ISSN E: 3006-1466
ISSN P: 3006-1458
CONTEMPORARY JOURNAL OF SOCIAL SCIENCE REVIEW
CJSSR
CONTEMPORARY JOURNAL OF SOCIAL SCIENCE REVIEW
Vol.03 No.03 (2025)

Appraising Alignment between Single National Curriculum Mathematics 2020 Standards and Punjab Examination Commission Assessment 2023

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Abstract
The Single National Curriculum (SNC) mathematics 2020 was framed to unify academic standards and promote critical thinking and cognitive rigor in mathematics. The current study was designed to measure the degree of alignment between the SNC 2020 mathematics and the Punjab Examination Commission (PEC) assessment 2023-2024, using Webb's Alignment Tool Second Version (WAT V2). The study was a descriptive quantitative content analysis. The data sources of the study were the SNC mathematics 8th-grade document, the PEC test 2023, and six reviewers. WAT V2 was used to measure alignment between mathematics curriculum standards and assessments. The results of the study declared that standard numbers and operations comprised 23.7% and algebra 15.52%, while the standard measurement, geometry, and statistics & probability were not tested. Only 33(48.5%) SLOs were targeted, while 35(51.5%) SLOs were not targeted in the PEC assessment 2023. Depth-of-knowledge (DOK) framework comprises four levels. The DOK level-1 comprised of 4(5.88%), level-2, 22(32.4%), level-3, 42(61.7%), level-4, 0(0%) in mathematics. The results depicted less focus on DOK levels-1, Recall, and level-4 strategic thinking during the development test in mathematics. On the basis of the results of the study, it was recommended that assessment developers focus on DOK level-1, and level-4 during framing assessment items. During the decision-making, the test items PEC assessment framework may be followed for whole curriculum content coverage to ensure balanced representation in the assessment.

Keywords: *Alignment, Assessment, Mathematics, Single National Curriculum*

INTRODUCTION

Mathematics is essential for developing critical thinking, logical reasoning, and problem-solving skills among learners. Mathematics serves as a critical tool for real-life decision-making and innovation. It remains a challenge to ensure every student receives a quality mathematics education that fosters deeper understanding. Mathematics not only sharpens analytical thinking but also prepares learners to face the demands of a data-driven world. From measuring quantities to interpreting information, math strengthens daily life skills. Building confidence in mathematics leads to improved academic outcomes and lifelong competence (Anderson, 2002; Popham, 2006).

Assessment refers to the process of gathering and interpreting information to make decisions about the effectiveness of the teaching and learning process. Assessment is important for instructional planning, managing learners' engagement, and assessing attainment of educational objectives. Assessment not only measures student learning but also drives what and how teachers teach (Black &Wiliam, 1998; Popham, 2006). A well-aligned assessment system reflects the priorities of the curriculum, supports data-driven decision-

ISSN E: 3006-1466
ISSN P: 3006-1458
CONTEMPORARY JOURNAL OF SOCIAL SCIENCE REVIEW
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CONTEMPORARY JOURNAL OF SOCIAL SCIENCE REVIEW
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making, and promotes quality in learning outcomes (Penuel et al., 2008; Wiliam, 2010). Alignment between curriculum and assessment is essential to sustain validity, fairness, and coherence of overall educational process in standards-based education (Webb, 2007; Wang & Herman, 2005).

The SNC mathematics 2020 was framed to unify learning expectations and ensure equitable access to foundational academic standards (Government of Pakistan, 2020). Curriculum outlines specific Student Learning Outcomes (SLOs) to guide teaching and assessment. Alignment refers to the match between curriculum, instruction, and assessment. When the curriculum is aligned with assessment, it measures what it intends to measure. Proper alignment ensures fair testing, effective teaching, and accurate evaluation of student learning. It also helps educators maintain focus on intended knowledge and skills, improving both classroom instruction and student achievement (Government of Pakistan, 2020).

The PEC is responsible for designing and regulating school-based assessments aligned with the curriculum in Punjab (PEC, 2022). The PEC plays a pivotal role in shaping classroom instruction to evaluate learners' knowledge in the curriculum; number operations, algebra, geometry, measurement, and data handling are provided in the mathematical standards (Government of Pakistan, 2020). When curriculum standards and assessment items reflect parallel expectations, teacher trainers and subject specialists can structure meaningful instruction and provide fair academic feedback (Webb, 2007). Penuel et al. (2008) reported that alignment enables evidence that accurately reflects SLOs and assessment. This study was framed to determine the degree of alignment between the SNC 2020 8th-grade mathematics standards and the PEC assessment 2023 administered across Punjab.

