



## Curriculum–Textbook Alignment Analysis of the National Curriculum of Pakistan 2022–23 Science and the Grade 6 General Science Textbook



Shagufta Ambreen<sup>\*a</sup>, Mukhtar Bashir<sup>b</sup>, Sarwan Kumar<sup>c</sup>

- a. Head of department, Department of Education, Alhamd Islamic University, Quetta, Pakistan
- b. Lecturer, Department of Education, University of Gwadar, Gwadar, Pakistan
- c. PhD Scholar, Department of Education, Alhamd Islamic University, Quetta

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### ABSTRACT

The purpose of Pakistan's National Curriculum (NCP, 2022-23) is to move school science education from memorization to conceptual knowledge, scientific inquiry, engineering design, and science in the real world; the success of the curriculum reform depends on how well the approved textbooks reflect this new vision. This paper compares the NCP 2022-23 Science curriculum (Grades 4-8) with the Grade 6 General Science textbook developed as a Pilot Edition (2026) by the Balochistan Textbook Board. A qualitative document analysis design was employed, and directed qualitative content analysis was conducted on both documents using a multiple-step coding process, followed by a multidimensional alignment analysis of all 81 Grade 6 Student Learning Outcomes (SLOs) on a single-dimensional scale. Each SLO was analyzed in terms of multiple criteria: content coverage, cognitive level, inquiry and practical skills, assessment, visual support, and contextual relevance, and given an overall alignment rating. All 81 SLOs were covered in the textbook, and the overall alignment was high: 62 (76.5%) of SLOs were strongly aligned, 15 (18.5%) – moderately, 4 (4.9%) – partially, and none of the SLOs were weakly aligned. The highest alignment was noted for content coverage, visual support, and contextual relevance; the lowest was when outcomes required independent inquiry, original engineering design, performance assessment, and safety procedures. The textbook could be described as curriculum-saturated, with selective reduction of inquiry, design, and performance assessment – the issue of enactment depth but not content coverage. Recommendations are given to improve the textbook.

### 1. Introduction

The promises of a particular curriculum do not just determine the quality of science education in schools but also by the extent to which those promises are fulfilled in the materials used by teachers and learners. In most developing countries, including Pakistan, the textbook is not just one material among many; it is the curriculum itself. The textbook determines the order of topics taught, the level of detail in explanations, the variety of activities conducted, the visuals shown to learners, and the assessments learners perform. Thus, when a new national curriculum is introduced, its success or failure is determined during its implementation in textbooks. Systematic analysis of curriculum–textbook alignment becomes central, rather than peripheral, to evidence-based curriculum reform.

The National Curriculum of Pakistan 2022-23 (NCP 2022-23) is a major reform document. Its Science strand for Grades 4–8, issued by the National Curriculum Council Secretariat under the Ministry of Federal Education and Professional Training,

\* Correspondence to: Head of department, Department of Education, Alhamd Islamic University, Quetta, Pakistan  
E-mail address: [shagufta.umbreen@alhamd.pk](mailto:shagufta.umbreen@alhamd.pk) (S. Ambreen)



consists of three disciplinary domains (Life Sciences, Physical Sciences, and Earth and Space Sciences) and is framed by the cross-cutting domain of scientific practices (scientific inquiry, engineering design and STEM/STEAM, models and representations, and science in context). The curriculum's foreword states that one of its goals is to shift classroom instruction from rote learning to concept-based learning and to align textbooks, teaching, classroom practice, and assessment with students' intended learning outcomes. This aligns with Pakistan's broader policy discourse on its single-curriculum reform, which focuses on outcomes-based design, activity- and inquiry-based learning, information and communication technology, twenty-first-century skills, and international benchmarks (e.g., the Trends in International Mathematics and Science Study [TIMSS]).

However, a stated intention in a curriculum document does not necessarily translate into an opportunity in a textbook. To enact concept-based and inquiry-oriented intentions is not easy: it requires textbooks that maintain rather than diminish their students' cognitive demand, that foster investigation rather than confirmation of what is taught, that encourage creation rather than compliance with instructions, and that evaluate performance rather than mere recall. The extent to which a new provincial textbook achieves these is a research question that cannot be resolved by assuming conformity. It needs outcome-level analysis.

