

BRIDGING COGNITIVE ASSESSMENT AND EDUCATIONAL DIVERSITY: DESIGN AND APPLICATION OF A COGNITIVE AUTONOMY ASSESSMENT DEVICE

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Abstract

The increasing diversity of learners in contemporary educational settings has created a need for assessment tools that can effectively measure cognitive autonomy across varied social, cultural, linguistic, and educational backgrounds. Cognitive autonomy, defined as an individual's capacity for independent thinking, self-regulation, critical decision-making, and reflective learning, plays a crucial role in academic achievement and lifelong learning. This study presents the design, development, and application of a **Cognitive Autonomy Assessment Device (CAAD)** aimed at evaluating cognitive autonomy among diverse learner populations. The device was developed through a systematic process involving theoretical framework construction, item generation, expert validation, pilot testing, and psychometric evaluation. The assessment incorporates dimensions such as independent problem-solving, self-directed learning, critical thinking, decision-making confidence, and metacognitive awareness. Data were collected from students representing diverse educational, socio-economic, and cultural backgrounds to examine the reliability and validity of the instrument. Statistical analyses demonstrated strong internal consistency, construct validity, and measurement stability across different learner groups. Findings indicate that the CAAD effectively identifies variations in cognitive autonomy and provides valuable insights into learners' independent learning capacities. The study highlights the potential of the device as an inclusive assessment tool that supports educational equity, personalized learning, and evidence-based instructional practices. The findings contribute to the growing discourse on diversity-sensitive educational assessment and offer practical implications for educators, researchers, and policymakers seeking to promote autonomous learning in increasingly heterogeneous educational environments.

1.INTRODUCTION

The twenty-first century educational landscape is characterized by unprecedented levels of diversity.

Educational institutions across the globe increasingly accommodate learners from varied cultural, linguistic, socioeconomic,

ethnic, and cognitive backgrounds. This diversity has transformed classrooms into dynamic spaces where students bring distinct experiences, learning styles, values, and intellectual capacities. While diversity enriches educational environments, it also presents significant challenges for educators, researchers, and policymakers seeking to ensure equitable learning opportunities and accurate assessment practices. Traditional assessment systems, which were often designed around standardized notions of academic achievement, frequently fail to capture the complex cognitive characteristics of diverse learners. Consequently, there is a growing demand for innovative assessment approaches that recognize individual differences while promoting educational equity and inclusion.

Among the numerous factors influencing student success, cognitive autonomy has emerged as a particularly significant construct. Cognitive autonomy refers to an individual's ability to think independently, make reasoned judgments, regulate learning processes, solve problems without excessive reliance on external guidance, and engage in reflective decision-making. It represents a fundamental dimension of intellectual development that supports academic achievement, lifelong learning,

creativity, and adaptability. In contemporary educational settings, where information is readily accessible and knowledge evolves rapidly, learners are increasingly expected to demonstrate autonomous thinking rather than merely reproduce memorized information. Consequently, educational systems are shifting their emphasis from content acquisition to the development of higher-order cognitive skills, including critical thinking, metacognition, self-regulation, and independent learning.

The concept of cognitive autonomy has its roots in several influential theoretical traditions. Constructivist theories of learning emphasize that knowledge is actively constructed by learners through interaction with their environment rather than passively received from instructors. Scholars such as Jean Piaget argued that cognitive development involves the gradual emergence of independent reasoning abilities that enable individuals to evaluate information critically and formulate personal understandings of reality. Similarly, Lev Vygotsky highlighted the social foundations of cognitive development while acknowledging the importance of internalization processes that ultimately foster autonomous thought. Contemporary educational psychology

further reinforces the importance of autonomy by linking self-directed learning, intrinsic motivation, and metacognitive awareness to improved academic outcomes.

Research has consistently demonstrated that cognitively autonomous learners exhibit greater academic resilience, stronger problem-solving abilities, enhanced motivation, and higher levels of engagement in educational activities. Such learners are more capable of adapting to new learning contexts, evaluating evidence critically, and making informed decisions. Furthermore, cognitive autonomy contributes to personal empowerment by enabling individuals to navigate complex social and professional environments independently. These qualities are particularly valuable in increasingly diverse educational contexts where learners encounter multiple perspectives, cultural frameworks, and sources of information.

Despite the recognized importance of cognitive autonomy, its assessment remains a challenging endeavor. Traditional educational assessments primarily focus on measuring knowledge acquisition, factual recall, and subject-specific competencies. Standardized examinations often emphasize correct answers rather than the cognitive processes underlying learning

and decision-making. As a result, many existing assessment tools provide limited insight into students' capacity for independent thinking, self-regulation, and reflective judgment. This limitation is particularly problematic in diverse educational settings where students may demonstrate cognitive strengths that are not adequately captured by conventional testing methods.

The challenges associated with assessing cognitive autonomy are further compounded by educational diversity. Learners from different cultural and socioeconomic backgrounds may express autonomy in distinct ways. Cultural values influence attitudes toward authority, collaboration, independence, and decision-making. For instance, students from collectivist cultures may demonstrate autonomy through responsible participation within a group, whereas learners from individualistic cultures may emphasize independent initiative and self-expression. Similarly, variations in educational experiences, language proficiency, and access to learning resources can shape the development and manifestation of cognitive autonomy. Consequently, assessment instruments that fail to account for such diversity may produce biased or

incomplete evaluations of learner capabilities.

The growing emphasis on inclusive education has intensified concerns regarding assessment fairness and validity. Inclusive educational frameworks advocate for equitable opportunities that accommodate diverse learner needs while recognizing individual strengths. Assessment practices play a crucial role in achieving this goal because they influence instructional decisions, resource allocation, academic placement, and educational outcomes. However, many conventional assessment tools continue to rely on uniform criteria that may disadvantage learners from underrepresented or marginalized groups. Scholars have therefore called for the development of culturally responsive and diversity-sensitive assessment methods capable of providing more accurate and meaningful evaluations.

In response to these challenges, educational researchers have increasingly explored alternative assessment approaches that prioritize cognitive processes, learner agency, and contextual factors. Performance-based assessments, portfolio evaluations, self-assessments, and metacognitive inventories represent efforts to move beyond traditional testing

paradigms. While these approaches offer valuable insights into learner development, they often lack standardization, scalability, or comprehensive measurement of cognitive autonomy. Moreover, many existing instruments focus on isolated dimensions of autonomous learning without providing an integrated framework for assessing the multifaceted nature of cognitive autonomy.

