



Validation of Cognitive Engagement Questionnaire among University Pre-Service Biology Teachers in Northwest, Nigeria

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Abstract

The study aims at validating Cognitive Engagement Questionnaire among Pre-service Biology Teachers of Universities in North-west zone, Nigeria. A descriptive survey research design was adopted on the population comprising of level 300 biology education students of the university program in the state universities in north-west zone, Nigeria. A Sample of thirty (30) pre-service biology teachers were selected using multistage sampling technique from two (2) universities in the zone. Face, content, construct validity and reliability were carried out and the result produced a significant values of logical face validity index (82.5%), overall content validity or Scale Validity Index (0.88), Convergent validity index ($r = 0.83$), Divergent validity index ($r = 0.23$), Reliability coefficient ($r = 0.88$). The reliability indices of the subscales recorded as; Cognitive Strategy (0.98), Deep Processing (0.92), Shallow Processing (0.88), and Persistence (0.80). The study concluded that the instrument is clear, relevant, suitable instrument is fit for measuring the intended psychological constructs of pre-service biology teachers' cognitive engagement, and further suggested that, Ministry of Education and the National Universities Commission (NUC) to adopt the PREBITCEQ as a standardized measuring instrument for monitoring the cognitive engagement of pre-service biology teachers across the universities in North-west zone Nigeria.

Keywords: Pre-service Teachers, Cognitive Engagement, Questionnaire, Validity and Reliability

Introduction

Validation of research instruments is a fundamental procedure in educational research that ensures the accuracy and dependability of the collected data. Validation serves as the essential prerequisite for ensuring that research findings are not merely "mathematical artifacts" but credible, reliable, and applicable facts in professional contexts (Karnia, 2024; Yong et al., 2026). In high-stakes environments such as teacher education, the use of psychometrically robust measurement is the only reliable way to identify internal psychological states. The validation process is multidimensional, traditionally encompassing the assessment of face validity, content validity, and construct validity to ensure that the instrument is fit for its intended purpose (Anggraini et al., 2023; Wang et al., 2023). This process begins with face validity, which serves as a preliminary assessment or "consistency check," determining the extent to which a tool appears, at first glance, to measure the intended variables. Although it is often considered the least rigorous form of validation due to its superficial nature, it remains essential for ensuring participant buy-in and establishing the perceived legitimacy of the study (Merkus, 2025). Recent researchers argue that face validity acts as a bridge between the researcher's intent and the respondent's cooperation; its success ensures that the questionnaire is perceived as a legitimate professional tool rather than an intrusive or irrelevant survey (Researcher.Life, 2025). For a specialized field like biology education, this means that the tool's language must reflect the specific pedagogical challenges of that discipline.

Next comes content validity, which typically involves a panel of experts using the Content Validity Index (CVI) to verify that the instrument aligns with the specific programs and professional standards of the discipline (Bhattacharyya et al., 2024). Content validity corresponds to the extent to which the items of the questionnaire adequately represent all dimensions of the measured concept. For the PREBITCEQ questionnaire, this means ensuring that every aspect of cognitive engagement such as persistence, deep processing, and shallow processing is proportionally represented in the questions (Zhang & Garcia, 2023); it acts as a safeguard against "construct under-representation" that could lead to the omission of critical aspects of the student's mental effort. Furthermore, construct validity constitutes the empirical bridge between the research tool and the theoretical attribute it aims to measure. Construct validity is the degree to which a test measures what it claims or aims to measure. In educational psychometrics, it provides irrefutable proof that the instrument's scores can be interpreted as a meaningful reflection of a specific psychological trait (Karnia, 2024). By presenting evidence of "convergence" and "divergence" validity of cognitive engagement, researchers ensure that the instrument captures a