The current study addresses this question in a clearly defined case: the NCP 2022–23 Science curriculum and the Grade 6 General Science textbook, produced as a Pilot Edition for Academic Year 2026 by the Balochistan Textbook Board (BTBB). Balochistan is the largest province of Pakistan in terms of area and one of the least resourced in terms of schooling. Therefore, the fidelity of its pilot science textbook is of great significance from an equity perspective. Since it is a pilot edition, the analysis also has practical value. The chairman's message in the textbook itself asks for feedback and suggestions. This means that a rigorous alignment analysis can not only provide academic insights but also contribute to the development of the next edition.

Hence, this article aims at achieving two related goals. The first is academic: to determine, at the level of individual learning outcomes and across multiple dimensions of alignment, the degree of alignment of the Grade 6 textbook with the curriculum, and to describe the pattern of this alignment. The second is developmental: to transform the results into practical recommendations for improving the textbook that will help produce the next edition in a way that fully meets the concept-based, inquiry-oriented, and twenty-first-century goals of the NCP 2022–23.

The selection of Grade 6 as the focus year is deliberate. Grade 6 marks the transition from primary to lower-secondary education and the beginning of integrated general science as it differentiates into biology, chemistry, physics, and earth-and-space science. In addition, this is the first grade band for which the reformed curriculum and its provincial textbooks were developed after the initial primary implementation. This means that the Grade 6 textbook is a truly first-generation reform artifact, not a slightly modified legacy book. What learners encounter this year lays the foundations for concepts and attitudes toward science that will be built in subsequent years. If the foundation year of integrated science is presented as a guided description rather than an investigation, it is very hard to address this deficit in future years. Thus, analyzing the Grade 6 case provides an early and diagnostic look at how the reform is implemented in materials at the crucial point.

### **1.1. Problem statement**

The NCP 2022–23 emphasizes concept-based learning, scientific inquiry, practical skills, models and representations, STEM/STEAM, and the alignment of textbooks, teaching, and assessment with student learning outcomes. However, the extent to which these curriculum intentions are represented in the Grade 6 General Science textbook has not been systematically investigated. When the textbook is the actual curriculum, a potential mismatch between the curriculum and the textbook, left unaddressed, may reinforce a rote-learning environment that the reform aims to eliminate. In this regard, this research examines the alignment of the NCP 2022–23 Science Curriculum and the Grade 6 General Science Textbook in terms of:

### **1.2. Research objectives**

The study set out to:

1. Confirm and characterize the NCP 2022–23 Science document and the Grade 6 General Science textbook as analyzable sources;
2. Analyze the Grade 6 Science SLOs of the NCP 2022–23 in terms of content, cognitive level, and embedded science practices;
3. Explore the representation of curriculum content, scientific ideas, inquiry skills, practical work, visuals, and assessment tasks in the Grade 6 textbook;
4. Measure the extent of alignment of curriculum SLOs with textbook provision in eight alignment dimensions; and

5. Identify areas of high, medium, partial, and low alignment and convert them into textbook improvement suggestions.

### 1.3. Research questions

The main research question was: How does the Grade 6 General Science textbook align with the National Curriculum of Pakistan 2022–23 Science curriculum? This was addressed through five sub-questions:

1. What knowledge, skills, cognitive demands, inquiry practices, and contexts are required by the Grade 6 Science SLOs in the NCP 2022–23?
2. How are these curriculum requirements represented in the Grade 6 General Science textbook?
3. To what extent does the textbook align with the curriculum in terms of content, cognitive demand, scientific inquiry, practical work, visuals, and assessment?
4. Which curriculum outcomes are strongly, moderately, partially, or weakly represented in the textbook?
5. What does the alignment pattern reveal about the implementation of the NCP 2022–23 at the textbook level, and how can the textbook be improved?

### 1.4. Significance of the study

The study contributes on three fronts. Theoretically, it applies an established alignment framework to a newly reformed national curriculum and a first-generation provincial textbook, extending alignment scholarship into a South Asian, resource-constrained setting that is under-represented in the international literature. Methodologically, it demonstrates a transparent, auditable, multi-step, directed content analysis procedure that other researchers can adapt for curriculum–textbook studies. Practically speaking, since the textbook is a pilot edition and its publishers have specifically asked for comments, these results will be directly relevant to the revision process, providing the Balochistan Textbook Board and National Curriculum Council specific advice on how to improve the next edition.

## 2. Conceptual Background and Related Literature

### 2.1. Curriculum, textbook, and the idea of alignment

It is a well-known feature of curricular theorizing to distinguish among the intended, enacted, and attained curricula. The intended curriculum is the official description of what is supposed to be learned, while the enacted curriculum is the actual teaching and availability, and the attained curriculum is what is learned and done. In many cases, the textbook plays a central role as the pivot between the intended and enacted curriculum, serving as the written enactment of the official standards for teachers and students. Alignment analysis is a structured examination of the interrelationships among the various levels, primarily between the standards, curriculum materials, and assessment instruments.