The emergence of educational technology and advanced psychometric methodologies has created new opportunities for developing innovative assessment tools. Digital assessment platforms enable the collection of rich data on learner behavior, decision-making patterns, problem-solving strategies, and self-regulatory processes. Advances in measurement theory support the development of instruments capable of capturing complex cognitive constructs with greater reliability and validity. These developments have paved the way for the creation of specialized assessment devices designed to evaluate cognitive autonomy across diverse learner populations.

The present study addresses this need through the design and application of a Cognitive Autonomy Assessment Device (CAAD). The device was developed to provide a comprehensive, reliable, and

inclusive means of measuring cognitive autonomy among learners from diverse educational backgrounds. Unlike conventional assessments that focus primarily on academic achievement, the CAAD seeks to evaluate key dimensions of autonomous cognition, including independent problem-solving, critical thinking, decision-making confidence, self-directed learning, metacognitive awareness, and reflective judgment. By integrating these dimensions into a unified assessment framework, the device offers a more holistic understanding of learner capabilities.

The development of the Cognitive Autonomy Assessment Device is grounded in the recognition that cognitive autonomy is both a psychological construct and an educational outcome. It encompasses not only the ability to perform cognitive tasks independently but also the willingness to assume responsibility for learning and decision-making processes. Therefore, the assessment device was designed to capture both cognitive and motivational aspects of autonomy. This multidimensional approach aligns with contemporary perspectives on learner development, which emphasize the interconnected nature of cognition, motivation, and self-regulation.

An important feature of the CAAD is its commitment to educational diversity and inclusivity. During the development process, particular attention was given to ensuring that assessment items were culturally neutral, linguistically accessible, and relevant to diverse learner populations. Expert reviews, pilot testing, and psychometric analyses were employed to identify and eliminate potential sources of bias. This approach reflects broader efforts within educational assessment research to create instruments that promote fairness and equitable representation.

The relevance of cognitive autonomy extends beyond individual educational outcomes. Contemporary societies increasingly require citizens who can think critically, evaluate information sources, solve complex problems, and participate effectively in democratic processes. Rapid technological advancements, globalization, and the proliferation of digital information have created environments in which independent judgment and critical thinking are essential competencies. Educational institutions therefore bear a responsibility not only to transmit knowledge but also to cultivate the cognitive autonomy necessary for active and informed citizenship. Reliable assessment tools are indispensable for monitoring progress toward these

objectives and informing evidence-based educational interventions.

Furthermore, the assessment of cognitive autonomy has significant implications for personalized learning. Modern educational paradigms emphasize the importance of tailoring instruction to individual learner needs, strengths, and preferences. Accurate assessment data can help educators identify students who may require additional support in developing autonomous learning skills while also recognizing those who demonstrate advanced levels of independence and critical thinking. Such information can guide instructional planning, curriculum development, and learner support services, ultimately enhancing educational effectiveness.

Within the field of diversity studies, the examination of cognitive autonomy offers a valuable lens through which to understand learner differences and educational equity. Traditional discussions of diversity often focus on demographic characteristics such as race, ethnicity, gender, language, and socioeconomic status. While these factors remain important, there is increasing recognition that cognitive diversity also plays a crucial role in shaping educational experiences and outcomes. Cognitive autonomy represents a key aspect of this

diversity because it influences how learners approach challenges, process information, and engage with educational opportunities. Assessing cognitive autonomy therefore contributes to a more comprehensive understanding of learner diversity and supports the development of inclusive educational practices.

The present study seeks to bridge the gap between cognitive assessment and educational diversity by introducing a novel assessment device specifically designed to measure cognitive autonomy in diverse educational contexts. Through rigorous development procedures and empirical validation, the study aims to demonstrate the reliability, validity, and practical applicability of the Cognitive Autonomy Assessment Device. By providing educators, researchers, and policymakers with a robust assessment instrument, the study contributes to ongoing efforts to promote equitable, inclusive, and learner-centered education.

Ultimately, the development of the Cognitive Autonomy Assessment Device represents an important step toward reimagining educational assessment in ways that acknowledge both cognitive complexity and learner diversity. As educational systems continue to evolve in

response to societal changes, the need for innovative assessment approaches will become increasingly pronounced. Instruments capable of measuring cognitive autonomy can support more effective teaching, foster independent learning, and contribute to the broader goal of educational equity. The present research therefore addresses a critical gap in assessment practice while advancing scholarly understanding of cognitive autonomy within diverse educational environments. Through its theoretical foundations, methodological rigor, and practical implications, the study seeks to contribute meaningfully to the fields of educational assessment, educational psychology, and diversity studies.

2.OBJECTIVES OF THE STUDY

1. To design and develop a Cognitive Autonomy Assessment Device (CAAD) for measuring cognitive autonomy among diverse learners.
2. To examine the reliability and validity of the Cognitive Autonomy Assessment Device across different learner populations.
3. To assess the levels of cognitive autonomy among students from diverse educational, cultural, and socio-economic backgrounds.

4. To investigate the relationship between cognitive autonomy and key learning outcomes such as critical thinking, self-directed learning, and decision-making skills.
5. To evaluate the effectiveness of the Cognitive Autonomy Assessment Device as an inclusive tool for supporting educational equity and diversity-sensitive assessment practices.

3. REVIEW OF LITERATURE

The concept of cognitive autonomy has gained considerable attention in contemporary educational research due to its strong association with independent learning, critical thinking, self-regulation, and academic success. As educational systems become increasingly diverse and learner-centered, researchers have emphasized the need to understand how cognitive autonomy develops across different educational, cultural, and socio-economic contexts. Recent studies have explored the relationship between autonomy and learning outcomes, the influence of educational diversity on cognitive development, the role of technology in fostering autonomous learning, and the importance of inclusive assessment practices. The present review

examines recent scholarly contributions related to cognitive autonomy, educational diversity, assessment innovation, and learner-centered pedagogies.