Alignment studies help to explore gaps and guide curriculum and assessment experts toward coherence. A well-aligned curriculum supports teaching and assessment. Teacher trainers can use curriculum documents to guide instruction, while assessment developers develop questions that match the required thinking level. When standards, instruction, and assessments are aligned, learning becomes more meaningful and measurable. For mathematics at the 8th-grade, this alignment is especially important to ensure that learners develop procedural fluency and conceptual understanding.

Statement of the Problem

It is important to gauge the degree of alignment between the SNC standards and assessment for standards-based education. This is the key tenet of standards-based curriculum reforms (Barthakur et al., 2022; Webb, 1997). The PEC contributes to measuring how well the SNC standards are being assessed in practice. There is growing concern among policymakers, curriculum planners, administrators, teachers, learners, and other relevant stakeholders regarding whether the PEC assessments truly reflect the SLOs, content scope, and cognitive levels stated in the SNC mathematics 2020. Misalignment between curriculum and assessment neglects key competencies, and a gap in the holistic development of mathematical thinking in learners. Previous studies reported vibrant results for alignment between the SNC and assessment in local and global perspectives. There is an essential need to measure the existing alignment between curriculum standards and assessment. The researchers are eager to explore and appraise the degree of alignment between the SNC mathematics and the PEC assessment 2023. Thus, the problem of the study was appraising alignment between the single national curriculum mathematics 2020 standards and the Punjab examination commission assessment 2023.

Significance of the Study

This study is helpful for curriculum planners to provide insights for curriculum and assessment alignment to ensure comprehensive content coverage and cognitive coherence in the curriculum. The results of the study are helpful for curriculum experts by identifying

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ISSN P: 3006-1458
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weaknesses in content representation and DOK levels, which enables them to refine learning standards and enhance the progression and clarity of mathematical outcomes. The results of the study are supportive for training institutions by providing guidelines in developing training modules that focus on the alignment between teaching strategies, curriculum, and assessment practices based on established alignment frameworks. This study is helpful for school administration as it presents data that can inform planning, monitoring, and evaluation processes to improve instructional quality and support curriculum implementation more effectively. This study is helpful for teachers because it promotes alignment-aware teaching practices, supports lesson planning based on SLOs, and aids in the construction of assessment tools that match the required cognitive levels. This study is helpful for learners by ensuring that they are assessed fairly on what they have taught. It contributes to balanced academic exposure, clearer learning outcomes, and effective performance in mathematics.

Research Objectives

The objectives of the present study were to;

- Explore the DOK levels consistency in mathematics curriculum.
- Determine the alignment between curriculum and assessment
- Measure the alignment between curriculum standards and PEC assessment

LITERATURE REVIEW

The SNC Mathematics 2020 was implemented to reduce disparities, promoting consistency, and improve quality in mathematics education. A central purpose was to provide uniform learning expectations across provinces with precise stated SLOs of each subject curriculum. However, true improvement in quality depends not only on curriculum content but also on how well it aligns with instruction and assessment practices. Misalignment can cause confusion in classrooms, limit skill development, and misguide teaching focus. Researchers argue that without strong alignment, even well-designed curricula fail to deliver intended learning outcomes (Porter, 2002; Schmidt et al., 2005). Therefore, aligning curriculum standards with meaningful assessment tools remains essential for effective mathematics education in Pakistan.

Curriculum alignment refers to the harmony among what is expected in the curriculum, what is taught by educators, and what is assessed through formal evaluation. Curriculum alignment ensures that what learners are expected to achieve, what is taught, and what is assessed on intended SLOs provide in curriculum standards (Webb, 2007; Porter, 2002). When curriculum standards and assessments reflect the SLOs, content, assessment, and then learning become more structured for teachers and learners. Moreover, when alignment is consistent, learning becomes more focused, and assessment becomes more meaningful (Reys & Kilpatrick, 2001). Misalignment can result in learners being assessed on content that was never taught, or in teaching that misses the expectations of the standards. Alignment is necessary to support teaching learning process classroom instruction, and fair assessment practices (Penuel et al., 2008; Wang & Herman, 2005).