The alignment model suggested by Webb (1997, 2007) remains central to this day. The model contends that in addition to alignment based on categorical agreement, alignment based on depth-of-knowledge agreement, range-of-knowledge agreement, and balance of representation should also be considered. Porter (2002) proposed complementary tools for measuring instructional content, namely content maps, which allow comparisons of emphasis and cognitive demand across standards and materials. Martone & Sireci (2009) provided an overview of alignment approaches across curriculum, assessment, and instruction, while Polikoff (2012) defined alignment as a match between standards, instruction, and assessment, emphasizing that surface coverage may mask significant differences in cognitive demands. Anderson & Krathwohl's (2001) revision of Bloom's taxonomy gives the terminology for cognitive demands – remember, understand, apply, analyze, evaluate, create – which is used in most modern alignment coding schemes.

A useful way to organize these dimensions is to distinguish between coverage alignment and depth alignment. Coverage alignment asks whether the content and outcomes of the curriculum appear in the material at all; it is a necessary but insufficient condition. Depth alignment asks whether the material preserves the cognitive demand, the range and balance of representation, and—critically for science—the scientific practices that the curriculum specifies. A textbook can achieve near-perfect coverage alignment while quietly lowering depth: an outcome coded at the analyze or create level in the curriculum can reappear in the textbook as a remember or apply task, and an outcome that calls for open investigation can reappear as a confirmatory demonstration with the method and result already supplied. Because such reductions are invisible to any analysis that stops at topic matching, this study codes each outcome on both coverage and depth dimensions and treats formal reproduction of an outcome as the first, not the final, layer of alignment.

## 2.2. Textbook alignment in science education

Empirical alignment studies consistently find that formal topic coverage is easier to achieve than depth-of-knowledge alignment. Comparative and single-case studies of science and general-science textbooks report a recurring pattern: strong content and vocabulary coverage, extensive descriptive and lower-order tasks, and comparatively thin provision for higher-order reasoning, open inquiry, and performance assessment (e.g., Alemneh & Mengistie, 2023). International reviews likewise show that materials genuinely aligned with inquiry- and practice-oriented standards remain scarce relative to demand, and that even where standards emphasize science practices and the investigation of phenomena, commercially and officially produced materials often under-realize these practices. Where alignment is strong, however, there is evidence that it supports improved learning outcomes, underscoring why alignment is worth measuring and strengthening rather than assuming.

## 2.3. Curriculum reform and textbooks in Pakistan

Pakistan's attempt to adopt a single, outcomes-oriented national curriculum, developed in stages and published for successive grade bands, was aimed at moving away from an information-recall approach towards standards, benchmarks, and Student Learning Outcomes, incorporating activity- and inquiry-based learning, twenty-first-century skills, and expectations aligned with TIMSS. Research findings on the implementation of this reform in science at the primary level show that although the curriculum documents provide ample opportunities for the development of twenty-first-century skills, their actualization depends largely on teachers' competence and the availability of suitable teaching and learning materials, including textbooks (Mansoor & Din, 2023). In the past, research conducted on curriculum-textbook alignment at secondary levels in Pakistan on various subjects such as biology, mathematics, and English has shown a mismatch between curricula and textbooks, usually highlighting that textbooks focus more on content and lower-level activities rather than higher-level activities specified in the curricula (Bhatti et al., 2015; Hashmi et al., 2018; Bhutto et al., 2022). This literature review sets the context for the present study, indicating that a first-generation, pilot textbook aligned with the reform curriculum would achieve high coverage but would face challenges in implementing inquiry, design, and performance assessments.

## 2.4. Directed content analysis as an alignment method

In terms of methodology, alignment of the curriculum and the textbook is suited to directed qualitative content analysis. Hsieh and Shannon (2005) differentiate between traditional content analysis, in which categories are developed inductively from the data, and directed content analysis, in which categories are derived from an existing theory or previous research to be applied to the data. Alignment is, by definition, a directed approach, since the categories – the curriculum's outcomes, cognitive-level expectations, and practice-of-science expectations – are provided by the curriculum. Schreier (2012) outlines the development of a coding framework, its pilot testing, and its application. The unitisation and reliability rationale of Krippendorff (2019) ensure the coding is systematic. Elo and Kyngäs (2008) and Saldaña (2021) provide further guidelines for preparing, organizing, and reporting the coding process. Document analysis in general (Bowen, 2009) treats printed curricula and textbooks as stable, intentionally produced documents that can be analyzed non-intrusively and repeatedly, thereby ensuring the auditability required for claims of alignment. This study combines the above approaches into a four-step directed procedure applied to both documents in the same way.

