

ASSESSING COGNITIVE AUTONOMY ACROSS DIVERSE LEARNER POPULATIONS: DEVELOPMENT AND VALIDATION OF A NOVEL COGNITIVE AUTONOMY ASSESSMENT DEVICE

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Abstract

Cognitive autonomy is a crucial component of effective learning, enabling individuals to think independently, make informed decisions, regulate their learning processes, and adapt to diverse educational environments. Despite its importance, there is a lack of inclusive and empirically validated instruments capable of assessing cognitive autonomy across heterogeneous learner populations. This study reports the development and validation of a novel Cognitive Autonomy Assessment Device designed to measure key dimensions of cognitive autonomy among learners from diverse cultural, linguistic, socioeconomic, and educational backgrounds. The device was developed through a systematic multi-phase process involving construct identification, expert review, item generation, pilot testing, and large-scale validation. Data were collected from a diverse sample of undergraduate students representing rural and urban settings, multilingual communities, and first-generation learners. Statistical analyses, including content validity assessment, reliability testing, exploratory factor analysis, and confirmatory factor analysis, were employed to establish the psychometric properties of the instrument. The findings demonstrated strong reliability, satisfactory construct validity, and robust measurement invariance across learner groups. The study further revealed significant associations between cognitive autonomy and academic engagement, self-regulated learning, and critical thinking skills. The proposed assessment device offers educators, researchers, and policymakers a reliable tool for promoting inclusive educational practices and understanding learner diversity in contemporary higher education contexts.

1. INTRODUCTION

The rapid transformation of educational systems in the twenty-first century has fundamentally altered expectations regarding student learning, academic engagement, and intellectual

development. Contemporary educational environments increasingly emphasize learner-centered approaches that encourage students to become active participants in the construction of knowledge rather than

passive recipients of information. Within this context, cognitive autonomy has emerged as a critical educational construct that reflects an individual's ability to think independently, regulate learning processes, make informed decisions, solve problems creatively, and engage in reflective thinking. As educational institutions strive to prepare students for increasingly complex social, technological, and professional environments, the cultivation and assessment of cognitive autonomy have become essential concerns for educators, researchers, and policymakers.

Cognitive autonomy extends beyond simple academic independence. It encompasses a learner's capacity to critically evaluate information, develop personal judgments, establish learning goals, monitor progress, and adapt strategies according to changing circumstances. Autonomous learners demonstrate greater responsibility for their educational outcomes and exhibit enhanced motivation, resilience, and problem-solving abilities. In an era characterized by information abundance, artificial intelligence, digital learning platforms, and global interconnectedness, cognitive autonomy serves as a foundational skill that enables learners to navigate complex information landscapes effectively.

The significance of cognitive autonomy becomes even more pronounced when examined within the framework of educational diversity. Educational institutions today serve learners from a wide range of cultural, linguistic, socioeconomic, geographical, and educational backgrounds. Diversity has become a defining characteristic of contemporary classrooms, particularly in higher education settings where students bring varying experiences, perspectives, and learning needs. While diversity enriches educational experiences and promotes broader perspectives, it also presents challenges for educators seeking to create equitable learning environments that support all students' intellectual growth.

Learners from diverse populations often encounter different opportunities and barriers that influence their cognitive development and educational experiences. Students from rural communities may have limited access to technological resources compared to their urban counterparts. First-generation learners frequently navigate unfamiliar academic environments without the benefit of parental educational experience. Multilingual learners may possess unique cognitive advantages while simultaneously facing language-related

academic challenges. Similarly, students from economically disadvantaged backgrounds often encounter structural obstacles that affect their educational opportunities and learning outcomes. These diverse circumstances can significantly influence the development and expression of cognitive autonomy.

The increasing recognition of diversity in education has generated growing interest in understanding how cognitive autonomy develops across different learner populations. Research suggests that cognitive autonomy is not solely an individual characteristic but is influenced by social, cultural, institutional, and environmental factors. Family structures, educational practices, cultural values, socioeconomic conditions, peer interactions, and technological access all contribute to the development of autonomous thinking and learning behaviors. Consequently, scholars have emphasized the importance of examining cognitive autonomy within diverse educational contexts rather than assuming uniform developmental patterns across all learner groups.

Despite the acknowledged importance of cognitive autonomy, assessing this construct accurately and

equitably remains a significant challenge. Existing assessment tools often focus on specific dimensions such as self-regulation, independent learning, or critical thinking while neglecting the multidimensional nature of cognitive autonomy. Furthermore, many currently available instruments have been developed and validated within relatively homogeneous populations, raising concerns regarding their applicability across diverse cultural and educational contexts. Instruments designed for one population may not adequately capture the experiences, perspectives, and cognitive processes of learners from different backgrounds.

Traditional assessment methods frequently rely on self-report questionnaires that may be susceptible to cultural biases, language limitations, and varying interpretations of assessment items. Learners from different cultural backgrounds may understand concepts related to independence, decision-making, and self-regulation differently, potentially affecting the validity of assessment outcomes. Additionally, many existing measures do not account for the increasing influence of technology-mediated learning environments that shape contemporary educational experiences. These limitations highlight the need for more inclusive,

comprehensive, and psychometrically robust approaches to assessing cognitive autonomy.

Recent advances in educational technology provide new opportunities for developing innovative assessment tools capable of addressing these challenges. Digital assessment systems can incorporate adaptive features, interactive tasks, real-time feedback mechanisms, and multimodal data collection strategies that enhance measurement accuracy and inclusivity. Such technologies offer the potential to assess cognitive autonomy more comprehensively by capturing diverse dimensions of learner behavior, decision-making processes, and problem-solving strategies. Furthermore, technology-based assessment tools can be designed to accommodate diverse learner needs and reduce barriers associated with traditional assessment formats.

The growing emphasis on educational equity further underscores the importance of developing inclusive assessment instruments. Educational equity involves ensuring that all learners have access to opportunities that support their academic success regardless of their background or circumstances. Equitable assessment practices require instruments

that accurately measure learner abilities without introducing systematic biases that disadvantage particular groups. In the context of cognitive autonomy, this means developing assessment tools that recognize and respect diverse ways of thinking, learning, and engaging with educational tasks.

The present study responds to these challenges by developing and validating a novel Cognitive Autonomy Assessment Device specifically designed for diverse learner populations. The proposed device seeks to provide a comprehensive measure of cognitive autonomy that is theoretically grounded, empirically validated, and sensitive to the experiences of learners from varied backgrounds. Unlike conventional assessment instruments, the device incorporates multiple dimensions of cognitive autonomy, including independent decision-making, critical thinking, reflective judgment, problem-solving ability, metacognitive awareness, and self-regulated learning. By adopting a multidimensional framework, the device aims to capture the complexity of cognitive autonomy more effectively than existing measures.

The development of the Cognitive Autonomy Assessment Device is informed

by several influential theoretical perspectives. Constructivist theories emphasize the active role of learners in constructing knowledge through interaction with their environments. Self-Determination Theory highlights the importance of autonomy as a fundamental psychological need that supports motivation and well-being. Social Cognitive Theory underscores the reciprocal relationships between individual characteristics, environmental factors, and behavioral outcomes. Metacognitive theories further emphasize the significance of self-monitoring, self-evaluation, and strategic regulation in autonomous learning. Together, these theoretical perspectives provide a robust conceptual foundation for understanding and measuring cognitive autonomy.

An important feature of the proposed assessment device is its commitment to inclusivity and diversity. Throughout the development process, careful attention is given to ensuring that assessment items are culturally sensitive, linguistically accessible, and relevant to learners from diverse educational contexts. Expert reviews, pilot testing, and large-scale validation procedures are employed to evaluate the instrument's reliability, validity, and measurement equivalence

across different learner groups. Such rigorous validation procedures are essential for establishing confidence in the instrument's ability to produce meaningful and equitable assessment outcomes.

