous samples, or utilize brief intervention windows that fail to capture the developmental maturation of strategy use [18], [16]. Additionally, research frequently overlooks the moderating roles of baseline executive function, anxiety severity, and environmental accommodations, limiting the generalizability and ecological validity of existing findings [13], [15]. Consequently, educators and clinicians lack clear, evidence-based guidance for selecting and sequencing strategy instruction that aligns with individual neuroprofiles [19].

The absence of integrated, theoretically grounded frameworks that unite academic and psychological outcomes represents a critical barrier to equitable educational practice [5], [16]. Without systematic understanding of how learning strategies function as dual-domain catalysts, schools risk implementing fragmented or counterproductive interventions that exacerbate masking, diminish autonomy, and perpetuate achievement gaps [7]. Addressing this problem requires rigorous investigation into strategy typologies, implementation conditions, and student-centered outcome metrics that collectively advance neurodiversity-affirming education and holistic learner development [19].

### Research Objective:

The primary objective of this study is to evaluate the impact of explicitly taught student learning strategies on academic development and psychological well-being among children with Autism Spectrum Disorder (ASD).

Secondary objectives include:

- (1) Identifying specific strategy clusters that yield synergistic dual-domain benefits
- (2) Examining individual difference moderators, including baseline executive functioning, anxiety severity, and sensory processing profiles
- (3) Assessing the mediating role of strategy internalization and academic self-efficacy in the relationship between strategy instruction and long-term outcomes.

Grounded in an integrated theoretical framework encompassing Self-Determination Theory, Cognitive Load Theory, and the Neurodiversity Paradigm, this investigation aims to generate empirically validated, neurodiversity-affirming pedagogical guidelines that optimize holistic learner development within inclusive educational settings.

### Literature Review:

Cognitive Load Theory (CLT) provides a foundational lens for understanding how instructional design and learning strategies mitigate working memory overload in autistic learners. Children with ASD frequently experience heightened extraneous cognitive load due to unpredictable instructional pacing, ambiguous social-communicative demands, and poorly scaffolded task structures [3]. Strategic instructional adaptations such as visual scaffolding, stepwise task decomposition, and advance organizers systematically reduce irrelevant processing demands, thereby freeing cognitive resources for schema construction and long-term retention. Recent neuroimaging and behavioral studies confirm that optimized cognitive load correlates with improved task accuracy, faster skill acquisition, and lower physiological stress markers during academic engagement [4], [18].

Metacognitive and self-regulatory learning strategies have emerged as critical drivers of autonomous academic engagement in ASD populations. Grounded in Social Cognitive Theory, which posits that self-efficacy, outcome expectations, and self-monitoring interact to shape behavioral persistence [17], [11], metacognitive training equips learners with explicit tools to plan, evaluate, and adjust their approach to complex academic tasks. Empirical trials demonstrate that structured instruction in goal-setting, strategy selection, and reflective journaling significantly improves reading comprehension, mathematical problem-solving, and independent homework completion [7]. Importantly, when metacognitive practices are paired with autonomy-supportive feedback, students report higher perceived

academic competence and marked reductions in anxiety-related task avoidance.

The integration of technology-assisted and multimodal learning strategies has substantially expanded the pedagogical toolkit for autistic learners, closely aligning with Universal Design for Learning (UDL) principles [6]. Interactive digital platforms, AI-driven adaptive tutoring systems, and sensory-regulated learning interfaces provide personalized pacing, immediate formative feedback, and multiple representation pathways that accommodate diverse information-processing preferences [6]. Longitudinal analyses indicate that students utilizing multimodal strategy instruction demonstrate accelerated vocabulary acquisition, improved narrative sequencing, and enhanced cross-contextual generalization of academic skills [8]. Crucially, evidence suggests that when technology functions as a co-regulatory scaffold rather than a replacement for human-mediated instruction, it simultaneously supports cognitive engagement and emotional safety.

Academic development trajectories in ASD are heavily contingent upon executive function scaffolding embedded within strategy instruction. Deficits in working memory flexibility, inhibitory control, and cognitive shifting are well-documented in autistic children, necessitating structured yet adaptable learning frameworks that gradually transfer regulatory control to the student [2]. Research integrating CLT with executive function training demonstrates that strategy routines incorporating predictable sequencing, errorless learning phases, and systematic fade-out of adult prompts yield superior literacy and numeracy gains compared to traditional didactic approaches. These structured strategies also interrupt cycles of academic frustration, which historically contribute to school refusal behaviors and diminished academic self-concept.

Psychological well-being outcomes in autistic learners are increasingly conceptualized through student-reported indicators of stress regulation, self-acceptance, social belonging, and resilience. Studies employing Self-Determination Theory (SDT)-aligned strategy instruction report

significant reductions in trait anxiety and depressive symptomatology, alongside marked increases in intrinsic motivation and perceived autonomy support [9], [10]. Contemporary neurodiversity-affirming frameworks emphasize that sustainable well-being improvements stem not from symptom suppression or behavioral compliance, but from environmental validation of cognitive differences and the explicit cultivation of self-advocacy competencies [5]. When learning strategies honor individual sensory preferences and alternative communication styles, students exhibit lower cortisol reactivity, reduced masking behaviors, and higher voluntary classroom participation.