During math instruction assessing learners only on recall tasks may fail to capture their full understanding. That is why cognitive complexity has become a central focus in modern curriculum design (Francis, 2018). The Webb's DOK framework is useful for understanding cognitive complexity of curriculum content. Webb's DOK divides tasks into four levels: recall, skill/concept, strategic thinking, and extended thinking. Each level represents a different kind of thinking that learners need to demonstrate. SNC shifted learning beyond memorization and assessment but often remain focused on lower-order tasks. The challenge lies not only in curriculum design but also in assessment. Various alignment models have developed to study curriculum and assessments alignment. The SEC model uses large-scale teacher-reported data to examine the alignment between taught content and

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ISSN P: 3006-1458
CONTEMPORARY JOURNAL OF SOCIAL SCIENCE REVIEW
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assessment practices, the CBE model evaluates curriculum and assessment alignment through structured analysis of academic rigor and balance (Polikoff, 2012). The WAT is widely used for its structured criteria and focus on cognitive demand. It evaluates alignment based on four areas: categorical concurrence, DOK consistency, range-of-knowledge correspondence, and balance of representation. Each level measure whether assessment items fairly and fully reflected in curriculum standards (Webb, 2007). The WAT is widely used for measuring consistency between curriculum standards and assessments based on content categories and cognitive demand using criteria of categorical concurrence and DOK levels. Each of these alignment models provides tools to assess whether learners are being assessed fairly and according to what the curriculum demands (CCSSO, 2002; Porter, 2002; Rind & Mughal, 2020; Webb, 2007).This framework supports curriculum designers and assessment developers in evaluating whether tasks reflect the cognitive expectations defined by academic standards (Iqbal & Rehman, 2021). The WAT utilizes quantitative coding procedure based on four key criteria;

- Categorical Concurrence; Ensures content categories in the curriculum align with those in assessments.
- DOK Consistency; Measures if assessments match the cognitive rigor of the curriculum.
- Range-of-Knowledge; Evaluates if assessments cover the full scope of curriculum topics.
- Balance of Representation: Ensures fair distribution of learning outcomes in assessments, preventing overemphasis on single topics.

The DOK framework classifies cognitive complexity into four levels;

- DOK level-1 (Recall); involves basic recall or routine procedures, such as solving a simple equation through simple procedures. For example, defining prime numbers, solving 5x8).
- DOK level-2 (Skill/Concept);focuses on applying skills or concepts, like interpreting graphs, using formulas in structured ways, interpreting data, explaining concepts. For example interpreting a bar graph, solving 2x+5=15).
- DOK level-3 (Strategic Thinking); requires reasoning, planning, or analyzing tasks with multiple steps or strategies in problem-solving with multiple strategies. For example, explaining why two odd numbers sum to an even number, designing a mathematical model).
- DOK level-4 (Extended Thinking); includes extended problem-solving involving connections across different mathematical domains, extensive investigation, synthesis of ideas, real-world application, integrating knowledge across domains. For example, designing a population growth model, or using multiple approaches to solve a problem (Webb, 2002; Webb, 2007).

Various local and international level studies were design for measuring alignment between curriculum and assessment adopting Webb's alignment model. Gulzar and Mahmood (2019) structured a study on the secondary school mathematics curriculum and BISE Lahore assessments alignment ay 9th-grade in Punjab. Results of the study revealed that the assessment only reflect the categorical concurrence criterion, while it failed to meet acceptable levels for DOK consistency, range-of-knowledge correspondence, and balance of representation. Furthermore, 97% of the assessment items were at DOK Level-1, 41% of level-2, 4%, level-3 and zero for level-4 reflecting a heavy emphasis on recall-level tasks. Notably, no items addressed DOK level-4, indicating that assessments lacked extended thinking or complex reasoning tasks expected from higher cognitive domains.

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Khurshid (2023) designed a study on the alignment between SNC 2022 science standards and the PEC 2023 assessments. The results of the study declared that categorical concurrence and DOK level consistency were achieved to some extent, balance of representation and range-of-knowledge remained weak reported partial alignment. Furthermore, 84% of the test items were concentrated at DOK Level-1 and Level-2, and no item addressed DOK Level-4, which limits the evaluation of higher-order thinking skills. He concluded that the effectiveness of curriculum reforms depends on the precision of assessment frameworks in representing the defined SLOs.