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specific internal mental state rather than unrelated psychological factors (Lim, 2024). The validation process is completed by the assessment of reliability, which ensures that the instrument provides stable and consistent results across different populations. "Internal consistency" often estimated by Cronbach's alpha, remains the gold standard for determining whether the items of a subscale systematically measure the same psychological attribute (Creswell & Guetterman, 2019). In professional teacher training contexts, recent psychometric evaluations suggest that reliability coefficients greater than 0.70 are indispensable for limiting measurement errors and ensuring data reliability (Frontiers in Education, 2025). The necessity of rigorous validation is particularly evident when measuring a complex concept such as cognitive engagement which represents the student's psychological commitment to the learning process, characterized by the use of advanced learning strategies, continuous persistence, and self-regulation (OECD, 2025; Spitzer et al., 2006). This concept requires intense mental effort to move from simple superficial memorization to deep processing and conceptual mastery. For future biology teachers, this process involves managing the high cognitive load associated with understanding complex vital processes and scientific theories. Given that these mental activities are internal and non-observable, they require a precisely calibrated measurement tool to be detected correctly. Despite the increase in research on students' cognitive engagement, a critical gap remains in the availability of specialized instrument in this discipline; many current questionnaires were developed for general populations or non-scientific disciplines, leading to a manifest scarcity of validated scales designed specifically for the unique academic requirements of biology students (MDPI, 2025). In the Nigerian context, and particularly within universities in the Northwest zone, there is an urgent need for specialized validation processes. The technical nature of biological sciences, coupled with the shift toward digital laboratory platforms, necessitates a tool sensitive to these specific requirements. This study fills this gap by evaluating the psychometric properties of the "Pre-service Biology Teachers' Cognitive Engagement Questionnaire" (PREBITCEQ), thereby offering educators a robust measuring tool to improve the quality of science teacher preparation.

Statement of the Problem

A lot of research in the Northwest region still uses instruments that lack solid proof of their validity and dependability. Significant measurement error can occur when an instrument does not have a confirmed Content Validity Index (CVI) or does not satisfy the internal consistency criteria (e.g., Cronbach's Alpha of 0.70) (Anggraini et al., 2023; Shockden & Onyejekwe, 2025). This results in perhaps faulty educational policies and incorrect assessments of students' learning demands (Bhattacharyya et al., 2024). It is still challenging for teacher-educators to empirically ascertain why some pre-service biology instructors succeed while others struggle, whilst having comparable access to resources, in the absence of a specialized and validated Cognitive Engagement Questionnaire (CEQ) (Asanre et al., 2024). Therefore, these pressing challenges necessitate the need to assess the psychometric qualities of a CEQ in order to make sure it is a "fit-for-purpose" instrument that can precisely measure pre-service biology students' mental investment, thereby offering a solid basis for enhancing science teacher preparation in Nigeria.

Objectives of the Study

The following research objectives guides the study

1. To determine the face validity index of Cognitive Engagement Questionnaire among Pre-service Biology Teachers of universities in North-west zone, Nigeria.
2. To assess the content validity index of Cognitive Engagement Questionnaire among Pre-service Biology Teachers of universities in North-west zone, Nigeria.
3. To find out the construct validity index of Cognitive Engagement Questionnaire among Pre-service Biology Teachers of universities in North-west zone, Nigeria.
4. To measure the reliability coefficient of Cognitive Engagement Questionnaire among Pre-service Biology Teachers of universities in North-west zone, Nigeria.

Research questions

The following research questions were answered in the study

1. What is the face validity index of Cognitive Engagement Questionnaire among Pre-service Biology Teachers of universities in North-west zone, Nigeria?
2. What is the content validity index of Cognitive Engagement Questionnaire among Pre-service Biology Teachers of universities in North-west zone, Nigeria?



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3. What are the construct validity indices of Cognitive Engagement Questionnaire among Pre-service Biology Teachers of universities in North-west zone, Nigeria?
4. What is the reliability coefficient of Cognitive Engagement Questionnaire among Pre-service Biology Teachers of universities in North-west zone, Nigeria?