The bidirectional relationship between academic development and psychological well-being is best explained through an integrated theoretical model that positions strategy internalization as the central mediating mechanism. As learners repeatedly apply structured yet flexible strategies across academic contexts, they accumulate mastery experiences that enhance self-efficacy (Social Cognitive Theory) [17], reduce cognitive friction and overload (CLT) [3], and satisfy core psychological needs for autonomy, competence, and relatedness (SDT) [9]. This positive feedback loop fosters academic persistence while simultaneously buffering against stress-induced disengagement and burnout. Recent longitudinal cohort studies confirm that dual-domain gains are most robust and sustainable when strategy instruction is delivered within neurodiversity-affirming, student-choice-rich, and predictably structured learning environments [16].

Despite the growing empirical base, significant methodological limitations persist within the current literature. Existing research disproportionately relies on short-term randomized controlled designs that fail to capture the developmental maturation of strategy use or the long-term consolidation of self-regulatory skills. Furthermore, many studies inadequately measure strategy internalization, relying instead on adult-reported compliance metrics that obscure student-perceived utility and autonomy. Intersectional factors, including gender disparities in autism diagnosis, co-occurring intellectual or attentional

conditions, and socioeconomic variability in resource access, remain insufficiently examined, limiting the ecological validity and equitable application of findings [7], [18].

This study directly addresses these methodological and theoretical gaps by employing a mixed-methods longitudinal design that tracks strategy implementation, internalization, and dual-domain outcomes across multiple academic semesters. By integrating student-perceived strategy utility scales, objective physiological stress markers, and teacher implementation fidelity assessments, the research moves beyond compliance-based metrics to capture authentic learner experiences. Aligning empirical inquiry with contemporary educational neuroscience and neurodiversity theory, the investigation aims to generate scalable, evidence-based pedagogical frameworks that systematically optimize both academic trajectories and psychological well-being for autistic children, ultimately informing more equitable and learner-centered inclusive education policies [5], [19].

### Methodology:

his study employs a mixed-methods sequential explanatory design embedded within a three-arm cluster-randomized controlled trial (cRCT) to evaluate the impact of student learning strategies on academic development and psychological well-being among children with Autism Spectrum Disorder (ASD). The quantitative phase utilizes a longitudinal framework with four assessment waves (baseline, 3-month, 6-month, and 12-month follow-ups) to capture developmental trajectories and causal mechanisms. The qualitative phase incorporates semi-structured interviews and classroom observations to contextualize quantitative findings, explore students' perceived utility of strategies, and identify implementation barriers. This design aligns with contemporary standards for educational intervention research [19] and enables robust inference regarding both efficacy and ecological validity.

### Participants and Sampling Strategy:

#### Target Population and Inclusion Criteria:

Participants include children aged 7–12 years with a confirmed ASD diagnosis (per DSM-5-TR criteria; American Psychiatric Association, 2022), enrolled in inclusive or specialized elementary classrooms. Inclusion criteria require: (1) verified ASD diagnosis by a licensed clinician within the past 24 months; (2) cognitive ability within the mild-to-moderate range (Full-Scale IQ  $\geq 70$  on WISC-V or equivalent); (3) functional communication skills (verbal or augmentative); and (4) parental consent and child assent. Exclusion criteria include co-occurring severe intellectual disability, uncontrolled epilepsy, or significant sensory impairments unaddressed by accommodations.

**Sampling and Power Analysis:** A stratified cluster sampling approach will recruit participants from 45 classrooms across 15 public schools, ensuring representation across socioeconomic status, geographic region, and educational setting. An a priori power analysis using G\*Power 3.1 [22] indicates that a sample of  $N = 360$  students (120 per condition) provides 95% power to detect small-to-moderate effect sizes ( $f = 0.15$ ) in multilevel models at  $\alpha = .01$ , accounting for an anticipated intraclass correlation coefficient (ICC) of 0.05–0.08 and 20% attrition over 12 months. Randomization occurs at the classroom level to minimize contamination, with stratification by school type and baseline academic performance.

### Measures and Instruments:

#### Primary Outcome Measures

**Academic Development:** Composite score derived from (a) standardized achievement tests (Woodcock-Johnson IV Tests of Achievement [14]) assessing reading, mathematics, and written language; and (b) teacher-rated Curriculum-Based Measurement (CBM) probes administered biweekly to track skill fluency and generalization.

**Psychological Well-Being:** Multi-method assessment including (a) the Revised Child Anxiety and Depression Scale – Child Version (RCADS-25 [15]); (b) the PedsQL™ Emotional Functioning

Scale [23]; and (c) physiological stress markers (salivary cortisol sampled at standardized timepoints [20]).

#### Predictor and Moderator Variables:

**Learning Strategy Use:** The Learning Strategies Inventory for Autism (LSIA; adapted from [24]; validated for ASD populations by [7]), a 40-item student-report measure assessing frequency and perceived utility of cognitive, metacognitive, and resource-management strategies.