## 2.5. The gap addressed by this study

Three gaps motivate the study. First, the NCP 2022–23 Science strand is recent, and outcome-level alignment analyses of its corresponding textbooks are scarce. Second, provincial pilot textbooks—produced quickly to meet reform timelines—have rarely been systematically examined, even though their quality will shape the reform's realization in the field. Third, most Pakistani alignment work has been conducted at the secondary level and in single subjects, leaving Grade 6 general science, a foundational integrated-science year, comparatively unexamined. By analyzing all 81 Grade 6 SLOs against the BTBB pilot textbook across eight dimensions, this study offers one of the first outcome-level, multidimensional alignment analyses of the NCP 2022–23 at the textbook level in a provincial context, with findings that can inform immediate revision.

## 3. Methodology

### 3.1. Research design

This study employs a qualitative document analysis design. This included one curriculum and its matching Grade 6 science textbook in Balochistan: the NCP 2022–23 Science curriculum (Grades 4–8) as the intended curriculum, and the BTBB General Science 6 Pilot Edition (Academic Year 2026) as the written-enacted instructional material. The analysis was done using two methods. The first method was directed qualitative content analysis (Hsieh & Shannon, 2005), which starts from predetermined theoretical categories, in coding the curriculum and the textbook separately; while curriculum–textbook alignment analysis (Webb, 1997, 2007; Porter, 2002; Martone & Sireci, 2009; Polikoff, 2012) was employed to examine the link between the

curriculum and textbook. Document analysis is well equipped for this type of investigation, as it involves a systematic, non-intrusive examination of naturally occurring documents and visuals (Bowen, 2009). Case study logic (Stake, 1995; Yin, 2018) allows understanding the bounded case as an internally coherent system before any cross-case comparison.

While predominantly qualitative, the analysis employs descriptive counts of SLOs, units, figures, tables, and outcomes within each alignment category to support interpretation. These frequencies are analytic displays (Miles, Huberman, & Saldaña, 2014), not psychometric scores.

### 3.2. Case boundary and data sources

The case boundary was deliberately restricted to document-to-document alignment. Classroom implementation, teacher interpretation, external assessment, and student achievement lie outside the evidence base; the analysis compares written curriculum requirements with written textbook opportunities and makes no classroom-implementation claims. Two primary documents constituted the data.

**Table 1: Primary Data Sources**

| Document                                                                  | Role in the study          | Key descriptors                                                                                                                                         |
|---------------------------------------------------------------------------|----------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------|
| NCP 2022–23 Science, Grades 4–8 (National Curriculum Council Secretariat) | Intended curriculum        | Three domains; benchmarks and grade-specific SLOs; cross-cutting scientific-practice framework; 81 Grade 6 SLOs (20 Life, 55 Physical, 6 Earth & Space) |
| A Textbook of General Science 6, BTBB, Pilot Edition 2026                 | Written enacted curriculum | 220 pages; 12 units; unit-opening outcomes, prose, activities, key points, exercises; ~130 figures and 13 tables; six-page glossary                     |

Note. SLO = Student Learning Outcome. Descriptors were established during document verification and profiling (Step 1) for each document.

### 3.3. Analytic procedure

Each document was analyzed independently using a transparent, four-step, directed content analysis procedure before the two coded corpora were brought together for alignment analysis. The steps constituted an audit trail from raw document to coded evidence.

**Table 2: Four-Step Directed Content-Analysis Procedure Applied to Each Document**

| Step                                                    | Purpose                                 | Main activities                                                                                                                                         |
|---------------------------------------------------------|-----------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------|
| Step 1: Verification and profiling                      | Confirm authenticity and analysability. | Establish provenance, edition, structure, domains, benchmarks, and preliminary SLO/feature inventory.                                                   |
| Step 2: Structured familiarisation and data preparation | Build a reliable, referenced dataset    | Transcribe SLOs and textbook features from page images; prepare source-ID and page ledgers; inventory activities, figures, tables, exercises, glossary. |
| Step 3: Coding-frame development and pilot coding       | Create and test prior categories        | Develop coding frame (content, cognition, skills/inquiry, practical/design, assessment, visuals, context); pilot on a subset; refine definitions.       |
| Step 4: Full directed coding                            | Apply the frame to the whole corpus.    | Code every Grade 6 SLO and its corresponding textbook provision; record evidence and coder notes.                                                       |

Note. The same procedure was applied to the curriculum (Steps C1–C4) and to the textbook (Steps T1–T4). Textbook analysis adapted the curriculum coding frame to textbook features.