Recent educational research has increasingly recognized cognitive autonomy as a critical component of twenty-first-century learning. According to Ryan and Deci (2020), autonomy represents one of the central psychological needs influencing learner motivation and engagement. Their work on Self-Determination Theory argues that learners who experience autonomy demonstrate higher levels of intrinsic motivation, persistence, and academic achievement. The researchers emphasize that educational environments supporting learner choice and independent thinking contribute significantly to intellectual growth and self-regulation. Their findings suggest that autonomy should not merely be viewed as a personal trait but as a developmental outcome influenced by educational practices and learning environments.

Similarly, Vansteenkiste, Niemiec, and Soenens (2020) examined the relationship between autonomy-supportive teaching and student learning outcomes. Their study found that students exposed to instructional methods encouraging

independent decision-making displayed stronger critical thinking skills and greater academic confidence. The researchers concluded that autonomy-supportive educational practices enhance learners' ability to evaluate information critically and engage in self-directed learning. These findings highlight the importance of developing assessment tools capable of measuring such cognitive capacities.

The increasing emphasis on critical thinking within higher education has further strengthened interest in cognitive autonomy. Facione and Gittens (2021) argue that autonomous thinkers possess the ability to analyze evidence, identify biases, and formulate reasoned conclusions. Their research demonstrates that critical thinking and cognitive autonomy are closely interconnected because both require learners to exercise independent judgment. The study emphasizes that educational institutions should evaluate not only knowledge acquisition but also the cognitive processes underlying decision-making and problem-solving. This perspective has contributed to growing calls for more sophisticated assessment instruments that capture higher-order cognitive abilities.

Educational diversity has emerged as another important area of investigation in recent literature. Banks (2021) argues that contemporary classrooms consist of learners from diverse linguistic, cultural, ethnic, and socio-economic backgrounds whose educational experiences shape cognitive development in different ways. According to Banks, diversity-sensitive educational practices must recognize these differences rather than impose uniform standards of learning and assessment. The study highlights that cognitive autonomy may manifest differently across cultural contexts, making inclusive assessment practices essential for equitable educational evaluation.

Gay (2021) further expands this perspective through her work on culturally responsive pedagogy. She argues that culturally responsive educational approaches encourage learners to connect academic knowledge with their personal experiences and cultural identities. Such approaches promote cognitive autonomy by empowering students to participate actively in knowledge construction. Gay's findings suggest that assessments designed without consideration of cultural diversity may fail to capture the full range of learners' cognitive capabilities. Consequently, educational assessment tools must be

developed with sensitivity to cultural and contextual differences.

Recent studies on multilingual and multicultural education have also highlighted the relationship between diversity and cognitive autonomy. García and Wei (2022) examined how multilingual learners engage in complex cognitive processes when navigating multiple linguistic systems. Their findings indicate that multilingual students often demonstrate advanced metacognitive awareness and adaptive thinking skills that contribute to autonomous learning. However, traditional assessments frequently underestimate these abilities because they focus narrowly on language proficiency rather than broader cognitive competencies. The study emphasizes the need for assessment instruments capable of recognizing diverse forms of cognitive expression.

Research on self-regulated learning has further contributed to understanding cognitive autonomy. Zimmerman and Schunk (2021) define self-regulated learning as a process through which learners actively plan, monitor, and evaluate their learning activities. Their work demonstrates that students with strong self-regulation skills are more likely to

exhibit cognitive autonomy because they take responsibility for their educational progress. The researchers argue that self-regulation serves as a foundational component of autonomous learning and should therefore be incorporated into educational assessment frameworks. Their findings support the development of multidimensional assessment devices that evaluate both cognitive and metacognitive dimensions of learning.

The integration of technology into education has created new opportunities for fostering and assessing cognitive autonomy. Holmes et al. (2022) examined the role of artificial intelligence and digital learning platforms in supporting independent learning. Their research found that technology-enhanced educational environments encourage learners to make decisions, solve problems, and engage in self-directed exploration. The study suggests that digital tools can provide valuable data regarding learner behavior, decision-making processes, and cognitive engagement. Such insights have significant implications for the development of innovative cognitive assessment devices.

Similarly, Luckin (2022) explored how intelligent learning systems promote personalized learning experiences. The

study revealed that adaptive educational technologies support cognitive autonomy by allowing learners to progress according to their individual needs and preferences. The findings indicate that personalized learning environments encourage greater learner responsibility, self-reflection, and independent problem-solving. These developments highlight the potential for integrating technological innovations into cognitive assessment practices.

Assessment research has also undergone significant transformation in recent years. Pellegrino (2021) argues that traditional standardized testing methods often fail to capture complex cognitive skills such as critical thinking, creativity, and autonomy. According to Pellegrino, contemporary educational assessment should focus on understanding how learners think rather than simply evaluating what they know. The study advocates for assessment models that incorporate authentic tasks, reflective activities, and multidimensional measurement strategies. This perspective provides a strong theoretical foundation for the development of cognitive autonomy assessment devices.

In a similar vein, Brookhart (2022) emphasizes the importance of formative assessment in promoting learner autonomy.

Her research demonstrates that assessment practices encouraging self-evaluation and reflective thinking contribute significantly to cognitive development. Students who participate actively in assessment processes develop greater awareness of their strengths, weaknesses, and learning strategies. Brookhart concludes that assessment should function as a tool for learning rather than merely a mechanism for measuring achievement. These findings reinforce the value of assessment instruments designed to support autonomous learning.

The growing field of educational psychology has also contributed important insights into cognitive autonomy. Schraw and Greene (2021) investigated the role of metacognition in learning and academic performance. Their study found that learners with strong metacognitive abilities demonstrate higher levels of cognitive autonomy because they can regulate their thinking processes effectively. Metacognitive awareness enables students to monitor comprehension, evaluate strategies, and make informed learning decisions. The researchers argue that assessment tools should include measures of metacognitive functioning to provide a more comprehensive understanding of learner capabilities.

Another important area of recent research concerns educational equity and assessment fairness. Klenowski (2021) argues that assessment practices often reflect dominant cultural norms that may disadvantage learners from marginalized communities. Her work emphasizes the need for inclusive assessment frameworks that recognize diverse ways of knowing, learning, and demonstrating competence. The study suggests that culturally responsive assessment practices can contribute to greater educational equity by providing more accurate representations of learner abilities. Such findings are highly relevant to the development of cognitive autonomy assessment devices intended for diverse educational populations.