**Executive Function:** Behavior Rating Inventory of Executive Function – Second Edition (BRIEF-2 [12]), completed by teachers and parents.

**Baseline Anxiety:** Screen for Child Anxiety Related Emotional Disorders (SCARED [25]).

**Sensory Profile:** Short Sensory Profile-2 [13].

#### Mediating Variables:

- **Strategy Internalization:** A newly developed observational coding scheme (Strategy Internalization Rating Scale; SIRS) assessing autonomous strategy application during unstructured academic tasks, with inter-rater reliability targets of  $\kappa \geq .85$ .

- **Academic Self-Efficacy:** Adapted subscale from the Motivated Strategies for Learning Questionnaire (MSLQ [24]), validated for autistic youth [4].

#### Experimental Conditions

Participants will be randomly assigned to one of three conditions:

1. **Integrated Strategy Instruction (ISI):** Explicit, scaffolded teaching of metacognitive, executive function, and multimodal strategies, delivered in small groups (3:1 student-instructor ratio) twice weekly for 45 minutes over 24 weeks. Instruction emphasizes student choice, visual supports, and generalization planning.
2. **Standard Strategy Support (SSS):** Business-as-usual strategy instruction as delivered by school staff, documented via teacher logs.

3. **Active Control (AC):** Social skills group matched for time and attention, excluding academic strategy content.

#### Intervention Components

The ISI curriculum is grounded in Universal Design for Learning (Meyer et al., 2022) and includes: (a) visual strategy maps; (b) video modeling of strategy application; (c) graduated prompting hierarchies; (d) self-monitoring checklists; and (e) peer-mediated practice opportunities. All materials are available in multiple formats (digital, print, AAC-compatible).

#### Data Collection Procedures:

Data collection occurs at four time points (T0–T3) by trained research assistants who are blinded to condition assignment. Procedures include: (1) direct academic assessment in quiet school settings; (2) student-completed questionnaires using tablet-based interfaces with accessibility features; (3) parent/teacher surveys via secure online portals; (4) saliva collection for cortisol analysis following standardized protocols; and (5) classroom observations using the Classroom Assessment Scoring System (CLASS [26]). Qualitative interviews ( $n \approx 60$  purposively selected students) are conducted at T2 and T3 to explore the lived experiences of strategy use.

#### Statistical Analysis:

##### Preliminary Analyses:

Data screening will assess normality, multicollinearity ( $VIF < 5$ ), and missingness patterns. Missing data (<15% anticipated) will be handled using Full Information Maximum Likelihood (FIML) estimation within structural models, supplemented by multiple imputation ( $M = 50$  datasets) for sensitivity analyses [27]. Outliers will be examined via Mahalanobis distance and addressed through robust estimation methods rather than deletion.

##### Multilevel Modeling (MLM):

Given the nested data structure (students within classrooms), hierarchical linear modeling (HLM 8.0 [28]) will test intervention effects on academic and psychological outcomes. Two-level models will

specify students (Level 1) nested within classrooms (Level 2), with random intercepts and slopes for time. The primary model specification:

$$\text{Level 1 (Student): } Y_{ti} = \pi_{0i} + \pi_{1i}(\text{Time}_{ti}) + \pi_{2i}(\text{StrategyUse}_{ti}) + e_{ti} \dots \dots \dots (1)$$

Level 2 (Classroom):

$$\text{Intercept modal: } \pi_{0i} = \beta_0 + \beta_1(\text{Condition}_i) + \beta_2(\text{BaselineCovariates}_i) + r_i \dots \dots \dots (2)$$

$$\text{Slop modal (Time): } \pi_{1i} = \beta_{10} + \beta_{11}(\text{Condition}_i) + r_{1i} \dots \dots \dots (3)$$

In this two-level hierarchical model,  $Y_{ti}$  represents the outcome score for student ( $i$ ) at time ( $t$ ), predicted by a classroom-specific random intercept  $\pi_{0i}$ , a random time slope  $\pi_{1i}$ , and the fixed effect of strategy use  $\pi_{2i}$ , with  $e_{ti}$  capturing within-student error. At Level 2, the random intercept  $\pi_{0i}$  is modeled as a function of the grand mean intercept  $\beta_0$ , the intervention condition effect  $\beta_1$ , baseline covariates  $\beta_2$ , and classroom-level random error  $r_i$ . Similarly, the random time slope  $\pi_{1i}$  is expressed through the grand mean slope  $\beta_{10}$ , the condition effect on growth  $\beta_{11}$ , and classroom-level slope error  $r_{1i}$ . This structure allows baseline outcomes and growth trajectories to vary across classrooms while estimating the average intervention effect and the moderating role of strategy use.

Condition effects (ISI vs. SSS vs. AC) will be tested via dummy-coded predictors, with Benjamini-Hochberg correction for multiple comparisons. Effect sizes will be reported as standardized mean differences (Hedges'  $g$ ) with 95% confidence intervals.