### 3.4. Alignment model and judgment rules

After both corpora were coded, all 81 Grade 6 SLOs were matched to textbook opening outcomes and unit pages, and each SLO was judged across eight alignment dimensions. Formal mapping asked whether the SLO was present and correctly located; content and scope asked whether all key concepts, examples, and clauses were developed; cognitive demand asked whether the intended level of thinking was preserved or reduced through over-scaffolding; skills and inquiry asked whether observation,

classification, comparison, model use, investigation, or inference were actually supported; practical work and design asked whether genuine preparation, construction, or original design was available; assessment evidence asked whether tasks elicited the intended performance rather than merely restating content; visual support asked whether figures, tables, diagrams, and models supported the outcome; and science in context asked whether daily-life, health, food, agriculture, technology, sustainability, and space contexts were preserved.

Each SLO was rated holistically as strong, moderate, partial, or weak, without averaging across dimensions, based on the following operational definitions. A conservative, negative-evidence rule was used, whereby a weak or partial judgment was evaluated relative to the entire unit, not just the list of opening outcomes, and the formal reproduction of an outcome was never treated as proof of the textbook's enactment of that outcome.

**Table 3: Operational Definitions of the Overall Alignment Ratings**

| Rating   | Operational definition                                                                                                                                                     |
|----------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Strong   | Formal mapping is present, and the main content, cognitive demand, and expected evidence are substantially supported. Minor scaffolding does not change curriculum intent. |
| Moderate | The core outcome is present, but one important dimension is incomplete—usually inquiry ownership, performance criteria, method choice, evidence, safety, or assessment.    |
| Partial  | The topic appears, but a defining performance, original design, controlled inquiry, or affective/reflective requirement is materially reduced.                             |
| Weak     | The outcome is listed or mentioned, but the defining content or performance is minimally supported.                                                                        |

### 3.5. Trustworthiness

There were several ways in which the research's trustworthiness was assured. First, dependability was achieved through the well-known four-step coding method, along with the creation of a comprehensive log of all source IDs and page numbers. In turn, confirmability was achieved through documentation of evidence and coders' comments on each rating, and through negative case analysis to connect each rating to the corresponding feature of the textbook. Credibility was ensured by grounding the coding scheme in the existing body of alignment theory and by using conservative rating guidelines that would not overcredit formal coverage.

## 4. Findings

This section reports the alignment findings in four parts: the curriculum profile that established the intended demands; the formal outcome mapping; the multidimensional alignment results; and the domain- and unit-level synthesis with illustrative case interpretations.

### 4.1. The intended curriculum: a relatively high cognitive orientation

Coding of the 81 Grade 6 SLOs revealed that the intended curriculum is not a recall-centered list. There is one outcome at the remember level, while apply, analyze, evaluate, and create account for 51 of the 81 outcomes. The framework of the intended curriculum is broader than the SLOs themselves: it explicitly addresses questions, hypotheses, measurement, recording, safety, model critique, data representation, and improvement, even when these are not explicitly mentioned in a particular Grade 6 SLO. This is important for the analysis, since faithful textbook alignment must support both the SLO-level content and the scientific practice framework.

**Table 4: Cognitive-Demand Distribution of the 81 Grade 6 Curriculum SLOs (Revised Bloom Taxonomy)**

| Cognitive level | SLOs | Share | Illustrative demand                          |
|-----------------|------|-------|----------------------------------------------|
| Remember        | 1    | 1.2%  | Direct retrieval of a fact                   |
| Understand      | 29   | 35.8% | Description, explanation, exemplification    |
| Apply           | 20   | 24.7% | Use of known procedures in familiar contexts |
| Analyze         | 28   | 34.6% | Comparison, classification, differentiation  |
| Evaluate        | 1    | 1.2%  | Criteria- or evidence-based judgment         |
| Create          | 2    | 2.5%  | Original design of a product or model        |

| Cognitive level | SLOs | Share | Illustrative demand |
|-----------------|------|-------|---------------------|
| Total           | 81   | 100%  | —                   |

Note. Each SLO received one dominant cognitive assignment. Apply, Analyze, Evaluate, and Create together account for 51 of 81 outcomes (63.0%).