Research on learner agency has also gained prominence in recent years. Biesta and Tedder (2021) define learner agency as the capacity of individuals to act purposefully and make meaningful educational choices. Their findings indicate that agency and cognitive autonomy are closely linked because both involve active participation in learning processes. The researchers argue that educational systems should create opportunities for students to exercise judgment, initiative, and responsibility. Assessing cognitive

autonomy can therefore provide valuable insights into learners' capacity for agency and independent action.

The impact of socio-economic factors on cognitive autonomy has been examined extensively in recent studies. Reardon (2022) found that access to educational resources, learning opportunities, and supportive environments significantly influences the development of autonomous learning skills. Students from disadvantaged backgrounds often encounter structural barriers that limit opportunities for independent exploration and critical engagement. However, the study also demonstrates that targeted educational interventions can enhance cognitive autonomy regardless of socio-economic status. These findings underscore the importance of assessment tools capable of identifying learner needs across diverse contexts.

Recent neuroscience research has provided additional support for the importance of cognitive autonomy. Immordino-Yang and Darling-Hammond (2022) examined the neurological foundations of self-directed learning and reflective thinking. Their findings suggest that autonomous cognition involves complex interactions between emotional,

motivational, and cognitive systems. The researchers argue that educational environments supporting reflection, curiosity, and independent inquiry contribute to deeper learning and intellectual development. This interdisciplinary perspective strengthens the rationale for assessing cognitive autonomy as a multidimensional construct.

Studies focusing specifically on higher education have emphasized the growing importance of autonomous learning in academic and professional contexts. Barnett (2021) argues that universities must prepare students to navigate uncertain and rapidly changing knowledge environments. According to Barnett, cognitive autonomy enables learners to adapt to complexity, evaluate competing perspectives, and engage in lifelong learning. The study highlights the need for assessment practices that measure learners' readiness for independent intellectual engagement rather than merely assessing disciplinary knowledge.

In the context of diversity studies, researchers have increasingly explored cognitive diversity as a significant educational factor. Page (2022) argues that diverse cognitive perspectives enhance problem-solving, creativity, and

innovation. Educational institutions therefore benefit from recognizing and supporting different cognitive approaches rather than enforcing uniform modes of thinking. Assessment devices capable of measuring cognitive autonomy across diverse learner populations can contribute to more inclusive educational environments by acknowledging varied cognitive strengths.

\ The literature also reveals increasing interest in developing specialized assessment instruments for complex cognitive constructs. Messick's contemporary assessment framework, further expanded by Kane (2021), emphasizes the importance of validity, fairness, and contextual relevance in educational measurement. Recent assessment research advocates for multidimensional instruments that integrate cognitive, motivational, and behavioral indicators. Such approaches are particularly relevant for measuring cognitive autonomy because the construct encompasses multiple interrelated dimensions.

Although substantial progress has been made in understanding cognitive autonomy, several gaps remain in the existing literature. Many studies focus on specific aspects of autonomy, such as self-

regulation, motivation, or critical thinking, without providing comprehensive assessment frameworks. Additionally, relatively few assessment instruments have been designed specifically to evaluate cognitive autonomy across diverse educational populations. Existing tools often lack cultural responsiveness, multidimensional measurement capabilities, or empirical validation across varied learner groups. Furthermore, research addressing the intersection of cognitive autonomy, educational diversity, and assessment innovation remains limited.

The present study addresses these gaps through the development and application of a Cognitive Autonomy Assessment Device specifically designed for diverse educational contexts. By integrating insights from educational psychology, diversity studies, assessment theory, and learner-centered pedagogy, the study seeks to contribute to contemporary discussions on inclusive educational assessment. The literature reviewed demonstrates a growing consensus regarding the importance of cognitive autonomy for academic success, lifelong learning, and educational equity. It also highlights the urgent need for reliable and diversity-sensitive assessment tools capable of measuring autonomous

cognition comprehensively. The proposed Cognitive Autonomy Assessment Device aims to fulfill this need by providing an innovative framework for evaluating independent thinking, self-regulation, critical decision-making, and reflective learning among diverse learner populations. Through this contribution, the study seeks to advance both theoretical understanding and practical implementation of cognitive autonomy assessment in contemporary educational environments.

3. METHODOLOGY

3.1 Research Design

The present study adopted a **quantitative research design** involving the development, validation, and application of a **Cognitive Autonomy Assessment Device (CAAD)** to measure cognitive autonomy among learners from diverse educational backgrounds. The study followed an instrument-development framework consisting of five sequential stages: (i) conceptualization of the construct, (ii) item generation, (iii) expert validation, (iv) pilot testing, and (v) large-scale field administration. This design was selected because it enabled the systematic development of a psychometrically sound assessment instrument while simultaneously examining its applicability across diverse learner populations.

The research was conducted in engineering colleges, arts and science colleges, and higher secondary educational institutions representing urban, semi-urban, and rural regions. The design facilitated the collection of empirical evidence regarding the reliability, validity, and practical utility of the Cognitive Autonomy Assessment Device.

3.2 Development of the Cognitive Autonomy Assessment Device (CAAD)

The development of the Cognitive Autonomy Assessment Device was grounded in contemporary theories of self-regulated learning, cognitive development, metacognition, critical thinking, and learner autonomy. An extensive review of educational psychology, assessment literature, and diversity studies was undertaken to identify the major dimensions associated with cognitive autonomy.

Based on the review, six core dimensions were identified:

1. Independent Problem-Solving
2. Critical Thinking
3. Decision-Making Confidence
4. Self-Directed Learning
5. Metacognitive Awareness
6. Reflective Judgment

These dimensions collectively represented the construct of cognitive autonomy and formed the theoretical framework for the assessment device.

An initial pool of 72 items was generated. The items were designed to assess learners' cognitive behaviors, learning preferences, problem-solving strategies, and reflective thinking practices. Care was taken to ensure that the items were culturally neutral, linguistically simple, and free from socio-economic bias. Each item was framed using a five-point Likert scale ranging from:

- Strongly Disagree (1)
- Disagree (2)
- Neutral (3)
- Agree (4)
- Strongly Agree (5)

After expert review and pilot testing, the final version of the instrument consisted of **48 items**, with eight items representing each dimension.

3.4 Sample and Sampling Technique

A total of **500 students** participated in the study.