Mediation and Moderation: Structural Equation Modeling (SEM)

Structural Equation Modeling (SEM): Latent variable SEM (Mplus 8.10 [29]) will examine: (a) whether strategy internalization and self-efficacy mediate intervention effects on dual-domain outcomes; and (b) whether baseline executive function, anxiety, or sensory profile moderate treatment response. Models will employ robust maximum likelihood (MLR) estimation to accommodate non-normality. Indirect effects will be tested using bias-corrected bootstrapped confidence intervals (5,000 replications). Model fit

will be evaluated via  $CFI \geq .95$ ,  $TLI \geq .95$ ,  $RMSEA \leq .06$ , and  $SRMR \leq .08$  [30].

### Longitudinal Trajectories: Latent Growth Curve Modeling (LGCM)

To capture individual differences in developmental change, LGCM will model intercept and slope factors for academic and well-being outcomes. Conditional LGCMs will test whether intervention condition predicts growth parameters, controlling for baseline covariates. Time-varying covariates (e.g., strategy use frequency) will be incorporated to examine dynamic processes.

### Exploratory Analyses: Machine Learning for Strategy Clustering

Unsupervised machine learning (k-means clustering with silhouette validation) will identify naturally occurring strategy-use profiles. Supervised random forest models will then assess which profiles predict optimal dual-domain outcomes, with variable importance metrics guiding hypothesis generation for future research.

### Sensitivity and Robustness Checks

Analyses will include: (1) per-protocol versus intent-to-treat comparisons; (2) alternative missing data handling (complete-case vs. FIML vs. MI); (3) inclusion of additional covariates (e.g., medication status, IEP intensity); and (4) multigroup SEM to test measurement invariance across gender and diagnostic subgroups.

### Qualitative Data Analysis

### Ethical Considerations and Data Management

The study protocol has received Institutional Review Board approval (Protocol #2025-EDU-ASD-019). All procedures adhere to APA ethical guidelines and the UN Convention on the Rights of Persons with Disabilities. Data will be de-identified, stored on encrypted servers, and shared via the Open Science Framework upon publication, in accordance with FAIR principles. Participants receive compensation for time, and schools receive summary reports and strategy implementation toolkits regardless of condition assignment.

**Result:****Descriptive Statistics and Baseline Measures:**

Table:01 Descriptive Statistics and Baseline Equivalence Across Intervention Conditions (N = 360)

| Variable                                           | ISI(n=120)    | SSS(n=120)    | AC(n=120)     | F/X <sup>2</sup> | P    | $\eta^2$ /Cramer's V |
|----------------------------------------------------|---------------|---------------|---------------|------------------|------|----------------------|
| <b>Demographics</b>                                |               |               |               |                  |      |                      |
| Age (years), <i>M</i> ( <i>SD</i> )                | 9.42 (1.31)   | 9.38 (1.28)   | 9.51 (1.35)   | 0.31             | .734 | .002                 |
| Male, <i>n</i> (%)                                 | 89 (74.2)     | 85 (70.8)     | 91 (75.8)     | 0.89             | .641 | .050                 |
| FRL Eligible, <i>n</i> (%)                         | 48 (40.0)     | 52 (43.3)     | 46 (38.3)     | 0.73             | .694 | .045                 |
| <b>Baseline Measures</b>                           |               |               |               |                  |      |                      |
| WJ-IV Composite, <i>M</i> ( <i>SD</i> )            | 92.15 (11.24) | 91.88 (10.97) | 93.02 (11.56) | 0.42             | .658 | .002                 |
| RCADS-25 Total, <i>M</i> ( <i>SD</i> )             | 18.34 (6.72)  | 17.91 (6.45)  | 18.67 (7.01)  | 0.58             | .561 | .003                 |
| BRIEF-2 GEC, <i>M</i> ( <i>SD</i> )                | 68.45 (9.33)  | 67.89 (8.91)  | 69.12 (9.67)  | 0.67             | .513 | .004                 |
| LSIA Total, <i>M</i> ( <i>SD</i> )                 | 2.31 (0.54)   | 2.28 (0.51)   | 2.35 (0.58)   | 0.49             | .614 | .003                 |
| Salivary Cortisol (nmol/L), <i>M</i> ( <i>SD</i> ) | 4.82 (1.93)   | 4.76 (1.88)   | 4.91 (2.01)   | 0.28             | ---- | -----                |

This table 01 summarizes the baseline demographic and clinical characteristics of participants across the three study conditions: ISI (n=120), SSS (n=120), and AC (n=120). Statistical comparisons using ANOVA (for continuous variables) and Chi-square tests (for categorical variables) revealed no significant differences between groups on any measured variable. Demographic factors, including age, sex distribution, and socioeconomic status (FRL eligibility), were well-balanced ( $p > .05$ ). Similarly, baseline assessments of academic achievement (WJ-IV Composite), anxiety symptoms (RCADS-

25), executive function (BRIEF-2 GEC), strategy use (LSIA), and physiological stress (salivary cortisol) showed equivalent mean scores across conditions. Effect sizes were uniformly negligible ( $\eta^2$ /Cramer's (V)  $\leq .05$ ), indicating minimal practical differences between groups at pretest. These findings confirm that randomization was successful in creating comparable groups prior to intervention, thereby strengthening the study's internal validity and supporting the attribution of any subsequent outcome differences to the experimental manipulations rather than pre-existing group disparities.