Research Methodology

The study adopted a descriptive survey research design. A descriptive survey study design is a quantitative method intended to give a methodical and precise description of the traits, attitudes, or behaviors of a target group. This approach places more emphasis on determining and recording the "what," "where," and "how" of the current circumstance than on investigating causal linkages or "why" a phenomenon happens (Karnia, 2024). It utilizes structured instruments (example Cognitive Engagement Questionnaire) to transform qualitative human experiences into quantifiable data for rigorous analysis. The population of this study comprises of level 300 biology education students enrolled in university program in the state universities in north-west zone, Nigeria. A Sample of thirty (30) pre-service biology teachers were selected randomly from two (2) universities in the north-west zone of Nigeria.

Presentation of Results

Research Question 1: What is the face validity index of Cognitive Engagement Questionnaire among Pre-service Biology Teachers of universities in North-west zone, Nigeria?

The Pre-service Biology Teachers' Cognitive Engagement Questionnaire was subjected to ten (10) experts chosen from universities in the North-west zone, Nigeria. The average percentage agreement scores of the ten (10) experts was calculated, and the Logical Face Validity index of 82.5% was established, which is an acceptable value as recommended by Anikwueze, (2010) and Poopola, (2016).

Table 1: Face Validity Index for Pre-service Biology Teachers' Cognitive Engagement

Validators	CI (30%)	TCT (30%)	L (40%)	FVI
1 st Validators	26	30	31	87
2 nd Validators	25	28	30	83
3 rd Validators	27	25	30	82
4 th Validators	25	25	27	77
5 th Validators	25	29	31	85
6 th Validators	24	20	32	76
7 th Validators	21	26	36	83
8 th Validators	22	25	30	77
9 th Validators	24	28	36	88
10 th Validators	28	29	30	87
FVIA	24.7	26.5	31.3	82.5

Key: CI: Clarity of Instructions, TCT: Time to Complete the Test, L: Language Usage; FVI: Face Validity Index, FVIA: Overall Face Validity Index

Research Question 2: What is the content validity index of Cognitive Engagement Questionnaire among Pre-service Biology Teachers of universities in North-west zone, Nigeria?

A panel of six (6) content experts evaluated the initial 20-items. According to Yusoff (2019) six steps are involved in content validation: creating a content validation form, choosing an expert review panel, performing content validation, evaluating the domain and items, assigning a score to each item, and determining the Content Validity Index (CVI). The experts thoroughly and critically examined the areas and the items of the questionnaire after which they assign a score to each item as they were requested. Then, the Content Validity Index (CVI) was calculated as:

$$I - CVI = \frac{\text{Agreed Item}}{\text{Number of Expert}} \quad S - CVI/Ave = \frac{\text{Sum of } I - CVI \text{ Scores}}{\text{Number of items}}$$

Relevance rating was classified as either 1 (relevance scale of 3 and 4) or 0 (relevance scale of 1 and 2). The acceptable cut-off score of CVI is 1 for three to five experts, 0.83 for six to eight experts, and 0.78 for at least nine experts. (Davis, 1992; Polit, Beck & Owen, 2007; Yusoff 2019). This study adopted a cut-off score for the content validity index of 0.83 and above, in accordance with the suggested range of acceptable cut-off scores provided by certain researchers.



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Table 2: Relevance Rating On Pre-Service Biology Teachers' Cognitive Engagements Questionnaire

Item	Expert 1	Expert 2	Expert 3	Expert 4	Expert 5	Expert 6	Expert in Agreement	I-CVI	Remark
1	1	1	1	1	1	1	5	0.83	Retained
2	1	0	1	1	1	1	5	0.83	Retained
3	1	0	0	1	1	1	4	0.66	Discarded
4	1	0	1	1	1	1	5	0.83	Retained
5	1	1	1	1	1	1	6	1	Retained
6	0	1	1	1	0	1	5	0.66	Discarded
7	1	1	1	0	1	1	5	0.83	Retained
8	1	1	1	1	0	1	5	0.83	Retained
9	1	1	1	1	1	0	5	0.83	Retained
10	1	1	1	1	1	1	6	1	Retained
11	1	1	1	0	0	1	4	0.66	Discarded
12	1	1	1	1	1	1	6	1	Retained
13	1	1	1	0	1	1	5	0.83	Retained
14	0	1	1	1	0	1	5	0.66	Discarded
15	1	1	1	1	1	1	6	1	Retained
16	1	1	1	0	1	1	5	0.83	Retained
17	1	0	1	1	1	1	5	0.83	Retained
18	1	0	1	1	1	1	5	0.83	Retained
19	1	0	1	1	1	1	5	0.83	Retained
20	1	1	1	1	1	1	6	1	Retained
							S-CVI/Ave	0.88	