Iqbal, Abbas, and Abbas (2024) framed a qualitative study to examine teachers' perceptions regarding the implementation of the SNC) for mathematics 5th-grade. Researchers interviewed 21 teachers; 15 from public and 6 from private schools using face-to-face using unstructured interviews. The collected data were analyzed through thematic analysis. The study revealed curriculum related challenges, including unrealistic grade-level expectations, lack of coherence between content, SLOs and textbook, and poor alignment curriculum and assessments.

Rind and Mughal (2020) designed a study to explore national curriculum of mathematics, 2006 at the secondary level and reported gaps in instructional design, and content implementation. Their study revealed minimum emphasizes on curriculum standards and skills, and neglected conceptual understanding, critical thinking, and the humanistic dimension of learning. Key domains like information handling and reasoning were less focused in assessment.

RESEARCH METHODOLOGY

This study was a descriptive quantitative content analysis. The SNC mathematics 2020 and the PEC tests 2023, and six reviewers were the primary sources of the data collection. The WAT V2 was used to measure the alignment between curriculum and assessment. The PEC developed and administered the mathematics standardized assessment at the elementary level. The SNC mathematics 2020 and the PEC mathematics tests 2023, 8th-grade, were explored regarding standards and SLOs. Each SLO from the curriculum was matched with related assessment items to evaluate alignment. The DOK framework was used to measure cognitive levels in curriculum standards and test items. There were four DOK levels; level-1 (Recall), level-2 (Skill/Concept), level-3 (Strategic Thinking), and level-4 (Extended Thinking). The DOK ratings helped to determine whether assessment items matched the expected complexity of each SLO. The WAT v2 guided reviewers in scoring alignment based on four core criteria; categorical concurrence, DOK consistency, range-of-knowledge correspondence, and balance of representation. These criteria provided a systematic way to assess whether the assessment accurately reflected the content and thinking levels intended by the SNC mathematics 2020. The WAT v2 was applied to guide the alignment process. The model evaluates alignment using four criteria: categorical concurrence, DOK Consistency, range-of-knowledge correspondence, and balance of representation. The DOK levels were assigned to the curriculum SLOs and assessment items, categorizing into four levels: level-1, level-2, Level-3, and level-4 of the Webb model (Webb, 2007). The analysis is based on two core alignment criteria; categorical concurrence, which assesses whether content categories from the curriculum appear in the assessment, and DOK consistency, which measures whether the cognitive level of assessment items matches the expected complexity of the curriculum SLOs. Each SLO was compared with related PEC assessment items to determine representation and cognitive alignment. The reviewers assigned DOK levels and curriculum standards and test questions using Webb's four-level classification; recall skill/concept, strategic thinking, and extended thinking for measuring alignment. Alignment results generated through WAT v2 were analyzed and interpreted to

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ISSN P: 3006-1458
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identify patterns, gaps, or mismatches between the curriculum and assessment. During the review, some items could not be coded due to ambiguity, lack of clarity about the SLOs, or disagreement among reviewers. These items were flagged as un-coded because at least two reviewers did not assign a matching SLO.

The reliability of the study was assessed using the intra-class correlation coefficient calculated according to the method of Shrout and Fleiss. 1979, as cited by Webb, 2005. Intra-class correlation reliability must be greater than .7. The pair-wise benchmark for assessment is calculated by pairing the reviewers who have given the same DOK level to a particular assessment item. Their same responses are then added and divided by the total number of all possible pairs of reviewers. The value of .7 or higher represents a good agreement, whereas a value less than .5 is considered as bad agreement among reviewers (Webb, 2005).

Table 1: Intra-Class Coefficient and Pairwise Comparison

Assessment Test	Grade	Intra Class Correlation	Pairwise Comparison	Obj. Pairwise Comparison
PEC	8	.99	.98	.72

Table 1 demonstrated that the intra-class correlation reliability for the 8th-grade PEC assessment was 0.99. The pair wise agreement among reviewers for DOK levels was 0.98, while the objective pair wise comparison yielded a value of 0.72, indicating strong consistency across reviewer judgments.

DATA ANALYSIS AND INTERPRETATION

The data collected from reviewers and WAT v2 were analyzed according to the study objectives.

Objective 1

To explore the DOK levels consistency in the mathematics curriculum.