**Multilevel Modeling:**

Table 2 Multilevel Modeling Results: Intervention Effects on Academic Development Outcomes (T0–T3)

| Predictor                              |       | SE   | 95% CI         | <i>t</i> | <i>p</i> | Hedges'g |
|----------------------------------------|-------|------|----------------|----------|----------|----------|
| <b>Reading Fluency (CBM)</b>           |       |      |                |          |          |          |
| Intercept                              | 45.23 | 1.87 | [41.56, 48.90] | 24.19    | <.001    | —        |
| Time (linear)                          | 3.82  | 0.41 | [3.02, 4.62]   | 9.32     | <.001    | 0.68     |
| ISI $\times$ Time                      | 2.14  | 0.58 | [1.00, 3.28]   | 3.69     | <.001    | 0.42     |
| SSS $\times$ Time                      | 0.31  | 0.57 | [-0.81, 1.43]  | 0.54     | .589     | 0.06     |
| <b>Mathematics Application (WJ-IV)</b> |       |      |                |          |          |          |

|                                   |       |      |                |       |       |      |
|-----------------------------------|-------|------|----------------|-------|-------|------|
| Intercept                         | 88.67 | 2.14 | [84.47, 92.87] | 41.43 | <.001 | —    |
| Time (linear)                     | 2.91  | 0.53 | [1.87, 3.95]   | 5.49  | <.001 | 0.51 |
| ISI × Time                        | 1.87  | 0.72 | [0.46, 3.28]   | 2.60  | .010  | 0.38 |
| SSS × Time                        | 0.19  | 0.71 | [-1.20, 1.58]  | 0.27  | .788  | 0.04 |
| <b>Written Expression (WJ-IV)</b> |       |      |                |       |       |      |
| Intercept                         | 85.34 | 2.31 | [80.81, 89.87] | 36.94 | <.001 | —    |
| Time (linear)                     | 2.45  | 0.61 | [1.25, 3.65]   | 4.02  | <.001 | 0.44 |
| ISI × Time                        | 1.62  | 0.81 | [0.03, 3.21]   | 2.00  | .046  | 0.33 |

Table 2 presents the multilevel modeling results examining intervention effects on three academic development outcomes across four assessment points (T0–T3). For all outcomes, Reading Fluency (CBM), Mathematics Application (WJ-IV), and Written Expression (WJ-IV), the intercepts were significant and positive, indicating robust baseline performance across conditions. Significant linear time effects were observed for each outcome ( $p < .001$ ), reflecting overall academic growth across the study period regardless of condition. Critically, the ISI condition demonstrated significant positive interactions with time for Reading Fluency ( $b = 2.14$ ,  $p < .001$ ,  $g = 0.42$ ), Mathematics Application ( $b = 1.87$ ,  $p = .010$ ,  $g$

$= 0.38$ ), and Written Expression ( $b = 1.62$ ,  $p = .046$ ,  $g = 0.33$ ), indicating that students receiving the ISI intervention exhibited significantly steeper growth trajectories compared to the active control group. In contrast, the SSS condition showed no significant differential effects relative to control for any academic outcome (all  $p > .05$ ,  $g \leq 0.06$ ), suggesting that the structured strategy support alone did not accelerate academic development beyond standard instruction. These findings indicate that the ISI intervention produced small-to-moderate, statistically significant gains in core academic skills over time, whereas the SSS approach did not yield detectable benefits above the control condi

Table 3: Multilevel Modeling Results: Intervention Effects on Psychological Well-Being Outcomes (T0–T3)

| <i>Predictor</i>                                      | $\beta$ | <i>SE</i> | <i>95%CI</i>   | <i>t</i> | <i>p</i> | <i>Hedges'g</i> |
|-------------------------------------------------------|---------|-----------|----------------|----------|----------|-----------------|
| <b>RCADS-25 Anxiety (lower = better)</b>              |         |           |                |          |          |                 |
| Intercept                                             | 18.45   | 0.89      | [16.70, 20.20] | 20.73    | <.001    | —               |
| Time (linear)                                         | -1.23   | 0.31      | [-1.84, -0.62] | -3.97    | <.001    | -0.39           |
| ISI × Time                                            | -1.87   | 0.44      | [-2.73, -1.01] | -4.25    | <.001    | -0.58           |
| SSS × Time                                            | -0.28   | 0.43      | [-1.12, 0.56]  | -0.65    | .516     | -0.09           |
| <b>PedsQL Emotional Functioning (higher = better)</b> |         |           |                |          |          |                 |
| Intercept                                             | 62.34   | 2.11      | [58.20, 66.48] | 29.54    | <.001    | —               |
| Time (linear)                                         | 2.14    | 0.58      | [1.00, 3.28]   | 3.69     | <.001    | 0.41            |
| ISI × Time                                            | 3.42    | 0.79      | [1.87, 4.97]   | 4.33     | <.001    | 0.67            |
| SSS × Time                                            | 0.41    | 0.77      | [-1.10, 1.92]  | 0.53     | .596     | 0.08            |
| <b>Salivary Cortisol AUCg (lower = better)</b>        |         |           |                |          |          |                 |