Based on the experts' judgment on the inter-rater review of the questionnaire's items, it indicates that; Out of the 20 items evaluated, 11 items (1,2,4,7,8,9,13,16,17,18 and 19) achieved a I-CVI of 0.83 and are considered relevant in the final draft of the questionnaire. Five (5) items (5, 10, 12, 15, and 20) achieved a perfect I-CVI of 1 and are purely considered relevant. Four (4) items (3, 6, 11 and 14) recorded an I-CVI of 0.66. Because these values fell below the accepted 0.83, they were deemed insufficiently relevant and were excluded from the final instrument. The Scale-level Content Validity Index (S-CVI/Ave) or overall Scale Validity calculated was 0.88. This indicates a high degree of content representation and demonstrates strong evidence of content validity, ensuring that the instrument is fit for measuring the intended psychological constructs.

Research Question 3: What are the construct validity indices of Cognitive Engagement Questionnaire among Pre-service Biology Teachers of universities in North-west zone, Nigeria?

The researcher employed a pairing technique which specifically involves comparing the scores of the current instruments against already established instruments. Pairing technique is a simultaneous assessment of convergent and divergent (discriminant) validity by correlating the research instruments with external measures (Flake & Fried, 2020).

Convergent Validity of Pre-service Biology Teachers Cognitive Engagement Questionnaire

Convergent validity of the Pre-service Biology Teachers' Cognitive Engagement Questionnaire (PREBITCE) was established by examining its relationship with relevant subscales of the Motivated Strategies for Learning Questionnaire (MSLQ) developed by Pintrich and De Groot (1990). The Pearson Correlation analysis revealed a significant positive correlation of $r = 0.83$ between the PREBITCE and the MSLQ cognitive subscales. The result indicates that the PREBITCE demonstrates a high degree of linear relationship with an existing, validated measure of the same construct and successfully captures the cognitive dimensions of student cognitive engagement and hence is good for the study (Boateng et al., 2018; Hair et al. 2019).

Divergent Validity of Pre-service Biology Teachers Cognitive Engagement Questionnaire

To determine the divergent validity of Pre-service Biology Teachers Cognitive Engagement Questionnaire, self-rated anxiety questionnaire (SRQ) developed by Spitzer et al (2006) was used which is empirically distinct. Theoretically, cognitive engagement reflects students' psychological investment in learning, deep processing strategies, and sustained effort in academic tasks. In contrast, self-rated anxiety reflects emotional tension, worry, and physiological arousal associated with evaluative academic situations. The scores of both the constructs, validity Pre-service Biology Teachers Cognitive Engagement Questionnaire and self-rated anxiety questionnaire was analyzed using Pearson Monument



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Correlation Coefficient and the r- value = 0.23 was found indicating a weak positive relationship (see appendix I). This low correlation coefficient proves that cognitive engagement, as measured by the PREBITCE, is a distinct construct from the students' anxiety levels and is pure measure of engagement rather than a proxy for emotional or affective states (Bobbio & Manganeli, 2023).

Research Question 4: What is the reliability coefficient of Cognitive Engagement Questionnaire among Pre-service Biology Teachers of universities in North-west zone, Nigeria?

Pilot test was conducted among a group of 30 level 300 Biology students of the two selected universities in the North who shared similar characteristics with the target population but were not included in the main sample. The Pre-service Biology Teachers' Cognitive Engagement Questionnaire was administered, retrieved, and subjected to reliability analysis using Cronbach's Alpha in SPSS Version 26. The result shown an overall reliability coefficient of 0.88, indicating strong internal consistency. The subscales recorded the following indices: Cognitive Strategy (0.98), Deep Processing (0.92), Shallow Processing (0.88), and Persistence (0.80). The overall reliability coefficients of Cognitive Engagement and sub-scales ranged between 0.703 and 0.865, surpassing the minimum recommended value of 0.70 (Kerlinger, 2000; Cohen, Manion & Morrison, 2007; Amirrudin, Nasution & Supahar, 2021). This confirms that the instruments employed in the study possess adequate internal consistency and are suitable for measuring the constructs under study.