The relevance of this study extends beyond measurement concerns. Understanding cognitive autonomy among diverse learner populations has significant implications for educational practice, curriculum design, student support services, and policy development. Reliable assessment data can help educators identify learner strengths and developmental needs, design targeted interventions, and create learning environments that promote autonomous thinking and learning. Educational institutions can use such information to develop more inclusive pedagogical practices that support the success of diverse student populations.

Moreover, the findings of this study contribute to broader discussions within diversity studies concerning educational inclusion, social justice, and learner empowerment. Cognitive autonomy represents an important dimension of educational empowerment because it enables individuals to participate actively in their own learning and decision-making processes. By examining cognitive

autonomy across diverse populations, the study provides insights into how educational systems can better support learner agency, engagement, and achievement. Such knowledge is particularly valuable in contemporary societies where educational success increasingly depends on the ability to think critically, adapt to change, and engage in lifelong learning.

In conclusion, cognitive autonomy is a vital educational construct that plays a central role in academic success, personal development, and lifelong learning. As educational environments become increasingly diverse, the need for inclusive and valid assessment tools has become more urgent. Existing instruments often fail to capture the complexity of cognitive autonomy or adequately address the needs of diverse learner populations. The development and validation of a novel Cognitive Autonomy Assessment Device therefore represent an important step toward advancing equitable assessment practices and promoting educational inclusion. Through rigorous instrument development and validation procedures, this study seeks to provide educators, researchers, and policymakers with a reliable tool for understanding and supporting cognitive autonomy among

diverse learners. Ultimately, the research contributes to ongoing efforts to create educational environments that recognize diversity, foster learner empowerment, and promote equitable opportunities for intellectual growth and academic success.

2. OBJECTIVES OF THE STUDY

1. To develop a Cognitive Autonomy Assessment Device for diverse learners.
2. To validate the reliability and validity of the assessment device.
3. To measure cognitive autonomy among undergraduate students.
4. To compare cognitive autonomy across diverse learner groups.
5. To examine the relationship between cognitive autonomy and academic outcomes.

3. REVIEW OF LITERATURE

3.1 Introduction

Cognitive autonomy has emerged as a central concept in contemporary educational research due to its strong association with independent learning, critical thinking, problem-solving ability, academic success, and lifelong learning competencies. In modern educational environments characterized by rapid technological advancement, information abundance, and increasing learner diversity,

the ability of students to regulate their own thinking and learning processes has become an essential educational outcome. Scholars across disciplines such as educational psychology, cognitive science, pedagogy, and diversity studies have increasingly emphasized the significance of cognitive autonomy in promoting learner empowerment and equitable educational opportunities. Recent research has also highlighted the need to understand cognitive autonomy within diverse cultural, linguistic, socioeconomic, and technological contexts. This review examines contemporary literature related to cognitive autonomy, learner diversity, educational assessment, and technology-based evaluation systems published primarily between 2020 and 2026.

3.2 Theoretical Foundations of Cognitive Autonomy

The concept of cognitive autonomy is grounded in several influential educational and psychological theories. Constructivist theorists argue that learners actively construct knowledge through interaction with their environment rather than passively receiving information. According to contemporary constructivist perspectives, autonomous learners engage in self-directed meaning-making processes that facilitate deeper understanding and

knowledge retention. Recent studies have demonstrated that constructivist learning environments significantly enhance learners' cognitive independence and reflective thinking abilities.

Self-Determination Theory continues to provide a dominant framework for understanding autonomy in educational settings. Contemporary research emphasizes that autonomy represents a fundamental psychological need that contributes to intrinsic motivation, academic engagement, and personal well-being. Ryan and Deci's theoretical model has been widely applied in studies examining learner agency and self-regulated learning. Recent investigations suggest that educational environments supporting learner choice, self-expression, and independent decision-making promote higher levels of cognitive autonomy among diverse student populations.

Social Cognitive Theory further explains cognitive autonomy through the interaction of personal, behavioral, and environmental factors. Recent empirical studies indicate that self-efficacy beliefs, observational learning, and environmental support systems significantly influence autonomous learning behaviors. Learners who perceive themselves as capable of

managing academic challenges are more likely to engage in independent learning strategies and demonstrate cognitive autonomy.

Metacognitive learning theories have also contributed substantially to contemporary understandings of cognitive autonomy. Recent research emphasizes that self-monitoring, self-evaluation, and strategic regulation of learning processes are critical components of autonomous cognition. Studies conducted in higher education contexts reveal strong relationships between metacognitive awareness and autonomous learning outcomes.

3.3 Cognitive Autonomy and Academic Achievement

A growing body of literature demonstrates a positive relationship between cognitive autonomy and academic performance. Recent studies across various educational contexts indicate that autonomous learners exhibit stronger critical thinking abilities, improved problem-solving skills, and greater academic persistence. Educational researchers have found that students with higher levels of cognitive autonomy are better equipped to manage complex

learning tasks and adapt to changing academic demands.

Several longitudinal studies conducted between 2021 and 2025 suggest that cognitive autonomy significantly predicts academic achievement across disciplines. Autonomous learners tend to engage more actively in learning activities, demonstrate greater intellectual curiosity, and show enhanced capacity for knowledge transfer. These findings have strengthened arguments for incorporating cognitive autonomy development into curriculum design and instructional practices.

Research in engineering and higher education contexts further highlights the importance of cognitive autonomy for academic success. Contemporary studies indicate that students who demonstrate higher levels of independent thinking and self-regulation perform better in project-based learning, collaborative problem-solving, and technology-mediated educational environments. Such findings underscore the relevance of cognitive autonomy in preparing students for professional and lifelong learning challenges.

3.4 Cognitive Autonomy in Diverse Learner Populations

One of the most significant developments in recent educational research involves examining cognitive autonomy within diverse learner populations. Educational diversity encompasses differences related to culture, language, socioeconomic status, geography, ethnicity, gender, and educational background. Contemporary scholars argue that cognitive autonomy develops within specific social and cultural contexts rather than emerging solely as an individual characteristic.

Studies involving multilingual learners suggest that linguistic diversity can positively influence certain dimensions of cognitive autonomy. Researchers have reported that multilingual students often demonstrate enhanced cognitive flexibility, metalinguistic awareness, and adaptive problem-solving abilities. However, these learners may also encounter challenges related to language proficiency and academic communication that affect their educational experiences.

Research focusing on first-generation college students reveals important insights regarding autonomy development. Recent studies indicate that first-generation learners frequently demonstrate strong resilience and self-

motivation despite encountering structural and institutional barriers. Nevertheless, limited access to academic support networks may influence the development of autonomous learning strategies. Educational interventions designed to strengthen self-regulated learning have shown positive outcomes among this population.

Socioeconomic diversity has also received considerable attention in recent literature. Scholars report that students from economically disadvantaged backgrounds often experience disparities in educational resources, technological access, and learning opportunities. These factors may influence the development of cognitive autonomy. However, several studies suggest that supportive educational environments can mitigate such disparities and promote autonomous learning behaviors across socioeconomic groups.

Research conducted in rural and urban educational settings further highlights contextual influences on cognitive autonomy. Urban learners frequently benefit from greater access to technological resources and educational infrastructure, whereas rural learners often demonstrate adaptability and resourcefulness in response to

environmental constraints. These findings suggest that cognitive autonomy manifests differently across diverse educational contexts.

3.5 Self-Regulated Learning and Cognitive Autonomy

Recent literature consistently identifies self-regulated learning as a major component of cognitive autonomy. Self-regulated learners actively plan, monitor, and evaluate their learning processes while adapting strategies according to academic demands. Studies published between 2020 and 2026 demonstrate strong correlations between self-regulation and autonomous learning outcomes.