Table 2: SLOs %age by DOK Levels in Mathematics

Grade	Total SLOs	DOK Levels	No. of SLOs	%age by levels
8	68	1	4	5.88%
		2	22	32.35%
		3	42	61.76%
		4	0	0%
Total	88		68	100

Table 2 showed that DOK level-1 comprised of 4(5.88%), level-2, 22(32.4%), level-3 42(61.7%), level-4, 0(0%) in mathematics. The results depicted less focused on DOK levels-1, and level-4, 5.88% ,recall and extended thinking, and strong focused on DOK level-2 and level-3, skill/concept, strategic thinking in mathematics.

Objective 2

To determine the Alignment between Curriculum Standard and PEC Assessment

Table 3: Marks/Point Value in the assessment tool by PEC

Point Value/item marks	1.5	5	5	5	5	6	Total
Items	32	2	2	2	2	2	42
Total Point Value/Marks	48	10	10	10	10	12	100

Table 3 showed the PEC assessment marks distribution, with 32 out of 42 items carrying 1.5 marks. This dominance of low-mark items may limit the assessment of deeper understanding and extended problem-solving.

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Table 4: List of un-coded Items

Class	Item no. assessment	No of Item	Total point value/ marks	Item% age w/in assessment tool	%point value
8	10,29,31	3	4.5	7.14	4.5

Table 4 demonstrated three assessment items (Nos. 10, 29, 31) that were not coded to any curriculum SLO. These un-coded items comprise 7.14% of items and 4.5% of total marks, affecting assessment validity.

Table 5: Assessment Items Targeted to Curriculum SLOs

Grade	Items	Total SNC SLOs	Targeted SLOs	%age targeted	SLOs not targeted	%age not targeted
8	42	68	33	48.5	35	51.5

Table 5 shows that there were total 68 SLOs in the SNC mathematics from which 42 items included for assessment. Only 33(48.5%) SLOs were targeted, while 35(51.5%) SLOs were not targeted in the PEC assessment. Overall results depicted that less than 50% SLOs were included in the final test.

Objective 3

To determine the Alignment between Curriculum Standard and PEC Assessment

Table 6: Summary of Attainment of Acceptable Alignment Level on Four Content Focus Criteria as Rated by Reviewers

Standards	Alignment Criteria			
	Categorical Concurrence	Depth-of-Knowledge Consistency	Range of Knowledge	Balance of Representation
Numbers & Operations	YES	YES	WEAK	WEAK
Algebra	YES	YES	WEAK	WEAK
Measurement	NO	NT	NT	NT
Geometry	NO	NT	NT	NT
Statistics & Probability	NO	NT	NT	NT

NT = Not Tested

Table 6 demonstrated only numbers and algebra domains align across the first two criteria, while others fail or are untested. This indicates a narrow focus and poor content balance in curriculum implementation.

Table 7: Range-of-Knowledge Correspondence and Balance of Representation between Standards and Assessment as Rated by Reviewers

Reporting Category			Hits		Range of Standards				Range of Know	% of Hits of Total Hits		Balance Index		Bal of Rep.
					Num Stds Hit		% of Total							
Standards	Dom Num	StdsNum	M	SD	M	SD	M	SD		M	SD	M	SD	
Numbers & Operations	1	48	66.5	0	22.6	.52	47.2	1.08	WEAK	36	0	.69	.01	WEAK
Algebra	2	18	29	0	8	0	44.4	0	WEAK	14	0	.63	0	WEAK
Measurement	0	0	0	0	0	0	NaN	0	NT	0	0	N/A	0	NT
Geometry	0	0	0	0	0	0	NaN	0	NT	0	0	N/A	0	NT
Statistics &Probability	0	0	0	0	0	0	NaN	0	NT	0	0	N/A	0	NT
Total	3	66	95.5	0	6.1	9.8	NaN	19		10	16	0.66	.19	

Table 7 revealed a significant imbalance in the assessment coverage. Only the numbers & operations and algebra domains were assessed, while the measurement, geometry,

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ISSN P: 3006-1458
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and statistics and probability domains were completely unrepresented. This indicated a narrow focus in the PEC mathematics assessment 8th-grade. Additionally, the appearance of NaN (Not a Number) values in the table, especially for the NT (not tested) standards, revealed a missing data or inapplicable calculations due to zero coverage. This further confirms the lack of comprehensive domain representation in the assessment.