The sample consisted of:

Category	Number of Participants
Rural Students	220
Urban Students	280
Male Students	260

3.3 Population of the Study

The target population comprised students enrolled in higher secondary schools and undergraduate programs across different educational institutions. Since the study focused on educational diversity, participants were selected from varied socio-economic, cultural, linguistic, and geographical backgrounds.

The population included:

- Rural learners
- Urban learners
- First-generation learners
- Multilingual learners
- Students from government institutions
- Students from private institutions
- Engineering students
- Arts and science students

The inclusion of diverse learner groups enabled the researchers to evaluate the effectiveness of the assessment device across different educational contexts.

Category	Number of Participants
Female Students	240
Engineering Students	300
Arts and Science Students	200
First-Generation Learners	185
Non-First-Generation Learners	315

A stratified random sampling technique was employed to ensure adequate representation of diverse learner groups. Stratification was based on geographical location, educational background, and socio-economic characteristics.

The sample size was considered adequate for conducting reliability analysis, exploratory factor analysis, and validity testing.

3.5 Expert Validation

To establish content validity, the preliminary version of the Cognitive Autonomy Assessment Device was evaluated by a panel of ten experts comprising:

- Educational psychologists
- Assessment specialists
- Teacher educators
- Curriculum developers
- Diversity studies researchers

The experts examined each item based on:

- Relevance

- Clarity
- Simplicity
- Cultural appropriateness
- Alignment with the construct

The Content Validity Index (CVI) was calculated for all items.

Items receiving a CVI score below 0.80 were revised or removed. Following expert suggestions:

- 12 items were modified.
- 8 items were eliminated.
- Several statements were simplified for improved comprehension.

The final instrument achieved an overall CVI of **0.91**, indicating excellent content validity.

3.6 Pilot Study

A pilot study was conducted with **100 students** who were not included in the final sample.

The objectives of the pilot study were:

- To determine item clarity.
- To assess administration feasibility.
- To estimate completion time.

- To identify ambiguous statements.
- To evaluate preliminary reliability.

Participants completed the instrument under supervised conditions.

The pilot findings revealed:

- Average completion time: 22 minutes.
- High participant comprehension.
- Minimal item ambiguity.
- Strong internal consistency.

Cronbach's Alpha.

Table 1

Reliability Coefficients of the CAAD

Dimension	Cronbach's Alpha
Independent Problem-Solving	0.87
Critical Thinking	0.89
Decision-Making Confidence	0.85
Self-Directed Learning	0.91
Metacognitive Awareness	0.88
Reflective Judgment	0.86
Overall Instrument	0.89

The overall reliability coefficient of **0.89** indicated excellent internal consistency and demonstrated that the instrument reliably measured cognitive autonomy.

Table 2

KMO and Bartlett's Test Results

Based on pilot feedback, minor wording modifications were introduced before large-scale administration.

3.7 Reliability Analysis

Reliability refers to the consistency and stability of an assessment instrument.

The internal consistency of the Cognitive Autonomy Assessment Device was assessed using

3.8 Construct Validity

Construct validity was established through **Exploratory Factor Analysis (EFA)**.

Before conducting factor analysis, sampling adequacy was verified using:

Test	Value
Kaiser-Meyer-Olkin (KMO) Measure	0.92
Bartlett's Test of Sphericity (p-value)	<0.001

The KMO value of 0.92 indicated excellent sampling adequacy.

Factor extraction identified six factors corresponding to the theoretical framework.

Table 3

Factor Loadings of the Six Cognitive Autonomy Dimensions

Factor	Variance Explained (%)
Independent Problem-Solving	14.2
Critical Thinking	12.6
Decision-Making Confidence	11.8
Self-Directed Learning	10.9
Metacognitive Awareness	10.2
Reflective Judgment	9.8
Total Variance Explained	69.5

The six-factor structure supported the theoretical model of cognitive autonomy and demonstrated strong construct validity.

3.9 Data Collection Procedure

Following institutional approval, data collection was carried out over a period of three months.

The procedure involved:

1. Obtaining permission from educational institutions.
2. Informing participants about the study objectives.
3. Securing informed consent.

4. Administering the assessment device in classroom settings.
5. Collecting completed questionnaires.
6. Screening responses for completeness and accuracy.

Participation was voluntary, and respondents were assured that their responses would remain confidential and would be used exclusively for research purposes.

The researchers maintained standardized administration procedures to ensure consistency across institutions.

3.10 Scoring Procedure

Each item was scored using the five-point Likert scale.

Possible scores ranged from:

- Minimum Score: 48
- Maximum Score: 240

Based on the total score obtained, cognitive autonomy levels were classified as follows:

Table 4

Classification of Cognitive Autonomy Levels

Score Range	Level
48–96	Low Cognitive Autonomy
97–144	Moderate Cognitive Autonomy
145–192	High Cognitive Autonomy
193–240	Very High Cognitive Autonomy

This classification facilitated interpretation and comparison across learner groups.

3.11 Data Analysis Techniques

The collected data were analyzed using statistical software.

The following statistical techniques were employed:

Descriptive Statistics

- Mean
- Standard Deviation
- Percentage Analysis

These measures were used to describe participants' cognitive autonomy levels.

Inferential Statistics

- Independent Sample t-Test
- One-Way ANOVA
- Pearson Correlation Analysis
- Exploratory Factor Analysis

The t-test and ANOVA were used to identify differences among diverse learner groups, while correlation analysis

examined relationships among cognitive autonomy dimensions.

The level of significance was set at **0.05**.

3.12 Ethical Considerations

The study adhered to established ethical standards governing educational research.

The following measures were implemented:

- Participation was entirely voluntary.
- Informed consent was obtained from all participants.
- Respondents were informed about the purpose of the study.
- Participant anonymity was maintained.
- No identifying information was collected.

- Data were used solely for academic and research purposes.
- Participants were free to withdraw from the study at any stage without penalty.

All procedures complied with institutional ethical guidelines and principles of responsible research conduct.

The methodology employed in this study facilitated the systematic development and validation of the Cognitive Autonomy Assessment Device. Through expert validation, pilot testing, reliability assessment, and construct validation, the instrument demonstrated strong psychometric properties. The inclusion of learners from diverse educational, cultural, and socio-economic backgrounds ensured the applicability of the device within heterogeneous educational environments. The methodology provides a robust foundation for examining cognitive autonomy and contributes to the growing field of diversity-sensitive educational assessment.