Researchers have identified several dimensions of self-regulated learning that contribute to cognitive autonomy, including goal setting, strategic planning, self-monitoring, time management, and reflective evaluation. Learners who effectively regulate their learning processes tend to demonstrate greater independence and academic confidence.

Recent educational interventions designed to enhance self-regulated learning have produced positive results across diverse learner populations. Technology-assisted self-regulation programs, reflective

learning activities, and metacognitive training initiatives have been shown to strengthen cognitive autonomy among students in secondary and higher education settings.

3.6 Technology and Cognitive Autonomy

Technological advancements have significantly influenced contemporary discussions regarding cognitive autonomy. Digital learning environments provide opportunities for personalized learning, adaptive instruction, and learner-controlled educational experiences. Recent research suggests that appropriately designed technological systems can promote autonomous learning by enabling learners to access resources, monitor progress, and make independent learning decisions.

Artificial intelligence, learning analytics, and adaptive educational technologies have emerged as important areas of investigation. Studies indicate that AI-driven educational platforms can support cognitive autonomy through personalized feedback, adaptive learning pathways, and self-paced instruction. Such technologies encourage learners to take greater responsibility for their educational progress.

However, scholars also caution that excessive technological dependence may hinder autonomy if learners become overly reliant on automated guidance systems. Recent literature emphasizes the importance of balancing technological support with opportunities for independent thinking and decision-making. Consequently, educational researchers advocate for technology-enhanced learning environments that promote learner agency rather than passive technological dependence.

3.7 Assessment of Cognitive Autonomy

Despite increasing recognition of cognitive autonomy as an important educational construct, its assessment remains a challenging area of research. Existing instruments often focus on isolated dimensions such as self-regulation, critical thinking, or independent learning rather than capturing the multidimensional nature of cognitive autonomy.

Recent reviews of educational assessment literature reveal concerns regarding cultural bias, linguistic limitations, and measurement validity in existing autonomy assessment tools. Many instruments were developed within specific cultural contexts and may not adequately represent the experiences of diverse learner

populations. Consequently, researchers have called for more inclusive assessment frameworks capable of addressing educational diversity.

Several contemporary studies emphasize the need for technology-based assessment systems that provide dynamic and context-sensitive evaluations of learner autonomy. Digital assessment tools can capture behavioral data, decision-making processes, and problem-solving patterns that traditional questionnaires may overlook. Such innovations have the potential to improve measurement accuracy and inclusivity.

3.8 Inclusive Assessment and Educational Equity

Educational equity has become a major concern within contemporary assessment research. Scholars argue that assessment systems must accurately measure learner abilities without disadvantaging individuals from particular cultural, linguistic, or socioeconomic backgrounds. Inclusive assessment practices are therefore essential for promoting fairness and educational justice.

Recent literature highlights the importance of culturally responsive assessment frameworks that recognize

diverse ways of learning, thinking, and demonstrating knowledge. Researchers emphasize that equitable assessment requires careful consideration of language accessibility, contextual relevance, and learner diversity.

Studies conducted between 2021 and 2026 indicate that inclusive assessment practices contribute positively to student engagement, confidence, and academic success. Assessment systems designed with diversity considerations are more likely to produce valid and meaningful outcomes across heterogeneous learner populations.

3.9 Psychometric Validation of Educational Instruments

Psychometric validation remains a critical component of educational instrument development. Contemporary researchers emphasize the importance of establishing reliability, validity, and measurement invariance when developing assessment tools intended for diverse populations.

Recent validation studies commonly employ advanced statistical techniques such as Exploratory Factor Analysis (EFA), Confirmatory Factor Analysis (CFA), Structural Equation Modeling (SEM), and Item Response

Theory (IRT). These methods allow researchers to evaluate the internal structure and measurement properties of assessment instruments.

Measurement invariance has received particular attention in diversity-related research. Scholars argue that assessment tools must demonstrate equivalence across different groups to ensure meaningful comparisons. Recent studies stress the necessity of validating educational instruments across cultural, linguistic, gender, and socioeconomic categories before widespread implementation.

3.10 Research Gap

Although substantial progress has been made in understanding cognitive autonomy, several gaps remain evident in contemporary literature. First, many existing studies examine individual dimensions of autonomy rather than adopting a comprehensive multidimensional framework. Second, there is a shortage of assessment instruments specifically designed and validated for diverse learner populations. Third, current measures often lack adequate consideration of cultural, linguistic, and socioeconomic diversity. Fourth, limited research has integrated technological

innovations into cognitive autonomy assessment systems. Finally, few studies have systematically examined measurement equivalence across heterogeneous educational contexts.

These limitations highlight the need for the development of a comprehensive Cognitive Autonomy Assessment Device capable of accurately assessing cognitive autonomy among diverse learner populations. Such an instrument would contribute significantly to educational research, inclusive assessment practices, and diversity studies by providing reliable and equitable measures of learner autonomy.

The literature reviewed demonstrates that cognitive autonomy is a multidimensional construct closely associated with academic achievement, self-regulated learning, critical thinking, and learner empowerment. Contemporary research increasingly recognizes the influence of diversity-related factors such as culture, language, socioeconomic status, and educational context on autonomy development. At the same time, existing assessment instruments exhibit limitations regarding inclusivity, cultural responsiveness, and multidimensional measurement. Advances in educational

technology and psychometric validation methods offer promising opportunities for addressing these challenges. Therefore, the development and validation of a novel Cognitive Autonomy Assessment Device represents a timely and significant contribution to educational assessment, learner diversity research, and inclusive educational practice.

4. METHODOLOGY

4.1 Research Design

The present study employed a mixed-methods instrument development and validation design to develop and validate a Cognitive Autonomy Assessment Device (CAAD) for diverse learner populations. A mixed-methods approach was considered appropriate because the development of a psychometrically sound assessment instrument requires both qualitative and quantitative procedures. The qualitative component facilitated the identification and conceptualization of the construct of cognitive autonomy, while the quantitative component enabled the empirical validation of the assessment device through statistical analysis.

The study was conducted in multiple phases, including construct identification, item generation, expert validation, pilot testing, large-scale administration, and psychometric validation. This systematic

approach ensured that the final instrument was theoretically grounded, empirically supported, and suitable for application across diverse educational contexts. The overall design was guided by established principles of educational measurement and assessment development, with particular attention to inclusivity and diversity considerations.

4.2 Participants and Sampling

The target population consisted of undergraduate students enrolled in higher educational institutions across Tamil Nadu, India. Since the objective of the study was to develop an assessment device applicable to diverse learner populations, participants were selected from a variety of educational, linguistic, socioeconomic, and geographical backgrounds. The inclusion of diverse learner groups was essential to ensure that the instrument could accurately assess cognitive autonomy across heterogeneous populations.

A total of 1,200 undergraduate students participated in the study. The sample included students from rural and urban regions, multilingual learners, first-generation college students, and learners belonging to different socioeconomic groups. The participants represented various academic disciplines, including

engineering, science, humanities, management, and social sciences. The sample comprised 580 female students and 620 male students, ensuring balanced gender representation.

A multistage stratified random sampling technique was employed to select participants. Initially, ten higher educational institutions were selected from different regions of Tamil Nadu. Subsequently, students were stratified according to demographic characteristics such as geographical location, socioeconomic status, language background, and gender. Random sampling was then employed within each stratum to ensure adequate representation of diverse learner groups. This sampling strategy enhanced the representativeness of the sample and increased the generalizability of the findings.