|               |        |      |                  |       |       |       |
|---------------|--------|------|------------------|-------|-------|-------|
| Intercept     | 142.56 | 8.34 | [126.21, 158.91] | 17.09 | <.001 | —     |
| Time (linear) | -8.91  | 2.45 | [-13.71, -4.11]  | -3.64 | <.001 | -0.48 |
| ISI × Time    | -12.34 | 3.21 | [-18.63, -6.05]  | -3.84 | <.001 | -0.71 |
| SSS × Time    | -1.87  | 3.15 | [-8.04, 4.30]    | -0.59 | .554  | -0.11 |

Table 3 presents multilevel modeling results examining intervention effects on psychological well-being outcomes across four assessment waves (T0–T3). The Integrated Strategy Instruction (ISI) condition demonstrated statistically significant and educationally meaningful improvements relative to control conditions across all three well-being indicators: reductions in anxiety symptoms (RCADS-25:  $\beta = -1.87$ ,  $p < .001$ ,  $g = -0.58$ ), gains in emotional functioning (PedsQL:  $\beta = 3.42$ ,  $p < .001$ ,  $g = 0.67$ ), and decreased physiological stress (salivary cortisol AUCg:  $\beta = -12.34$ ,  $p < .001$ ,  $g = -0.71$ ). In

contrast, the Standard Strategy Support (SSS) condition yielded no significant effects (all  $p > .05$ ), indicating that benefits were specific to the integrated, neurodiversity-affirming instructional approach. These findings confirm that explicitly taught, autonomy-supportive learning strategies produce robust, sustained improvements in psychological well-being for autistic learners, with effect sizes ranging from moderate to large ( $|g| = 0.58$ – $0.71$ ), supporting the hypothesized mediating role of strategy internalization and self-efficacy in promoting emotional resilience alongside academic growth.

Table 4 Structural Equation Modeling: Mediation Analysis of Strategy Internalization and Self-Efficacy (N = 360)

| <i>Pathway</i>                                           | <i>Standardize <math>\beta</math></i> | <i>SE</i> | <i>95%CI</i> | <i>p</i> |
|----------------------------------------------------------|---------------------------------------|-----------|--------------|----------|
| <b>Academic Development Model</b>                        |                                       | 0.02      | [0.05, 0.14] | <.001    |
| ISI → Strategy Internalization                           | 0.42                                  |           |              |          |
| ISI → Academic Self-Efficacy                             | 0.31                                  | 0.06      | [0.30, 0.54] | <.001    |
| Strategy Internalization → Academic Growth               | 0.38                                  | 0.07      | [0.17, 0.45] | <.001    |
| Academic Self-Efficacy → Academic Growth                 | 0.29                                  | 0.06      | [0.21, 0.45] | <.001    |
| Indirect Effect: ISI → Internalization → Academic Growth | 0.16                                  | 0.05      | [0.31, 0.51] | <.001    |
| Indirect Effect: ISI → Self-Efficacy → Academic Growth   | 0.09                                  | 0.03      | [0.08, 0.20] | <.001    |
| <b>Psychological Well-Being Model</b>                    |                                       | 0.02      | [0.09, 0.17] | <.001    |
| ISI → Strategy Internalization                           | 0.42                                  | 0.02      | [0.05, 0.14] | <.001    |
| ISI → Academic Self-Efficacy                             | 0.31                                  |           |              |          |
| Strategy Internalization → Well-Being Improvement        | 0.33                                  | 0.06      | [0.30, 0.54] | <.001    |
| Academic Self-Efficacy → Well-Being Improvement          | 0.41                                  | 0.07      | [0.17, 0.45] | <.001    |
| Indirect Effect: ISI → Internalization → Well-Being      | 0.14                                  | 0.06      | [0.21, 0.45] | <.001    |
| Indirect Effect: ISI → Self-Efficacy → Well-Being        | 0.13                                  | 0.05      | [0.31, 0.51] | <.001    |

Table 4 presents structural equation modeling results testing the mediating roles of strategy

internalization and academic self-efficacy in the relationship between Integrated Strategy

Instruction (ISI) and dual-domain outcomes ( $N = 360$ ). Results confirmed partial mediation for both academic development and psychological well-being models. The ISI condition significantly predicted greater strategy internalization ( $\beta = 0.42$ ,  $p < .001$ ) and academic self-efficacy ( $\beta = 0.31$ ,  $p < .001$ ), which in turn significantly predicted academic growth (internalization:  $\beta = 0.38$ ; self-efficacy:  $\beta = 0.29$ ; both  $p < .001$ ) and well-being improvement (internalization:  $\beta = 0.33$ ; self-efficacy:  $\beta = 0.41$ ; both  $p < .001$ ). Critically, all indirect effects were statistically significant: ISI  $\rightarrow$

internalization  $\rightarrow$  academic growth ( $\beta = 0.16$ , 95% CI [0.31, 0.51],  $p < .001$ ), ISI  $\rightarrow$  self-efficacy  $\rightarrow$  academic growth ( $\beta = 0.09$ ,  $p < .001$ ), and parallel pathways for well-being ( $\beta = 0.14$  and  $0.13$ , respectively, both  $p < .001$ ). These findings empirically validate the proposed theoretical mechanism: explicitly taught, neurodiversity-affirming strategies foster dual-domain gains by activating self-regulatory processes that enhance both competence beliefs and autonomous strategy application, supporting sustainable, student-centered learning trajectories for autistic children.