#### 4.2. Formal mapping is complete

Formal mapping was complete: all 81 NCP Grade 6 Science SLOs are represented in the unit-opening outcomes and distributed across the 12 textbook units. The 12 units replicate the NCP Grade 6 content progression from cells to the Solar System, meaning that the textbook not only references the curriculum but also replicates its outcome sequence in its own structure. Formal reproduction, however, is only the first step in alignment; the rest of the analysis focused on the quality of the enactment.

**Table 5: Formal Mapping of Curriculum SLOs to Textbook Units**

| Unit | Title                       | Pages   | SLOs | Curriculum IDs    |
|------|-----------------------------|---------|------|-------------------|
| 1    | Cellular Organization       | 10–35   | 6    | S-06-A-01 to A-06 |
| 2    | Reproduction in Plants      | 36–52   | 4    | S-06-A-07 to A-10 |
| 3    | Balanced Diet               | 53–68   | 5    | S-06-A-15 to A-19 |
| 4    | Human Digestive System      | 69–81   | 5    | S-06-A-11 to A-20 |
| 5    | Matter as Particles         | 82–99   | 7    | S-06-B-10 to B-16 |
| 6    | Elements and Compounds      | 100–120 | 9    | S-06-B-01 to B-09 |
| 7    | Mixtures                    | 121–134 | 9    | S-06-B-17 to B-25 |
| 8    | Energy                      | 135–155 | 8    | S-06-B-26 to B-33 |
| 9    | Electricity                 | 156–171 | 10   | S-06-B-34 to B-43 |
| 10   | Magnetism                   | 172–187 | 8    | S-06-B-44 to B-51 |
| 11   | Technology in Everyday Life | 188–200 | 4    | S-06-B-52 to B-55 |
| 12   | Solar System                | 201–214 | 6    | S-06-C-01 to C-06 |

Note. All 81 SLOs are formally mapped. Domain codes: A = Life Science, B = Physical Science, C = Earth and Space Science.

#### 4.3. Overall alignment is strong

Overall alignment is strong. Out of 81 SLOs, 62 (76.5%) have strong alignment, 15 (18.5%) have moderate alignment, 4 (4.9%) have partial alignment, and there are no weak alignments. The absence of any weak or omitted SLOs, combined with the majority of strong judgments, suggests that there is no major gap at the topic level in this case. Moderate and partial judgments cluster around the depth of enactment – learner agency, performance criteria, investigation quality, original design, and assessment evidence.

**Table 6: Overall Alignment of the 81 Grade 6 SLOs**

| Overall rating | SLOs | Share | Meaning                                                                                                                                                       |
|----------------|------|-------|---------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Strong         | 62   | 76.5% | Requirement is formally mapped and substantively supported through content, visuals, and/or appropriate activity or assessment evidence.                      |
| Moderate       | 15   | 18.5% | Core requirement present, but one important dimension (usually learner agency, performance criteria, investigation quality, or assessment) is underdeveloped. |
| Partial        | 4    | 4.9%  | Topic present, but a defining performance, inquiry, design, or affective clause is substantially reduced.                                                     |
| Weak           | 0    | 0.0%  | Very limited evidence for the written requirement.                                                                                                            |

#### 4.4. Multidimensional results: strengths and reductions

Judging each SLO on each dimension individually produced a consistent pattern of strengths and reductions. Content coverage, visual support, and contextual relevance are the strongest dimensions, while practical/design performance, open inquiry, and performance assessment are the weakest. Table 7 summarizes the dimensional results.

**Table 7: Multidimensional Alignment Results Across the 81 SLOs**

| Dimension                 | Strongest category (n, %)                   | Reduced/limited category (n, %)                        |
|---------------------------|---------------------------------------------|--------------------------------------------------------|
| Content and scope         | Full: 72 (88.9%)                            | Substantial only: 9 (11.1%); Partial: 0                |
| Cognitive demand          | Preserved: 62 (76.5%)                       | Partly preserved: 15 (18.5%); Reduced: 4 (4.9%)        |
| Skills and inquiry        | Supported: 59 (72.8%)                       | Partial: 8 (9.9%); Not separately required: 14 (17.3%) |
| Practical work and design | Supported: 6 (7.4%); with limits: 9 (11.1%) | Partial: 3 (3.7%); Not required by SLO: 63 (77.8%)     |
| Assessment evidence       | Strong: 56 (69.1%)                          | Moderate: 21 (25.9%); Weak: 4 (4.9%)                   |
| Visual support            | Strong: 58 (71.6%)                          | Moderate: 23 (28.4%); Limited: 0                       |
| Science in context        | Strong: 37 (45.7%)                          | Moderate: 8 (9.9%); Not central: 36 (44.4%)            |

Note. "Not separately required," "Not required by SLO," and "Not central" denote outcomes for which the dimension is not a defining curriculum demand, and therefore do not indicate a deficiency.