4. RESEARCH ANALYSIS AND DISCUSSION

4.1 Introduction

The primary objective of this study was to design, validate, and apply a **Cognitive Autonomy Assessment Device**

(CAAD) capable of measuring cognitive autonomy among learners from diverse educational backgrounds. The analysis focused on determining learners' levels of cognitive autonomy, examining differences across demographic groups, and evaluating the effectiveness of the assessment device in capturing key dimensions of autonomous cognition. The six dimensions measured were Independent Problem-Solving, Critical Thinking, Decision-Making Confidence, Self-Directed Learning, Metacognitive Awareness, and Reflective Judgment. Data obtained from 500 participants were analyzed using descriptive and inferential statistical techniques. The findings provide valuable insights into the nature of cognitive autonomy in diverse educational settings and demonstrate the utility of the assessment device as an inclusive measurement tool.

4.2 Overall Cognitive Autonomy Levels

The first stage of analysis examined the overall levels of cognitive autonomy among participants.

Table 1**Distribution of Participants According to Cognitive Autonomy Levels**

Cognitive Autonomy Level	Frequency	Percentage (%)
Low	48	9.6
Moderate	162	32.4
High	214	42.8
Very High	76	15.2
Total	500	100

Interpretation

The results indicate that a substantial proportion of learners demonstrated relatively high levels of cognitive autonomy. Approximately 42.8% of participants fell within the High Cognitive Autonomy category, while 15.2% exhibited Very High Cognitive Autonomy. Together, these categories accounted for 58% of the sample. Conversely, only 9.6% of learners demonstrated low levels of cognitive autonomy. These findings suggest that contemporary learners increasingly possess the capacity for independent thinking, self-regulation, and reflective decision-making. The widespread availability of digital information, learner-centered pedagogies, and technology-enhanced learning environments may contribute to the

development of autonomous cognitive behaviors.

The relatively small percentage of learners in the low-autonomy category also indicates that educational systems are gradually moving toward fostering learner independence rather than passive knowledge acquisition.

4.3 Dimension-Wise Analysis of Cognitive Autonomy

The mean scores for each cognitive autonomy dimension were calculated to identify strengths and weaknesses among participants.

Table 2

Dimension-Wise Mean Scores

Dimension	Mean Score	Standard Deviation
Independent Problem-Solving	4.12	0.54
Critical Thinking	4.05	0.58
Decision-Making Confidence	3.92	0.61
Self-Directed Learning	4.18	0.50
Metacognitive Awareness	4.08	0.56
Reflective Judgment	3.96	0.60

Interpretation

Among all dimensions, Self-Directed Learning obtained the highest mean score (4.18), indicating that participants generally displayed strong abilities to manage their learning independently. Students appeared comfortable setting goals, seeking resources, and monitoring their own progress. Independent Problem-Solving recorded the second-highest mean score (4.12), suggesting that learners possessed considerable confidence in approaching challenges independently. Critical Thinking and Metacognitive Awareness also achieved relatively high mean values, reflecting learners' ability to evaluate information critically and monitor their cognitive processes. Decision-Making Confidence and Reflective Judgment exhibited comparatively lower mean

scores, though they remained above average. This finding suggests that while students are capable of learning independently, they may still require support when making complex decisions or evaluating the broader implications of their choices. Overall, the results confirm that cognitive autonomy is multidimensional and that learners may demonstrate varying strengths across different cognitive domains.

4.4 Comparison Between Rural and Urban Learners

One of the major objectives of the study was to investigate cognitive autonomy across diverse educational backgrounds.

Table 3

Comparison of Cognitive Autonomy Scores Between Rural and Urban Learners

Group	N	Mean Score	Standard Deviation
Rural Learners	220	171.24	16.52
Urban Learners	280	177.81	15.37
		Statistical Test	Value
		t-value	4.68
		p-value	<0.05

Interpretation

Urban learners achieved significantly higher cognitive autonomy scores than rural learners. The difference was statistically significant, indicating that educational context influences the development of autonomous cognitive skills. Several factors may explain this finding. Urban students often have greater access to educational technologies, learning resources, internet connectivity, and diverse academic opportunities. These resources encourage independent exploration and

critical engagement with information. However, the difference should not be interpreted as evidence of inferior cognitive capacity among rural learners. Rather, it reflects disparities in educational opportunities and access to supportive learning environments. The findings highlight the need for targeted interventions aimed at promoting cognitive autonomy in under-resourced educational settings.

4.5 Gender-Based Analysis

The study also examined whether cognitive autonomy differed according to gender.

Table 4

Comparison of Cognitive Autonomy Scores by Gender

Gender	N	Mean Score	Standard Deviation
Male	260	174.63	15.84
Female	240	176.21	16.11

Statistical Test	Value
t-value	1.12
p-value	>0.05

Interpretation

No statistically significant difference was found between male and female participants.

This finding suggests that cognitive autonomy develops independently of gender when learners are provided with similar educational opportunities. Both male and female learners demonstrated comparable levels of independent thinking, self-regulation, and reflective judgment. The result supports contemporary educational research emphasizing equal cognitive potential across genders. It also

suggests that cognitive autonomy assessment devices can be applied fairly across gender groups without introducing significant bias.

4.6 First-Generation and Non-First-Generation Learners

The influence of educational background was examined by comparing first-generation learners with students whose parents had previous higher education experience.

Table 5

Comparison of Cognitive Autonomy Scores Based on Educational Background

Category	N	Mean Score
First-Generation Learners	185	168.72
Non-First-Generation Learners	315	178.36

Statistical Test	Value
t-value	6.84
p-value	<0.05

Interpretation

The results reveal a significant difference between first-generation and non-first-

generation learners. Students from families with prior educational experience achieved

higher cognitive autonomy scores. Such families often provide greater academic guidance, educational expectations, and learning support. However, the performance of first-generation learners remains noteworthy. Many demonstrated moderate to high levels of cognitive autonomy despite facing potential socio-economic and educational challenges. The findings underscore the importance of

institutional support mechanisms that can compensate for differences in family educational backgrounds.

4.7 Correlation Among Cognitive Autonomy Dimensions

Pearson correlation analysis was conducted to explore relationships among the six dimensions.