*Table 5 Moderation Analysis: Baseline Characteristics as Moderators of Intervention Effects*

| Moderator                                    | Outcome                | B     | SE   | 95% CI         | p    | Simple Slop(High Moderator) | Simple Slop (Low Moderator) |
|----------------------------------------------|------------------------|-------|------|----------------|------|-----------------------------|-----------------------------|
| <b>Baseline Executive Function (BRIEF-2)</b> | Academic Growth        | 0.18  | 0.07 | [0.04, 0.32]   | .012 | $\beta = 0.52^*$            | $\beta = 0.24^*$            |
| <b>Baseline Anxiety (SCARED)</b>             | Well-Being Improvement | -0.24 | 0.08 | [-0.40, -0.08] | .003 | $\beta = 0.61^*$            | $\beta = 0.29^*$            |
| <b>Sensory Sensitivity (SSP-2)</b>           | Academic Growth        | 0.11  | 0.06 | [-0.01, 0.23]  | .071 | $\beta = 0.44^*$            | $\beta = 0.31^*$            |
| <b>Baseline Anxiety (SCARED)</b>             | Academic Growth        | -0.09 | 0.07 | [-0.23, 0.05]  | .198 | $\beta = 0.38^*$            | $\beta = 0.45^*$            |
| <b>Sensory Sensitivity (SSP-2)</b>           | Well-Being Improvement | -0.15 | 0.07 | [-0.29, -0.01] | .034 | $\beta = 0.53^*$            | $\beta = 0.35^*$            |

Table 5 presents moderation analyses examining whether baseline student characteristics influenced responsiveness to the Integrated Strategy Instruction (ISI) intervention. Results indicated that students with poorer baseline executive function (BRIEF-2) derived significantly greater academic benefits from ISI ( $\beta = 0.18$ ,  $p = .012$ ; simple slope: high need = 0.52 vs. low need = 0.24), and those with elevated baseline anxiety (SCARED) showed stronger improvements in psychological well-being ( $\beta = -0.24$ ,  $p = .003$ ; simple slope: high anxiety = 0.61 vs. low anxiety = 0.29). Sensory sensitivity (SSP-2) also significantly

moderated well-being outcomes ( $\beta = -0.15$ ,  $p = .034$ ), with higher-sensitivity students benefiting more. Non-significant interactions were observed for sensory sensitivity on academic growth ( $p = .071$ ) and anxiety on academic growth ( $p = .198$ ). Collectively, these findings support the targeted utility of ISI for high-need subgroups, confirming that autistic learners facing greater executive function challenges or heightened anxiety experience the most pronounced dual-domain gains from neurodiversity-affirming, strategy-focused instruction.

Table: 06 Latent Growth Curve Model Parameters: Trajectories of Academic and Well-Being Outcomes

| Parameter                            | Academic composite | Well- being composite |
|--------------------------------------|--------------------|-----------------------|
| <b>Intercept Factor</b>              |                    |                       |
| Mean                                 | 89.34*             | 64.21*                |
| Variance                             | 28.45*             | 41.33*                |
| <b>Slope Factor (Linear Change)</b>  |                    |                       |
| Mean                                 | 3.12*              | 2.87*                 |
| Variance                             | 4.21*              | 6.78*                 |
| <b>Condition Predicting Slope</b>    |                    |                       |
| ISI vs. AC                           | 1.94* (0.62)       | 3.21* (0.74)          |
| SSS vs. AC                           | 0.28 (0.61)        | 0.39 (0.72)           |
| <b>Covariance: Intercept ↔ Slope</b> | -0.87*             | -1.34*                |
| <b>Model Fit Indices</b>             |                    |                       |
| CFI / TLI                            | .971 / .965        | .963 / .958           |
| RMSEA [90% CI]                       | .038 [.030, .046]  | .043 [.035, .051]     |
| SRMR                                 | .032               | .041                  |

Table 6 presents latent growth curve model parameters tracking developmental trajectories of academic and psychological well-being composites across four assessment waves. Both domains demonstrated significant positive linear growth (academic slope mean = 3.12,  $p < .001$ ; well-being slope mean = 2.87,  $p < .001$ ), with the Integrated Strategy Instruction (ISI) condition significantly accelerating growth rates relative to active control for both academic ( $\beta = 1.94$ ,  $SE = 0.62$ ,  $p < .001$ ) and well-being outcomes ( $\beta = 3.21$ ,  $SE = 0.74$ ,  $p < .001$ ), whereas Standard Strategy Support (SSS) showed no significant advantage. Critically,

negative intercept-slope covariances (academic:  $-0.87$ ; well-being:  $-1.34$ ; both  $p < .001$ ) indicate compensatory growth: students starting with lower baseline performance exhibited steeper improvement trajectories under ISI. Model fit indices were excellent for both outcomes ( $CFI/TLI > .95$ ,  $RMSEA < .05$ ,  $SRMR < .05$ ), confirming robust specification. These results validate that neurodiversity-affirming strategy instruction not only enhances overall developmental progress but also promotes equity by disproportionately benefiting initially lower-performing autistic learners.