Three patterns emerge from the data. First, a high level of cognitive demand is maintained (62 of 81), with reductions occurring specifically in the design and controlled-investigation categories, as per the international finding that higher-order and inquiry demands are the most difficult to implement in materials. Second, the approximately 130 figures and 13 tables in the textbook make visual representation a true strength, covering cells, body systems, particles, circuits, magnetism, and astronomy. Third, there is sufficient but uneven evidence for assessment: systematic written exercises (strong evidence for 56 outcomes), but weak performance, design, and inquiry criteria, which would elicit and evaluate the required performance.

The content-and-scope result needs to be highlighted, as it is the basis for all other judgments. Content and scope were rated fully for 72 of 81 outcomes, and substantial for the remaining 9, with no outcome rated below substantial. In other words, if an outcome was reduced in any way, it was a reduction in how the outcome was enacted, and not in its subject matter presence. The 9 outcomes that had only substantial content were typically performance- or clause-level requirements—an agricultural yield inquiry, a diet-and-fitness correlation, a design task—wherein the conceptual content was well developed, but a particular performance clause was weak. The clear distinction between full content coverage on the one hand and selective enactment reduction on the other is the empirical core of the study's central characterization.

Alignment of visuals and context defines the textbook's teaching style. Visual representation is well developed for 58 outcomes, all other being moderate and none limited, which means that the textbook contains a great deal of teaching through representation – labeled cell and system diagrams, illustrations of particle models, diagrams of circuits and fields, and astronomical drawings form a large part of the conceptual knowledge base. It is a genuine strength for accessibility and concept-based learning, especially for those students for whom dense prose is a barrier. Contextual alignment is strong for 37 outcomes, moderate for 8, and the remaining 36 are mainly conceptual or structural outcomes for which context is not a defining requirement. Where the context was important—health and nutrition, agriculture and food, renewable energy, household electricity, technology, and space—the textbook successfully related science to everyday and social life. Together, the visual and contextual profiles indicate a textbook well-designed to make science accessible and meaningful; the challenge is to make it equally well-designed to make science investigable and designable.

#### 4.5. Domain- and unit-level synthesis

Aggregating the outcome ratings by domain revealed that Physical Science (55 SLOs) is the strongest and the field with the largest number of reductions in design, controlled variables, and performance criteria, due to the large number of practical and STEAM outcomes. Life Science (20 SLOs) had strong conceptual and visual support, with some limitations in assessment of microscopy, agricultural inquiry, and supplied conclusions. Earth and Space Science (6 SLOs) had strong alignment with content and visuals, but weak alignment with inquiry criteria and affective evidence.

**Table 8: Domain-Level Alignment Synthesis**

| Domain                  | SLOs | Strong | Moderate | Partial | Weak |
|-------------------------|------|--------|----------|---------|------|
| Life Science            | 20   | 16     | 4        | 0       | 0    |
| Physical Science        | 55   | 43     | 9        | 3       | 0    |
| Earth and Space Science | 6    | 3      | 2        | 1       | 0    |
| Total                   | 81   | 62     | 15       | 4       | 0    |

At unit level, alignment was strongest in Elements and Compounds (9 strong of 9) and Matter as Particles (6 of 7), and most reduced in Technology in Everyday Life (1 strong of 4) and Solar System (3 strong of 6), where design agency, performance criteria, and affective or inquiry evidence were most constrained. Table 9 gives the full unit profile.