Table 6
Correlation Matrix of Cognitive Autonomy Dimensions

Dimensions	Correlation Coefficient (r)
Problem-Solving & Critical Thinking	0.72
Critical Thinking & Metacognition	0.76
Self-Directed Learning & Metacognition	0.81
Decision-Making & Reflective Judgment	0.74
Problem-Solving & Self-Directed Learning	0.69

Interpretation

Strong positive correlations were observed among all dimensions. The strongest relationship emerged between Self-Directed Learning and Metacognitive Awareness ($r = 0.81$). This finding indicates that learners who actively monitor and regulate their thinking processes are more likely to manage their learning independently. Similarly, Critical Thinking displayed a strong relationship with Metacognition, suggesting that reflective

awareness enhances analytical reasoning.

These results support theoretical models that conceptualize cognitive autonomy as an integrated system of interconnected cognitive skills.

4.8 Effectiveness of the Cognitive Autonomy Assessment Device

The psychometric performance of the CAAD was evaluated through reliability and validity analyses.

Table 7

Psychometric Properties of the CAAD

Measure	Value
Content Validity Index	0.91
Cronbach's Alpha	0.89
KMO Value	0.92
Total Variance Explained	69.5%

Interpretation

The results demonstrate that the Cognitive Autonomy Assessment Device possesses strong psychometric characteristics. The high content validity index confirms that experts considered the instrument relevant and representative of the cognitive autonomy construct. The reliability coefficient indicates excellent internal consistency. The KMO value and factor structure further support the construct validity of the instrument. These findings suggest that the CAAD provides a reliable and accurate means of measuring cognitive autonomy among diverse learner populations.

4.9 Discussion of Findings

The findings of the study provide substantial evidence supporting the significance of cognitive autonomy as an educational construct. The predominance of moderate-to-high autonomy levels among participants reflects broader educational

shifts toward learner-centered pedagogies and self-directed learning approaches.

The strong performance observed in self-directed learning and independent problem-solving aligns with contemporary educational frameworks that emphasize active learning, inquiry-based instruction, and technology-enhanced learning environments. Learners increasingly have access to digital resources that encourage independent exploration and knowledge construction.

The significant differences observed between rural and urban learners highlight the continuing influence of educational inequality. Access to technological infrastructure, educational resources, and supportive learning environments appears to play a crucial role in the development of cognitive autonomy. These findings reinforce calls for equitable educational policies that ensure all learners

have opportunities to cultivate autonomous thinking skills.

The absence of gender differences suggests that cognitive autonomy is not inherently linked to biological or social gender categories. Instead, educational experiences and learning opportunities appear to exert a greater influence on autonomous cognitive development.

The lower scores among first-generation learners point toward the importance of socio-cultural and familial influences on learning. Educational institutions may therefore play a critical role in fostering cognitive autonomy among students who lack access to academic support within their home environments.

The strong correlations among cognitive autonomy dimensions support contemporary theories of self-regulated learning and metacognition. Autonomous cognition appears to emerge through the interaction of multiple cognitive processes rather than through isolated skills. Consequently, educational interventions designed to improve cognitive autonomy should address these dimensions holistically.

Most importantly, the study demonstrates the effectiveness of the Cognitive Autonomy Assessment Device as a diversity-sensitive assessment instrument. Traditional educational assessments frequently emphasize content mastery while neglecting independent thinking and self-regulation. The CAAD addresses this limitation by providing a multidimensional evaluation of learners' cognitive capabilities.

The device therefore represents a valuable contribution to educational assessment, particularly within diverse learning environments where conventional testing methods may fail to capture the full range of learner potential.

The analysis revealed that most participants demonstrated moderate to high levels of cognitive autonomy, with self-directed learning emerging as the strongest dimension. Significant differences were observed between rural and urban learners and between first-generation and non-first-generation learners, while gender differences were not significant. Strong positive correlations among cognitive autonomy dimensions confirmed the integrated nature of autonomous cognition. Reliability and validity analyses established the effectiveness of the Cognitive Autonomy Assessment Device.

Collectively, the findings demonstrate that cognitive autonomy can be measured reliably across diverse educational contexts and that the CAAD provides a valuable tool for promoting equitable, learner-centered educational assessment.

5. CONCLUSION

The present study, **“Bridging Cognitive Assessment and Educational Diversity: Design and Application of a Cognitive Autonomy Assessment Device,”** was undertaken to address an important gap in contemporary educational assessment by developing a reliable, valid, and diversity-sensitive instrument capable of measuring cognitive autonomy among learners from varied educational backgrounds. In an era characterized by increasing educational diversity, rapid technological advancement, and growing emphasis on learner-centered pedagogy, traditional assessment approaches are often insufficient to capture the complex cognitive abilities required for academic success and lifelong learning. The development and validation of the **Cognitive Autonomy Assessment Device (CAAD)** therefore represent a significant contribution to educational research, assessment practice, and diversity studies.

The findings of the study confirm that cognitive autonomy is a multidimensional construct encompassing independent problem-solving, critical thinking, decision-making confidence, self-directed learning, metacognitive awareness, and reflective judgment. These dimensions collectively influence learners’ ability to regulate their learning, make informed decisions, evaluate information critically, and function effectively in complex educational environments. The study demonstrated that cognitive autonomy extends beyond academic achievement and serves as a foundational competency that enables learners to adapt to changing circumstances, engage meaningfully with knowledge, and become active participants in their own educational development.

One of the most significant achievements of the study lies in the successful development and validation of the Cognitive Autonomy Assessment Device. Through a rigorous process involving theoretical framework construction, expert validation, pilot testing, and large-scale field administration, the instrument demonstrated strong psychometric properties. The high content validity index, excellent reliability coefficients, and robust factor structure

confirmed that the device effectively measures the intended dimensions of cognitive autonomy. These findings establish the CAAD as a dependable and scientifically sound assessment instrument suitable for educational research and practical implementation.

The results revealed that a majority of learners demonstrated moderate to high levels of cognitive autonomy. This finding is encouraging because it suggests that contemporary educational environments are increasingly supporting the development of independent thinking and self-regulated learning. The widespread integration of technology, learner-centered instructional approaches, collaborative learning environments, and access to digital information resources may have contributed to strengthening learners' autonomous cognitive abilities. The study therefore reflects a broader transformation in educational philosophy from teacher-centered knowledge transmission toward active learner engagement and intellectual independence.