Table 8: Categorical Concurrence between Standards and Assessment rated Reviewers

Reporting Category			Level by Standards			Hits		Categorical Concurrence
Standards	Domain Number	Standard Number	Level	Num of Stds	% w/in RC by Level	Mean	SD	
Numbers & Operations	1	48	1 2 3	4 23 21	8.3 47.9 43.7	66.5	0	YES
Algebra	2	18	2 3	1 16	5.8 94.2	29	0	YES
Measurement	0	0	2	1	100	0	0	NO
Geometry	0	0	2	1	100	0	0	NO
Statistics & Probability	0	0	3	1	100	0	0	NO
Total	3	66	1 2 3	4 26 38	6 38 56	95.5	0	

Table 8 demonstrated alignment between categorical concurrence and SLOs for standards numbers & operations, and algebra. However, there is no alignment between categorical concurrence and SLOs for the measurement, geometry, and statistics & probability. This showed that assessment did not fully represent the SLOs outlined in the SNC across all standards and reflected gap. This represents partial alignment and a lack of comprehensive coverage of the curriculum.

Table 9: Alignment between Standards and DOK Levels Consistency Rated by Reviewers

Reporting Category			Hits		DOK Level of Item						DOK Consistency
Standards	Domain Num	Std Num	M	SD	% Under	SD	% At	SD	% Above	SD	
Numbers & Operations	1	48	66.5	0	6.77	0	23.7	1	69.55	1	YES
Algebra	2	18	29	0	15.5	0	56.9	0	27.59	0	YES
Measurement	0	0	0	0	0	0	0	0	0	0	NT
Geometry	0	0	0	0	0	0	0	0	0	0	NT
Statistics & Probability	0	0	0	0	0	0	0	0	0	0	NT
Total	3	66	95.5	0	9.42	0	33.77	0.6	56.81	0.6	

Table 9 showed alignment between standards and DOK Levels consistency. The standard numbers and operations comprised of 23.7%, algebra15.52%. The standard of measurement, geometry, and statistics & probability were NT(not tested) PEC assessment.

Results

The study was framed to explore alignment between SNC mathematics 2020 and the PEC test 2023 8th-grade. The results of the study reported that standard numbers and operations comprised of 23.7% and algebra 15.52%, while the standard measurement, geometry, and statistics & probability were not tested. Only 33(48.5%) SLOs were targeted, while 35(51.5%) SLOs were not targeted in the PEC assessment 2023.Depth –of-knowledge (DOK) framework comprised of four levels. The DOK level-1 comprised of 4(5.88%), level-2, 22(32.4%), level-3, 42(61.7%), level-4, 0(0%) in mathematics. The results depicted less

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ISSN P: 3006-1458
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focused on DOK levels-1 recall and level-4 strategic thinking during developing test in mathematics. On the basis of the results of the study, it was recommended that assessment developer focused on DOK level-1, and level-4 during framing assessment items. During deciding test items PEC assessment framework may follow for whole curriculum content coverage to ensure balance representation.

Conclusions

The study results concluded that there is weak alignment between the curriculum standard and PEC assessment. Curriculum standard numbers and operations, and algebra included in the test, but there was no representation of measurement, geometry, and statistics and probability.

Discussion

This study was designed to analyze the alignment between the SNC mathematics, and the PEC assessment for 8th-grade students. The results showed that only 48.5% of the SLOs were assessed, and 51.5% were less focused. The measurement, geometry, and statistics domains of the curriculum have weak involvement in test development. Major focus was at DOK level-2 and level-3. The Curriculum SLOs lacked coverage at level-1 (recall) and level-4 (extended thinking), highlighting a serious gap in cognitive depth content coverage. The current study results were consistent with the study results of Gulzar and Mahmood (2019), which showed weak alignment and weak representation of DOK level-4 in mathematics at 9th-grade, and also consistent with the results of the study, Khurshid (2023) revealed that the SNC science curriculum and PEC assessment were partially aligned, and less test items assessed higher-order thinking.

Recommendations

On the basis of the results of the study, it is recommended that assessment developers focus on DOK level-1 and DOK level-4 when selecting test items for the 8th grade. During the decision-making process for test items, PEC assessment administration may focus on whole content coverage to ensure balanced representation of the curriculum.

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