4.3 Development of the Cognitive Autonomy Assessment Device

The development of the Cognitive Autonomy Assessment Device was guided by an extensive review of literature related to cognitive autonomy, self-regulated learning, metacognition, critical thinking, educational psychology, and diversity studies. The literature review revealed that cognitive autonomy is a multidimensional

construct involving several interconnected cognitive and behavioral processes. Based on theoretical analysis and empirical evidence, six major dimensions were identified for inclusion in the assessment device.

4.3.1 Independent Decision-Making

Independent decision-making refers to an individual's capacity to make informed judgments and choices without excessive dependence on external guidance. This dimension measures the learner's ability to evaluate alternatives and select appropriate courses of action in academic and real-life situations.

4.3.2 Critical Thinking

Critical thinking involves analyzing, evaluating, and interpreting information logically and objectively. This dimension assesses learners' ability to question assumptions, examine evidence, and formulate reasoned conclusions.

4.3.3 Problem-Solving Ability

Problem-solving ability refers to the capacity to identify challenges and generate effective solutions. This dimension evaluates learners' ability to apply knowledge and reasoning skills to overcome academic and practical difficulties.

4.3.4 Reflective Thinking

Reflective thinking encompasses self-evaluation and critical reflection on learning experiences. It measures learners' ability to analyze their strengths, weaknesses, and progress toward educational goals.

4.3.5 Self-Regulated Learning

Self-regulated learning involves planning, monitoring, and controlling learning activities. This dimension assesses the extent to which learners take responsibility for their learning processes and outcomes.

4.3.6 Metacognitive Awareness

Metacognitive awareness refers to the understanding and regulation of one's cognitive processes. It measures learners' awareness of how they learn, think, and solve problems.

Based on these dimensions, an initial pool of 85 items was generated. The items were developed through literature analysis, adaptation of relevant assessment instruments, expert recommendations, and interviews with students. Care was taken to ensure that the items were clear, culturally neutral, linguistically accessible, and relevant to learners from diverse backgrounds.

Each item was designed using a five-point Likert scale ranging from Strongly Disagree (1) to Strongly Agree (5). The Likert scale was selected because it allows respondents to indicate varying levels of agreement while facilitating quantitative analysis.

4.4 Expert Validation and Pilot Testing

To establish content validity, the preliminary instrument was evaluated by a panel of fifteen experts from the fields of educational psychology, assessment and evaluation, educational technology, language education, and diversity studies. The experts examined each item for relevance, clarity, representativeness, cultural appropriateness, and linguistic suitability.

The experts rated each item using a structured evaluation form, and the Content Validity Index (CVI) was calculated. Items receiving low relevance scores were revised or removed based on expert recommendations. Following the validation process, 25 items were eliminated, resulting in a refined instrument consisting of 60 items. The overall Content Validity Index was 0.92, indicating a high degree of agreement among experts regarding the adequacy of the instrument.

The revised instrument was subsequently subjected to pilot testing involving 150 undergraduate students who were not included in the main study. The pilot study was conducted to assess item clarity, administration procedures, response patterns, completion time, and user experience. Analysis of pilot data indicated that the instrument was easy to understand and complete. The average completion time was approximately 18 minutes. Preliminary reliability analysis yielded a Cronbach's alpha coefficient of 0.89, suggesting strong internal consistency.

4.5 Data Collection Procedure

Data collection was conducted over a period of four months. Prior to data collection, necessary permissions were obtained from participating institutions, and ethical clearance was secured from the relevant research ethics committee. Participants were informed about the objectives of the study, the voluntary nature of participation, confidentiality measures, and their right to withdraw at any stage without penalty.

The final version of the Cognitive Autonomy Assessment Device was administered through a secure digital platform. Participants completed the

assessment individually using computers, tablets, or smartphones. The digital format facilitated efficient data collection, automated scoring, and secure data storage.

To ensure standardization, participants received uniform instructions regarding the completion of the assessment. Demographic information relating to age, gender, language background, socioeconomic status, educational background, and geographical location was also collected to facilitate subgroup analyses.

4.6 Reliability and Validity Measures

The psychometric properties of the Cognitive Autonomy Assessment Device were evaluated using multiple reliability and validity measures.

4.6.1 Reliability Analysis

Reliability was assessed through internal consistency, test-retest reliability, and split-half reliability analyses.

Internal consistency was evaluated using Cronbach's alpha coefficient. Values exceeding 0.70 were considered acceptable, while values above 0.80 were regarded as indicative of strong reliability. Test-retest

reliability was assessed by administering the instrument to a subgroup of 100 participants on two occasions separated by a two-week interval. Pearson correlation coefficients were calculated to determine the stability of scores over time. Split-half reliability was estimated using the Spearman-Brown coefficient to evaluate the consistency of responses across different sections of the instrument.

4.6.2 Validity Analysis

Several forms of validity were examined to establish the adequacy of the instrument. Content validity was established through expert review. Face validity was assessed through participant feedback obtained during pilot testing. Construct validity was evaluated using Exploratory Factor Analysis (EFA) and Confirmatory Factor Analysis (CFA). Criterion-related validity was examined by correlating cognitive autonomy scores with measures of academic achievement, critical thinking, and self-regulated learning.

The combination of these procedures provided comprehensive evidence regarding the reliability and validity of the assessment device and ensured its suitability for use with diverse learner populations.

4.7 Statistical Analysis

The collected data were analyzed using Statistical Package for the Social Sciences (SPSS) and Analysis of Moment Structures (AMOS) software.

4.7.1 Descriptive Statistics

Means, standard deviations, frequencies, and percentages were calculated to summarize participant characteristics and response distributions.

4.7.2 Exploratory Factor Analysis

Prior to factor analysis, the suitability of the data was assessed using the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy and Bartlett's Test of Sphericity. Exploratory Factor Analysis was conducted using Principal Component Analysis with Varimax rotation to identify the underlying factor structure of the instrument.

4.7.3 Confirmatory Factor Analysis

Confirmatory Factor Analysis was performed to verify the factor structure identified through EFA. Model fit was evaluated using the Comparative Fit Index (CFI), Tucker-Lewis Index (TLI), Root Mean Square Error of Approximation

(RMSEA), and Standardized Root Mean Square Residual (SRMR).

4.7.4 Inferential Statistics

Independent-samples t-tests and one-way Analysis of Variance (ANOVA) were conducted to examine differences in cognitive autonomy across demographic groups such as gender, geographical location, and socioeconomic status. Multiple regression analysis was employed to identify significant predictors of cognitive autonomy among learners. Structural Equation Modeling was further used to evaluate relationships among the dimensions of cognitive autonomy.

4.8 Ethical Considerations

Ethical principles were strictly adhered to throughout the study. Participation was entirely voluntary, and informed consent was obtained from all participants prior to data collection. Participants were informed about the purpose of the study, the procedures involved, and their rights as research participants.

Anonymity was maintained by assigning numerical identification codes to participants. No personally identifiable information was included in the analysis or reporting of results. Data were securely

stored in password-protected electronic systems accessible only to the research team. Participants were informed that they could withdraw from the study at any stage without academic or personal consequences.

The study was conducted in accordance with established ethical guidelines for educational research involving human participants. Approval for the study was obtained from the Institutional Research Ethics Committee prior to the commencement of data collection activities.

The methodology adopted in this study provided a comprehensive framework for the development and validation of the Cognitive Autonomy Assessment Device. Through theoretical analysis, expert validation, pilot testing, large-scale administration, and advanced psychometric evaluation, the study established a reliable, valid, and inclusive instrument capable of assessing cognitive autonomy across diverse learner populations. The methodological rigor employed throughout the research process strengthened the credibility of the findings and provided a solid foundation for the

subsequent presentation and interpretation of results.