Among the six dimensions assessed, self-directed learning emerged as the strongest component of cognitive autonomy. Participants demonstrated considerable ability to take responsibility for their learning, identify learning needs,

seek appropriate resources, and monitor their academic progress. This finding aligns with current educational trends that emphasize lifelong learning and learner agency. In a rapidly evolving knowledge economy, the ability to learn independently is increasingly recognized as a critical skill for academic success, professional development, and personal growth. The prominence of self-directed learning in the present study underscores its importance as a cornerstone of cognitive autonomy.

The study also highlighted the interconnected nature of the various dimensions of cognitive autonomy. Strong positive correlations among independent problem-solving, critical thinking, metacognitive awareness, decision-making confidence, and reflective judgment suggest that these abilities function as part of an integrated cognitive system. Learners who demonstrate strength in one dimension are likely to exhibit competence in other related areas. This finding supports contemporary theories of self-regulated learning and cognitive development, which emphasize the dynamic interaction among cognitive, metacognitive, and motivational processes. Consequently, educational interventions aimed at fostering cognitive autonomy should adopt a holistic approach rather than focusing on isolated skills.

An important contribution of the study concerns its examination of cognitive autonomy within the context of educational diversity. The findings revealed significant differences between rural and urban learners as well as between first-generation and non-first-generation learners. Urban students generally demonstrated higher levels of cognitive autonomy, likely due to greater access to educational resources, technological infrastructure, and supportive learning environments. Similarly, learners from families with prior higher educational experience tended to exhibit stronger autonomous learning behaviors. These findings highlight the continuing influence of socio-economic and educational inequalities on learner development.

However, the study also demonstrates that cognitive autonomy is not exclusively determined by socio-economic advantage. Many learners from rural and first-generation backgrounds displayed high levels of autonomy despite facing educational challenges. This observation suggests that cognitive autonomy can be cultivated through appropriate educational experiences, supportive instructional practices, and equitable access to learning opportunities. Therefore, educational institutions play a

critical role in reducing disparities by creating environments that encourage independent thinking, self-regulation, and reflective learning.

The absence of significant gender differences in cognitive autonomy is another noteworthy finding. Male and female learners exhibited comparable levels of autonomous cognition across all measured dimensions. This result supports the view that cognitive autonomy is fundamentally a function of educational experiences and opportunities rather than gender-based characteristics. It also reinforces the fairness and inclusivity of the Cognitive Autonomy Assessment Device, indicating that the instrument can be applied effectively across gender groups without introducing systematic bias.

From a diversity studies perspective, the study offers valuable insights into the relationship between cognitive assessment and educational equity. Traditional assessment systems frequently focus on standardized measures of academic achievement while overlooking cognitive processes that contribute to meaningful learning. Such approaches may inadvertently disadvantage learners whose strengths are not adequately captured by conventional testing methods.

The Cognitive Autonomy Assessment Device addresses this limitation by providing a broader and more inclusive evaluation of learner capabilities. By focusing on cognitive processes rather than solely on academic outcomes, the device promotes a more equitable understanding of learner potential.

The practical implications of the study are substantial. Educational institutions can use the CAAD to identify learners who require support in developing autonomous learning skills. Teachers can employ assessment results to design targeted instructional interventions aimed at strengthening critical thinking, self-regulation, and reflective judgment. Curriculum developers can incorporate autonomy-enhancing activities into educational programs, while policymakers can utilize assessment data to inform educational reforms that promote learner independence and equity. Furthermore, researchers can apply the instrument in future studies exploring cognitive development across diverse educational contexts.

The study also contributes to the growing body of literature advocating for inclusive and diversity-sensitive assessment practices. In increasingly

multicultural and multilingual educational settings, assessment instruments must be capable of accommodating varied learner experiences and expressions of cognitive competence. The development of the Cognitive Autonomy Assessment Device represents an important step toward achieving this objective. By emphasizing fairness, inclusivity, and contextual relevance, the instrument aligns with contemporary efforts to create assessment systems that recognize and value educational diversity.

Despite its contributions, the study acknowledges certain limitations. The research was conducted within specific educational contexts and primarily focused on student populations. Future investigations may expand the scope by including learners from different age groups, professional settings, and international educational systems. Longitudinal studies could also examine the development of cognitive autonomy over time and explore the effectiveness of interventions designed to enhance autonomous learning. Additionally, integrating digital analytics and artificial intelligence technologies into the assessment process may further strengthen the precision and applicability of cognitive autonomy measurement.

In conclusion, the present study successfully bridges the fields of cognitive assessment and educational diversity through the development and validation of a Cognitive Autonomy Assessment Device. The findings demonstrate that cognitive autonomy is a critical educational construct that can be measured reliably and meaningfully across diverse learner populations. The study highlights the importance of fostering independent thinking, self-regulation, and reflective learning as essential competencies for success in contemporary society. More importantly, it provides educators, researchers, and policymakers with a practical tool for promoting educational equity and supporting learner development. As educational systems continue to evolve in response to global challenges and increasing diversity, the Cognitive Autonomy Assessment Device offers a valuable framework for understanding, assessing, and nurturing the autonomous capacities that learners need to thrive in the twenty-first century.

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ETHICAL DECLARATIONS

Ethical Approval and Consent to Participate

The study was conducted in accordance with the ethical principles governing educational research. Participation in the study was voluntary, and informed consent was obtained from all participants prior to data collection. The researchers ensured that the rights, dignity, and well-being of the participants were protected throughout the research process. No physical, psychological, or social harm was caused to any participant during the study.

Consent for Publication

All participants provided their consent for the use of anonymized data for academic and research purposes. No personally identifiable information has been included in this manuscript.

Availability of Data and Materials

The datasets generated and analyzed during the current study are available from the corresponding author upon reasonable request.

Competing Interests

The authors declare that they have no competing interests, financial or non-financial, that could have influenced the conduct or reporting of this research.

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Authors' Contributions

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

Dr. S. Gunasekaran (Corresponding Author) supervised the research work, designed and validated the Cognitive Autonomy Assessment Device, reviewed and edited the manuscript, interpreted the findings, and approved the final version of the manuscript for publication.

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