Conclusion

Based on the findings of this research study, the following conclusions were made:

1. The Logical Face Validity index of 82.5% was established, confirming that the Pre-service Biology Teachers Cognitive Engagement Questionnaire is relevant, clear, and logically related to cognitive engagement of Pre-service biology teachers.
2. 16 items achieved the I-CVI of 0.83 and above with overall or Scale validity index (S-CVI/Ave) of 0.88 showing strong evidence of content validity and ensuring that the instrument is fit for measuring the intended psychological constructs.
3. A convergent validity index revealed significant positive correlation of ($r = 0.83$) indicating a high degree of linear relationship with an existing, validated measure of the same construct and successfully captures the cognitive dimensions of student cognitive engagement and hence is good for the study.
4. Divergent validity coefficient (r - value = 0.23) was found indicating a weak positive relationship proving that PREBITCEQ, is a pure measure of cognitive engagement rather than a proxy for emotional or affective states.
5. The overall reliability coefficients of ($r = 0.88$) was established, indicating strong internal consistency, that of subscales are Cognitive Strategy (0.98), Deep Processing (0.92), Shallow Processing (0.88), and Persistence (0.80). These prove the suitability of the instrument in measuring the constructs of cognitive engagement.
6. The final draft of the questionnaire is as follows:

		Sub-Scale: Cognitive Strategy				
S/N	Items	5	4	3	2	1
1	As I study for Biology test, I try to put together the information I learned from lectures and from the book.					
2	When doing homework, I try to remember what the lecturer said in class so I can answer the questions correctly.					
3	When studying Biology I put important ideas into my own words.					
4	When I study for Biology test I try to remember as many facts as I can.					
		Sub-Scale: Deep Processing				
S/N	Items	1	2	3	4	5



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|---|---|
| 5 | I use what I have learned from old homework/assignments and the textbook to do new assignments. |
| 6 | When studying Biology, I try to combine different pieces of information from course materials and text books. |
| 7 | I like to draw pictures or diagrams to answer some Biology questions. |
| 8 | I classify questions/problems into categories before I begin to answer them. |

Sub-Scale: Shallow Processing

S/N	Items	1	2	3	4	5
9	When I study for a Biology tests, I used past answers in my notes or in the textbook to help me memorize the procedures involved.					
10	To me, reviewing past questions and answers is a good way to study for Biology exams.					
11	I try to complete Biology homework or assignments as fast as possible without checking my accuracy.					
12	When I read something in Biology books that doesn't interest me, I skip it and hope that the Biology teacher explains it in class.					

Sub-Scale: Persistence

S/N	Items	1	2	3	4	5
13	If I have difficulty in answering Biology assignment, I try to think deeply what I was taught in the class					
14	If I have difficulty in understanding a concept in Biology, I go over it again and again until I understand it.					
15	When I have problem in answering Biology questions, I'm more likely to check examples in the text book to try to figure answer.					
16	When I run into a difficult task in Biology I usually don't give up.					

Rating Scales: Strongly Agree=5, Agree=4, Undecided=3, Disagree=2, Strongly Disagree=1

Recommendations

Based on the conclusions drawn from the psychometric evaluation of the PREBITCEQ, the following recommendations are made:

1. The Ministry of Higher Education and the National Universities Commission (NUC) are advised to adopt the PREBITCEQ as a standardized measuring instrument for monitoring the psychological investment of pre-service teachers across the universities in North-west zone Nigeria.
2. Biology lecturers in universities are advised to utilize the subscale results specifically those related to Deep Processing, Cognitive Strategy and Persistence to tailor their instructional methods.
3. Quality assurance units within tertiary institutions are also advised to integrate the PREBITCEQ into their student support frameworks.



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