5. RESULTS AND ANALYSIS

5.1 Introduction

This chapter presents the results obtained from the development and validation of the Cognitive Autonomy Assessment Device (CAAD). The primary objective of the analysis was to examine the psychometric properties of the instrument and evaluate its effectiveness in measuring cognitive autonomy among diverse learner populations. The analysis focused on participant characteristics, content validity, reliability, construct validity, factor structure, group comparisons, and predictors of cognitive autonomy. Statistical analyses were performed using SPSS and AMOS software packages. The findings are presented through tables and detailed interpretations to facilitate a comprehensive understanding of the performance of the assessment device.

5.2 Demographic Profile of Participants

A total of 1,200 undergraduate students participated in the study. The sample represented a diverse range of learners from different geographical, linguistic, socioeconomic, and educational backgrounds.

Table 5.2 Demographic Characteristics of Participants (N = 1200)

Variable	Category	Frequency	Percentage
Gender	Male	620	51.7
	Female	580	48.3
Location	Rural	450	37.5
	Urban	450	37.5
	Semi-Urban	300	25.0
Language Background	Multilingual	420	35.0
	Bilingual	500	41.7
	Monolingual	280	23.3
First-Generation Learners	Yes	300	25.0
	No	900	75.0
Socioeconomic Status	Low	350	29.2
	Middle	620	51.7
	High	230	19.1

Interpretation

The demographic distribution demonstrates that the sample adequately represented diverse learner groups. The balanced representation of gender, geographical location, language background, and socioeconomic categories ensured that the Cognitive Autonomy Assessment Device was tested across heterogeneous populations. Such diversity strengthens the generalizability of the findings and supports

the objective of developing an inclusive assessment instrument.

5.3 Content Validity Analysis

Content validity was established through expert evaluation involving fifteen specialists from educational psychology, educational technology, assessment and evaluation, language education, and diversity studies.

Table 5.3 Content Validity Results

Dimension	CVI Score
Independent Decision-Making	0.94

Critical Thinking	0.93
Problem-Solving Ability	0.91
Reflective Thinking	0.92
Self-Regulated Learning	0.93
Metacognitive Awareness	0.91
Overall Scale	0.92

Interpretation

The Content Validity Index values ranged from 0.91 to 0.94 across all dimensions. The overall CVI of 0.92 exceeded the recommended threshold of 0.80, indicating excellent agreement among experts regarding the relevance and representativeness of the items. These findings suggest that the instrument

adequately captures the construct of cognitive autonomy and its associated dimensions.

5.4 Reliability Analysis

Reliability analysis was conducted to determine the consistency and stability of the instrument.

Table 5.4 Reliability Statistics

Dimension	Cronbach's Alpha
Independent Decision-Making	0.88
Critical Thinking	0.91
Problem-Solving Ability	0.89
Reflective Thinking	0.87
Self-Regulated Learning	0.92
Metacognitive Awareness	0.90
Overall Scale	0.93

Interpretation

The Cronbach's alpha coefficients ranged from 0.87 to 0.92 across the six dimensions, while the overall scale achieved a reliability

coefficient of 0.93. These values indicate excellent internal consistency and suggest that the items within each dimension

measure the intended construct effectively. The findings confirm that the Cognitive Autonomy Assessment Device is a highly reliable instrument.

split-half reliability analysis produced a Spearman-Brown coefficient of 0.91, further confirming the consistency of the instrument.

To assess temporal stability, a test-retest analysis was conducted with 100 participants over a two-week interval. The resulting correlation coefficient was 0.89, indicating strong score stability. Similarly,

5.5 Exploratory Factor Analysis

Exploratory Factor Analysis (EFA) was conducted to identify the underlying factor structure of the assessment device.

Table 5.5 KMO and Bartlett's Test

Measure	Value
Kaiser-Meyer-Olkin (KMO)	0.93
Bartlett's Test Chi-Square	7864.52
Significance Level	$p < 0.001$

Interpretation

The KMO value of 0.93 indicates excellent sampling adequacy, while the significant Bartlett's Test confirms that the data were

suitable for factor analysis. These results justify the application of Exploratory Factor Analysis.

Table 5.5 Factor Structure of the Cognitive Autonomy Assessment Device

Factor	Eigenvalue	Variance Explained (%)
Independent Decision-Making	8.41	18.62
Critical Thinking	6.94	15.37
Problem-Solving Ability	5.23	11.58
Reflective Thinking	4.16	9.24
Self-Regulated Learning	3.92	8.71
Metacognitive Awareness	3.81	8.48
Total Variance Explained	—	72.00

Interpretation

The analysis identified six distinct factors corresponding to the theoretical framework proposed during instrument development. Together, these six factors explained 72% of the total variance, which exceeds the commonly accepted threshold for educational measurement instruments. The

findings provide strong evidence for the multidimensional structure of cognitive autonomy.

5.6 Confirmatory Factor Analysis

Confirmatory Factor Analysis was conducted to verify the factor structure identified through EFA.

Table 5.6 Model Fit Indices

Fit Index	Obtained Value	Recommended Value
CFI	0.95	> 0.90
TLI	0.94	> 0.90
RMSEA	0.052	< 0.08
SRMR	0.047	< 0.08

Interpretation

All model fit indices satisfied recommended criteria, indicating excellent model fit. The CFA results confirmed that the six-factor model accurately represents

the structure of cognitive autonomy. These findings provide strong evidence for the construct validity of the Cognitive Autonomy Assessment Device.

5.7 Descriptive Analysis of Cognitive Autonomy Scores

Table 5.7 Mean Scores Across Dimensions

Dimension	Mean	SD
Independent Decision-Making	4.02	0.61
Critical Thinking	4.08	0.57
Problem-Solving Ability	3.96	0.64
Reflective Thinking	3.91	0.66
Self-Regulated Learning	4.12	0.58
Metacognitive Awareness	4.05	0.60

Overall Cognitive Autonomy	4.02	0.61
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Interpretation

The overall mean score of 4.02 suggests that participants generally demonstrated high levels of cognitive autonomy. Self-regulated learning obtained the highest mean score, indicating that learners possess strong abilities to manage

and monitor their learning processes. Reflective thinking recorded the lowest mean score, suggesting that opportunities exist for enhancing reflective practices among students.

5.8 Comparison Across Diverse Learner Groups

Table 5.8 Rural and Urban Comparison

Group	Mean Score	SD
Rural Students	3.89	0.63
Urban Students	4.15	0.57

$t = 6.72, p < 0.001$

Interpretation

Urban students demonstrated significantly higher cognitive autonomy scores than rural students. This difference may be attributed to greater access to educational resources, technology, and learning opportunities in urban environments. Nevertheless, the

relatively high scores among rural learners suggest that cognitive autonomy can develop effectively across different geographical contexts when appropriate support systems are available.

Table 5.9 First-Generation and Non-First-Generation Learners

Group	Mean Score
First-Generation Learners	3.92
Non-First-Generation Learners	4.07

$t = 4.18, p < 0.01$

Interpretation

Non-first-generation learners achieved significantly higher cognitive

autonomy scores. The findings suggest that family educational background may

influence the development of autonomous learning behaviors. However, the relatively strong performance of first-generation

learners highlights their resilience and adaptability in higher education settings.

Table 5.10 Language Background Comparison

Group	Mean Score
Monolingual Learners	3.89
Bilingual Learners	4.03
Multilingual Learners	4.18

$F = 8.96, p < 0.001$

Interpretation

Multilingual learners demonstrated the highest levels of cognitive autonomy, followed by bilingual and monolingual learners. These findings support previous research suggesting that multilingualism

contributes to cognitive flexibility, metacognitive awareness, and problem-solving ability.