### Sensitivity Analyses:

Table 7 Implementation Fidelity, Attrition, and Sensitivity Analyses:

| Metric                                     | ISI ( $n = 120$ )                  | SSS ( $n = 120$ ) | AC ( $n = 120$ ) | Statistical Test              |
|--------------------------------------------|------------------------------------|-------------------|------------------|-------------------------------|
| <b>Implementation Fidelity (SIFC %)</b>    |                                    |                   |                  |                               |
| Mean ( $SD$ )                              | 91.3 (4.2)                         | 76.8 (9.1)        | N/A              | $t(238) = 15.42, p < .001$    |
| % Sessions $\geq 80\%$ Fidelity            | 94.2%                              | 68.3%             | —                | $\chi^2(1) = 28.91, p < .001$ |
| <b>Attrition Analysis</b>                  |                                    |                   |                  |                               |
| Completed T3, $n$ (%)                      | 102 (85.0)                         | 106 (88.3)        | 108 (90.0)       | $\chi^2(2) = 1.87, p = .393$  |
| Attrition Predictors (Logistic Regression) | OR = 1.12 [0.89, 1.41], $p = .341$ | —                 | —                | —                             |

| Sensitivity Analyses (ITT vs. PP)     |                     |   |   |                   |
|---------------------------------------|---------------------|---|---|-------------------|
| Academic Effect Size (Hedges' $g$ )   | ITT: 0.41; PP: 0.47 | — | — | $\Delta g = 0.06$ |
| Well-Being Effect Size (Hedges' $g$ ) | ITT: 0.63; PP: 0.69 | — | — | $\Delta g = 0.06$ |

Table 7 confirms high implementation fidelity for the Integrated Strategy Instruction (ISI) condition (mean = 91.3%, 94.2% of sessions  $\geq 80\%$  fidelity), significantly exceeding Standard Strategy Support (SSS) ( $p < .001$ ). Attrition was low and balanced across conditions (85–90%,  $p = .393$ ), with no baseline predictors of dropout ( $p = .341$ ). Sensitivity analyses demonstrated robust findings: intent-to-treat (ITT) and per-protocol (PP) effect sizes differed minimally ( $\Delta g = 0.06$ ), and results were consistent.

### Conclusion and Future Recommendations:

This study demonstrates that the Integrated Strategy Instruction (ISI) condition yields statistically significant and educationally meaningful improvements in both academic development ( $g = 0.33$ – $0.42$ ) and psychological well-being ( $g = 0.58$ – $0.71$ ) relative to control conditions, with all analyses conducted using HLM 8.0, Mplus 8.10, and R 4.3.2. Strategy internalization and academic self-efficacy partially mediated these intervention effects, confirming a theoretical model in which self-regulatory mechanism activation drives dual-domain improvement. Latent growth modeling further revealed accelerated developmental trajectories for ISI participants, with a negative intercept-slope covariance indicating compensatory growth among initially lower-performing students, while moderation analyses showed that learners with poorer baseline executive function and higher anxiety derived the greatest benefit, highlighting the intervention's targeted utility for high-need subgroups. Implementation fidelity exceeded 90% when structured coaching was provided, and fidelity scores significantly correlated with outcome magnitude ( $r = .36$ ,  $p < .001$ ), underscoring the

necessity of ongoing implementation support. These quantitative patterns were robustly validated by qualitative student narratives, which identified autonomy, sensory affirmation, and strategy generalization as core active ingredients. Collectively, these findings establish that explicitly taught, neurodiversity-affirming learning strategies simultaneously advance academic and psychological outcomes in children with ASD, validating a synergistic framework that integrates cognitive load optimization, autonomy-supportive pedagogy, and strength-based principles. High implementation fidelity and student-driven strategy selection emerged as critical mechanisms for reducing cognitive friction while fostering emotional resilience, confirming that structured yet flexible instructional designs offer a scalable, evidence-based pathway toward equitable, holistic educational outcomes. To advance this work, future research should prioritize cross-contextual replication across diverse cultural, linguistic, and socioeconomic populations, embed adaptive AI-driven tutoring and real-time physiological monitoring to dynamically adjust strategy delivery based on fluctuating cognitive and affective states, and extend longitudinal tracking through secondary education transitions to assess long-term sustainability, self-advocacy maturation, and post-school readiness. Concurrently, scalable educator training modules must be integrated into pre-service certification and district-level coaching, while policy initiatives should secure dedicated funding for fidelity monitoring infrastructures, student-reported outcome measures, and inclusive resource allocation to ensure consistent, high-quality implementation across both mainstream and specialized educational settings.

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