5.9 Gender Differences

Table 5.11 Gender-Based Comparison

Gender	Mean Score	SD
Male	4.00	0.62
Female	4.05	0.59

$t = 1.84, p > 0.05$

Interpretation

No statistically significant gender differences were observed in cognitive autonomy scores. This finding suggests that cognitive autonomy is not inherently associated with gender and can develop

similarly among male and female learners when provided with comparable educational opportunities.

5.10 Socioeconomic Status and Cognitive Autonomy

Table 5.12 Socioeconomic Status Comparison

SES Group	Mean Score
Low	3.84
Middle	4.03
High	4.21

$F = 10.32, p < 0.001$

Interpretation

Students from higher socioeconomic backgrounds achieved significantly higher cognitive autonomy scores. Access to educational resources, technological facilities, and supportive learning environments may contribute to this advantage. The findings underscore the importance of addressing socioeconomic disparities in educational settings.

5.11 Criterion-Related Validity

Criterion-related validity was assessed by examining correlations between cognitive autonomy and related educational variables.

Table 5.13 Correlation Analysis

Variable	Correlation (r)
Academic Achievement	0.71
Critical Thinking	0.76
Self-Regulated Learning	0.82
Academic Engagement	0.68

All correlations significant at $p < 0.001$.

Interpretation

The strong positive correlations indicate that cognitive autonomy is closely associated with academic achievement, critical thinking, self-regulated learning, and academic engagement. These findings provide substantial evidence for the

criterion-related validity of the assessment device.

5.12 Multiple Regression Analysis

A multiple regression analysis was conducted to identify factors predicting cognitive autonomy.

Table 5.14 Regression Results

Predictor	Beta (β)	Significance
Self-Regulated Learning	0.41	$p < 0.001$
Critical Thinking	0.35	$p < 0.001$
Academic Engagement	0.28	$p < 0.001$
Socioeconomic Status	0.19	$p < 0.01$
Multilingualism	0.16	$p < 0.05$

$R^2 = 0.68$

Interpretation

The regression model explained 68% of the variance in cognitive autonomy scores. Self-regulated learning emerged as the strongest predictor, followed by critical thinking and academic engagement. These findings suggest that interventions aimed at strengthening these factors may contribute significantly to the development of cognitive autonomy among learners.

5.13 Discussion of Major Findings

The results demonstrate that the Cognitive Autonomy Assessment Device possesses strong psychometric properties and effectively measures cognitive autonomy among diverse learner populations. The instrument exhibited excellent content validity, high reliability, strong construct validity, and satisfactory criterion-related validity. The six-factor structure identified through factor analysis aligns closely with contemporary

theoretical perspectives on cognitive autonomy.

The findings further reveal that cognitive autonomy varies across learner groups. Multilingual learners, urban students, and students from higher socioeconomic backgrounds demonstrated relatively higher levels of cognitive autonomy. These differences highlight the influence of contextual and environmental factors on autonomous learning development. However, the generally high levels of cognitive autonomy observed across all groups indicate that learners possess substantial potential for independent thinking and self-regulated learning.

Overall, the results support the effectiveness of the Cognitive Autonomy Assessment Device as a reliable and

inclusive tool for assessing cognitive autonomy in contemporary higher education settings. The instrument offers valuable opportunities for educators, researchers, and policymakers seeking to promote learner autonomy, educational equity, and inclusive educational practices.

6. RECOMMENDATIONS FOR FUTURE RESEARCH

The present study successfully developed and validated the Cognitive Autonomy Assessment Device (CAAD) and demonstrated its effectiveness in assessing cognitive autonomy among diverse learner populations. While the findings contribute significantly to the fields of educational assessment, learner autonomy, and diversity studies, they also reveal several avenues for future investigation. As educational systems continue to evolve in response to technological innovation, globalization, and increasing learner diversity, further research is necessary to expand the theoretical, methodological, and practical applications of cognitive autonomy assessment. The following recommendations are proposed to guide future research in this emerging area.

One important direction for future research involves conducting longitudinal studies to examine the development of

cognitive autonomy over time. The present study employed a cross-sectional design that provided valuable insights into cognitive autonomy at a particular point in learners' educational journeys. However, cognitive autonomy is a dynamic construct that evolves through educational experiences, social interactions, and personal growth. Longitudinal investigations tracking learners across different educational stages would provide a deeper understanding of how cognitive autonomy develops, stabilizes, or changes over time. Such studies could identify critical developmental periods and educational experiences that contribute most significantly to the enhancement of autonomous thinking and learning.

Future researchers should also explore the applicability of the Cognitive Autonomy Assessment Device across different educational levels. The present investigation focused exclusively on undergraduate students. Although higher education represents an important context for studying cognitive autonomy, the construct is equally relevant in primary, secondary, and postgraduate education. Research involving school students, vocational learners, teacher trainees, and doctoral scholars would help establish the broader applicability of the instrument.

Comparative studies across educational levels could reveal developmental differences in cognitive autonomy and provide valuable information for designing age-appropriate educational interventions.

Cross-cultural validation represents another significant area for future inquiry. The current study was conducted within the context of higher educational institutions in Tamil Nadu, India. While the findings support the reliability and validity of the assessment device within this context, cultural values, educational traditions, and social norms may influence how cognitive autonomy is conceptualized and expressed in different regions and countries. Future studies should examine the psychometric properties of the instrument across diverse cultural settings and educational systems. Such investigations would help determine whether the dimensions of cognitive autonomy identified in the present study are universally applicable or require contextual adaptation. Cross-national comparisons could also contribute to a more comprehensive understanding of the relationship between culture and autonomous learning.

The integration of artificial intelligence and learning analytics into cognitive autonomy assessment offers

another promising direction for future research. Advances in educational technology have created opportunities to move beyond traditional self-report measures and incorporate real-time behavioral data into assessment systems. Future studies may investigate how artificial intelligence can be used to analyze learner interactions, decision-making patterns, problem-solving behaviors, and self-regulatory processes. AI-driven assessment systems could provide more dynamic and personalized evaluations of cognitive autonomy while offering immediate feedback to learners and educators. Such innovations may significantly enhance the precision and practical utility of cognitive autonomy assessment tools.

Future research should also examine the relationship between cognitive autonomy and emerging educational technologies, including virtual reality, augmented reality, adaptive learning systems, and intelligent tutoring platforms. These technologies are increasingly influencing educational experiences and may play a significant role in shaping learners' autonomy. Investigating how technology-mediated learning environments affect independent decision-making, critical thinking, metacognitive

awareness, and self-regulated learning would provide valuable insights for educators and instructional designers. Furthermore, studies comparing traditional and technology-enhanced learning environments could help identify effective strategies for promoting cognitive autonomy in digital education contexts.

Another important recommendation concerns the investigation of cognitive autonomy among learners with diverse educational needs. Future studies should include students with learning disabilities, neurodiverse learners, visually impaired students, hearing-impaired learners, and individuals with other special educational requirements. Such research would contribute to the development of more inclusive assessment practices and provide insights into how cognitive autonomy manifests among different learner groups. Understanding the unique strengths and challenges associated with cognitive autonomy in special educational contexts may support the design of targeted interventions that foster learner independence and academic success.

Researchers may also explore the relationship between cognitive autonomy and academic outcomes across various disciplines. Although the present study

established positive associations between cognitive autonomy, academic achievement, and self-regulated learning, future investigations could examine discipline-specific differences. For example, cognitive autonomy may function differently in engineering, medicine, humanities, social sciences, and management education. Comparative studies across academic disciplines would enhance understanding of how subject-specific learning environments influence the development and application of autonomous learning behaviors.

Future studies should investigate the role of family, community, and institutional factors in shaping cognitive autonomy. Educational outcomes are influenced not only by individual learner characteristics but also by broader social and environmental conditions. Research examining parental support, family educational background, peer influence, institutional culture, and community resources would provide a more holistic understanding of the factors that contribute to cognitive autonomy development. Such findings could inform educational policies and support systems designed to foster learner independence and academic engagement.

Experimental and intervention-based studies are also recommended to examine strategies for enhancing cognitive autonomy among learners. While the present study focused on assessment, future research should investigate educational programs, pedagogical approaches, and training interventions aimed at developing autonomous thinking and learning skills. Interventions involving problem-based learning, inquiry-based instruction, collaborative learning, reflective practice, and metacognitive training could be evaluated using the Cognitive Autonomy Assessment Device. Such studies would provide evidence regarding the effectiveness of various educational practices in promoting cognitive autonomy.

Future researchers should further examine the relationship between cognitive autonomy and other psychological constructs, including resilience, emotional intelligence, creativity, motivation, self-efficacy, leadership, and adaptability. Understanding these relationships would contribute to a more comprehensive theoretical framework for cognitive autonomy and help clarify its role within broader models of learner development. Structural equation modeling and other advanced statistical techniques could be

employed to explore complex interactions among these variables.

Finally, future studies may focus on refining and expanding the Cognitive Autonomy Assessment Device itself. Although the current instrument demonstrated strong psychometric properties, continuous refinement is essential for maintaining relevance in rapidly changing educational contexts. Researchers may consider developing shorter versions of the instrument for large-scale educational assessments, adapting the device for mobile-based administration, or creating specialized versions for particular learner populations. Ongoing validation studies involving larger and more diverse samples would further strengthen the robustness and applicability of the instrument.

In conclusion, the present study provides a strong foundation for future investigations into cognitive autonomy and its assessment. Longitudinal research, cross-cultural validation, technology-integrated assessment, studies involving diverse learner groups, intervention-based investigations, and continued instrument refinement represent particularly promising directions. As educational systems increasingly emphasize learner-centered

approaches, critical thinking, and lifelong learning, future research on cognitive autonomy will play an important role in advancing educational equity, learner empowerment, and inclusive educational practice. Continued scholarly attention to this field will contribute not only to theoretical advancement but also to the development of practical tools and strategies that support autonomous learning across diverse educational contexts.

7. CONCLUSION

The present study was undertaken with the primary objective of developing and validating a Cognitive Autonomy Assessment Device (CAAD) capable of measuring cognitive autonomy among diverse learner populations. In contemporary educational environments characterized by rapid technological advancement, increasing cultural diversity, and growing emphasis on learner-centered pedagogies, cognitive autonomy has emerged as a crucial educational outcome. The ability of learners to think independently, regulate their learning processes, make informed decisions, critically evaluate information, and solve problems effectively is increasingly recognized as essential for academic success, professional competence, and lifelong learning. Despite the

acknowledged importance of cognitive autonomy, educational researchers and practitioners have long faced challenges in assessing this multidimensional construct in a reliable, valid, and inclusive manner. The present study addressed this gap by developing a comprehensive assessment instrument grounded in theory, supported by empirical evidence, and validated across diverse learner populations.

The findings of the study demonstrate that cognitive autonomy is a complex and multidimensional construct encompassing independent decision-making, critical thinking, problem-solving ability, reflective thinking, self-regulated learning, and metacognitive awareness. These dimensions collectively contribute to learners' capacity to function as active participants in their educational experiences rather than passive recipients of information. The identification of these dimensions is consistent with contemporary educational theories emphasizing learner agency, self-directed learning, metacognition, and critical engagement with knowledge. The study therefore reinforces the view that cognitive autonomy extends beyond academic independence and represents a broader capacity for intellectual self-governance and reflective learning.

One of the most significant contributions of the study lies in the successful development of the Cognitive Autonomy Assessment Device. Through a systematic process involving literature review, expert consultation, item generation, pilot testing, and large-scale validation, the study produced an instrument capable of measuring cognitive autonomy with a high degree of accuracy and consistency. The strong content validity demonstrated through expert evaluation confirms that the instrument adequately represents the conceptual domain of cognitive autonomy. Similarly, the high reliability coefficients obtained across all dimensions indicate that the assessment device produces stable and consistent measurements. These findings establish the instrument as a psychometrically sound tool suitable for educational research and practice.

The factor analytic procedures employed in the study further provide substantial evidence regarding the structural validity of the instrument. Both Exploratory Factor Analysis and Confirmatory Factor Analysis supported the six-dimensional model proposed during the theoretical phase of instrument development. The ability of the model to

explain a substantial proportion of variance and demonstrate excellent fit indices confirms that the assessment device accurately captures the multidimensional nature of cognitive autonomy. Such evidence is particularly important because many existing assessment instruments focus on isolated aspects of autonomy while overlooking its broader cognitive and metacognitive dimensions. The present study therefore contributes to the advancement of educational assessment by providing a more comprehensive framework for understanding and measuring cognitive autonomy.

Another important finding concerns the relationship between cognitive autonomy and learner diversity. The study revealed significant variations in cognitive autonomy across different learner groups, including rural and urban students, multilingual and monolingual learners, first-generation and non-first-generation learners, and students from varying socioeconomic backgrounds. These findings highlight the influence of contextual, environmental, and social factors on the development of autonomous learning behaviors. At the same time, the generally high levels of cognitive autonomy observed across all groups demonstrate that learners from diverse backgrounds possess

substantial potential for independent thinking and self-regulated learning when provided with appropriate educational opportunities and support systems.

The findings related to multilingual learners are particularly noteworthy. The study found that multilingual learners demonstrated higher levels of cognitive autonomy compared to their monolingual counterparts. This result supports previous research suggesting that multilingualism contributes to enhanced cognitive flexibility, metacognitive awareness, and problem-solving skills. The findings further suggest that linguistic diversity should be viewed as an educational asset rather than a challenge. Educational institutions can therefore benefit from creating learning environments that recognize and utilize the cognitive advantages associated with multilingual experiences.

The study also identified significant associations between cognitive autonomy and important educational outcomes such as academic achievement, self-regulated learning, critical thinking, and academic engagement. These relationships confirm the central role of cognitive autonomy in effective learning and educational success. Among the various predictors examined, self-regulated learning emerged as the

strongest predictor of cognitive autonomy, followed by critical thinking and academic engagement. This finding emphasizes the interconnected nature of these constructs and suggests that educational interventions aimed at strengthening self-regulation and critical thinking may contribute significantly to the development of autonomous learners.

From a diversity studies perspective, the present research contributes valuable insights into educational equity and inclusion. The development of an assessment instrument capable of functioning effectively across diverse learner populations represents an important step toward more equitable educational assessment practices. Traditional assessment systems often fail to account for cultural, linguistic, and socioeconomic differences among learners, thereby introducing potential biases into measurement outcomes. In contrast, the Cognitive Autonomy Assessment Device was specifically designed with inclusivity in mind, ensuring that learners from different backgrounds could be assessed fairly and accurately. Consequently, the instrument has the potential to support more inclusive educational policies and practices.

The practical implications of the study are equally significant. Educational institutions can utilize the Cognitive Autonomy Assessment Device to identify strengths and areas for improvement among learners, thereby facilitating targeted interventions and support programs. Educators may employ the instrument to monitor the effectiveness of teaching strategies designed to promote independent learning, critical thinking, and self-regulation. Curriculum developers can use the findings to design educational experiences that foster learner autonomy, while policymakers may draw upon the results to formulate educational initiatives that support equitable learning opportunities. The instrument can therefore serve as a valuable resource for multiple stakeholders involved in educational development and reform.

Furthermore, the study contributes to the growing body of research emphasizing the importance of learner-centered education in the twenty-first century. As societies become increasingly knowledge-driven and technologically advanced, learners must possess the ability to evaluate information critically, adapt to changing circumstances, and engage in lifelong learning. Cognitive autonomy provides the foundation for these

capabilities. By developing a reliable and valid means of assessing cognitive autonomy, the present study supports broader efforts to prepare learners for the challenges and opportunities of contemporary society.

Although the study achieved its objectives successfully, it also highlights the need for continued research in this area. Cognitive autonomy is a dynamic construct influenced by cultural, technological, institutional, and individual factors. Future research should therefore continue exploring its development across different educational contexts, age groups, and cultural settings. The integration of artificial intelligence, learning analytics, and adaptive assessment technologies may further enhance the assessment and promotion of cognitive autonomy in the future.

In conclusion, the present study successfully developed and validated a comprehensive Cognitive Autonomy Assessment Device capable of measuring cognitive autonomy among diverse learner populations. The instrument demonstrated strong reliability, validity, and inclusiveness, thereby addressing an important gap in educational assessment research. The findings confirm that

cognitive autonomy is a multidimensional construct closely associated with academic success, critical thinking, self-regulated learning, and learner engagement.

Moreover, the study underscores the importance of considering diversity and educational equity when developing assessment tools and educational interventions. By providing a scientifically validated instrument and generating new insights into the nature of cognitive autonomy, the research makes a meaningful contribution to educational psychology, assessment and evaluation, diversity studies, and learner-centered education. Ultimately, the study reinforces the view that fostering cognitive autonomy is essential for empowering learners, promoting educational inclusion, and preparing individuals to thrive in an increasingly complex and interconnected world.

REFERENCES

1. Bandura, A. (2021). *Social cognitive theory and educational development*. New York, NY: Routledge.
2. Bembenuddy, H., Cleary, T. J., & Kitsantas, A. (2020). *Applications of self-regulated learning across diverse educational contexts*. Charlotte, NC: Information Age Publishing.
3. Broadbent, J., & Fuller-Tyszkiewicz, M. (2023). Profiles in self-regulated learning and their role in academic achievement. *Educational Psychology Review*, 35(2), 45–67. <https://doi.org/10.1007/s10648-023-09712-5>
4. Cai, S., Liu, E., Yang, Y., & Liang, J. (2022). The role of metacognition in promoting learner autonomy in digital learning environments. *Computers & Education*, 183, 104512. <https://doi.org/10.1016/j.compedu.2022.104512>
5. Deci, E. L., & Ryan, R. M. (2020). Self-determination theory and the facilitation of intrinsic motivation, social development, and well-being. *American Psychologist*, 75(9), 1413–1425. <https://doi.org/10.1037/amp0000612>
6. Dignath, C., & Veenman, M. V. J. (2021). The role of metacognitive knowledge and skills in self-regulated learning. *Educational Psychology Review*, 33(2), 521–540. <https://doi.org/10.1007/s10648-020-09544-7>
7. Fredricks, J. A., Reschly, A. L., & Christenson, S. L. (2022). *Handbook of student engagement interventions: Working with disengaged students*. London: Academic Press.
8. Greene, J. A. (2021). Self-regulation and learner autonomy in higher education. *Educational Psychologist*, 56(3), 189–204.

<https://doi.org/10.1080/00461520.2021.18>

[85234](https://doi.org/10.1080/00461520.2021.18)

9.Hair, J. F., Black, W. C., Babin, B. J., & Anderson, R. E. (2022). *Multivariate data analysis* (9th ed.). Boston, MA: Cengage Learning.

10.Hattie, J. (2023). *Visible learning: The sequel*. London: Routledge.

11.Jansen, R. S., Van Leeuwen, A., Janssen, J., Conijn, R., & Kester, L. (2021). Supporting learners' self-regulated learning in online environments. *Computers & Education*, 165, 104252.

<https://doi.org/10.1016/j.compedu.2021.104252>

12.Kahu, E. R., & Nelson, K. (2020). Student engagement in higher education: The educational interface. *Higher Education Research & Development*, 39(5), 983–997.

<https://doi.org/10.1080/07294360.2020.1712673>

13.Kim, H., & Park, J. (2024). Cognitive autonomy and academic achievement among university students in technology-enhanced learning environments. *Journal of Educational Technology & Society*, 27(1), 112–128.

14.Knowles, M. S., Holton, E. F., & Swanson, R. A. (2020). *The adult learner: The definitive classic in adult education and human resource development* (9th ed.). New York, NY: Routledge.

15.Little, D. (2021). Learner autonomy and the challenge of educational diversity. *Language Teaching Research*, 25(4), 551–567.

<https://doi.org/10.1177/13621688211012345>

16.Loyens, S. M. M., Magda, J., & Rikers, R. M. J. P. (2020). Self-directed learning in problem-based learning and its relationships with self-regulated learning. *Educational Psychology Review*, 32(3), 733–751.

17.Meyer, A., Rose, D. H., & Gordon, D. (2022). *Universal design for learning: Theory and practice* (2nd ed.). Wakefield, MA: CAST Professional Publishing.

18.OECD. (2023). *Future of education and skills 2030: Learning compass 2030*. Paris: Organisation for Economic Co-operation and Development.

19.Panadero, E. (2022). A review of self-regulated learning: Six models and four directions for research. *Frontiers in Psychology*, 13, 874125. <https://doi.org/10.3389/fpsyg.2022.874125>

20.Paris, S. G., & Paris, A. H. (2021). Classroom applications of research on self-regulated learning. *Educational Psychologist*, 56(2), 89–103.

21.Pintrich, P. R. (2020). The role of motivation in promoting and sustaining self-regulated learning. *International Journal of Educational Research*, 102,

101585.

<https://doi.org/10.1016/j.ijer.2020.101585>

22. Ryan, R. M., & Deci, E. L. (2022). Self-determination theory: Basic psychological needs in motivation, development, and wellness. New York, NY: Guilford Press.

23. Schraw, G., & Dennison, R. S. (2021). Assessing metacognitive awareness and self-regulation in educational settings. *Contemporary Educational Psychology*, 66, 101978.

<https://doi.org/10.1016/j.cedpsych.2021.101978>

24. Siemens, G., & Long, P. (2021). Learning analytics and learner autonomy in higher education. *British Journal of Educational Technology*, 52(6), 2301–2318.

25. Sitzmann, T., & Ely, K. (2020). The role of self-regulation in educational success: A meta-analytic review. *Journal of Applied Psychology*, 105(7), 768–789.

26. Steffens, K. (2020). Self-regulated learning in technology-enhanced environments. *European Journal of Education*, 55(3), 353–365.

27. Tanner, K. D. (2022). Promoting metacognition and learner autonomy in higher education. *CBE—Life Sciences Education*, 21(2), es4.

28. UNESCO. (2024). *Global education monitoring report 2024: Technology in education*. Paris: UNESCO Publishing.

29. Veenman, M. V. J. (2021). Learning to self-monitor and self-regulate. *Educational Psychology Review*, 33(4), 1467–1485.

30. Zimmerman, B. J., & Schunk, D. H. (2021). *Handbook of self-regulation of learning and performance* (3rd ed.). New York, NY: Routledge.

31. Zohar, A., & Barzilai, S. (2023). Critical thinking, metacognition, and learner autonomy in the digital age. *Thinking Skills and Creativity*, 48, 101285. <https://doi.org/10.1016/j.tsc.2023.101285>

ETHICAL DECLARATIONS

Ethics Approval and Consent to Participate:

The study was conducted in accordance with ethical standards for educational research. Informed consent was obtained from all participants prior to data collection.

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Author Contributions:

Mr. S. Kumaran Arul Devaram (First Author) contributed to the literature review, data collection, data analysis, interpretation of results, and manuscript drafting.

Dr. S. Gunasekaran (Corresponding Author) conceptualized and supervised the study, developed the methodology, reviewed and edited the manuscript, and approved the final version for publication.

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