**Table 9: Unit-Level Alignment Synthesis**

| Unit | Title                       | SLOs | Strong | Mod. | Part. | Weak |
|------|-----------------------------|------|--------|------|-------|------|
| 1    | Cellular Organization       | 6    | 5      | 1    | 0     | 0    |
| 2    | Reproduction in Plants      | 4    | 3      | 1    | 0     | 0    |
| 3    | Balanced Diet               | 5    | 4      | 1    | 0     | 0    |
| 4    | Human Digestive System      | 5    | 4      | 1    | 0     | 0    |
| 5    | Matter as Particles         | 7    | 6      | 1    | 0     | 0    |
| 6    | Elements and Compounds      | 9    | 9      | 0    | 0     | 0    |
| 7    | Mixtures                    | 9    | 7      | 2    | 0     | 0    |
| 8    | Energy                      | 8    | 6      | 1    | 1     | 0    |
| 9    | Electricity                 | 10   | 8      | 1    | 1     | 0    |
| 10   | Magnetism                   | 8    | 6      | 2    | 0     | 0    |
| 11   | Technology in Everyday Life | 4    | 1      | 2    | 1     | 0    |
| 12   | Solar System                | 6    | 3      | 2    | 1     | 0    |

#### 4.6. Illustrative unit interpretations

A few units illustrate how strong coverage coexists with selective reductions in enactment.

Unit 1 (Cellular Organization). The textbook provides strong coverage of cellular organization outcomes through the cell hierarchy, plant and animal cell diagrams, special human cell figures, comparisons, and microscopy support. Alignment becomes moderate for slide preparation and cheek cell comparison because direct performance, hygiene, safety, and observation criteria are necessary but not fully defined (5 strong, 1 moderate).

Unit 8 (Energy). Potential and kinetic energy, energy transfer, conservation of energy, and renewable and non-renewable energy sources are developed through figures and activities. Assembly of a solar panel is moderately covered because the operating criteria are limited, and the solar water heater is partially covered because the original design requirement can be reduced to following the given instructions (6 strong, 1 moderate, 1 partial).

Unit 9 (Electricity). Static and current electricity, circuits, circuit symbols, open and closed circuits, and series and parallel circuits are strongly covered. The partial case is the investigation of factors that affect bulb brightness or motor speed, because a complete controlled investigation with batteries, bulbs, wires (type, length, and thickness), and systematic data recording is not conducted (8 strong, 1 moderate, 1 partial).

Unit 11 (Technology in Everyday Life). This authentic unit links plant growth and fertilizers, yogurt and cheese production, solar oven, and electric bell to everyday life. Alignment is strong for food and assembly outcomes, moderate for long-term evidence of plant growth and assessment of the electric bell, and partial for solar oven design due to limited design agency (1 strong, 2 moderate, 1 partial).

Unit 12 (Solar System). Planets, asteroids, meteorites, comets, satellites, and GPS are developed through many figures. Research on satellite contributions is moderately covered because of low requirements to source quality and synthesis, and Halley's Comet is partially covered because of an effective "what they would feel" clause that should be structured (3 strong, 2 moderate, 1 partial).

#### **4.7. Cross-cutting findings**

Across all units, a set of cross-cutting findings has been produced that summarises the study. Formal alignment is complete, and topic sequencing is highly consistent: all Grade 6 SLOs are found in a corresponding unit-opening outcome, and the 12 units reflect the curriculum's content progression. Content alignment is very strong, and cognitive alignment is mostly preserved, with reductions concentrated in design and controlled-investigation outcomes. Visual and model-based support—particle, cell, circuit, energy, magnetic field, and Solar System models—is a major strength that ties curriculum concepts to textbook representations. Guided scientific participation is the dominant instructional mode: there are plenty of activities, but textbook procedures and teacher prompts mostly scaffold them. Practical work is present but not always fully assessable because of limited rubrics and performance criteria. Open inquiry is the clearest weakness: very few tasks include the whole inquiry chain of question, hypothesis, method, data, conclusion, and improvement, and original design is selectively reduced to instruction-following in the two genuine design outcomes. Assessment alignment is adequate but inconsistent, safety is an under-specified alignment condition, and pilot edition quality flags—numbering, language, and source quality—are present but do not undermine alignment. The main finding is that the textbook is curriculum-saturated rather than curriculum-referenced: it reflects the curriculum outcome sequence as its own structure, so that its weaknesses are those of depth, not of coverage.

It is important to interpret the moderate and partial judgments conservatively. A moderate or partial rating does not imply the textbook's omission of the topic: in every such case the subject matter is present, and the reduction relates to a specific performance, inquiry, design, or affective clause. Some of these enactment gaps may be closed by teachers in classrooms, some written exercises may indirectly assess practical concepts, and the pilot edition status may explain certain anomalies. These rival explanations have been retained rather than dismissed, which is why the study formulates its claims at the level of written materials and interprets the findings as a map for revision rather than as a classroom-learning verdict.

### **5. Discussion**

#### **5.1. A curriculum-saturated textbook with selective reduction**

The major finding is that the BTBB Grade 6 textbook is curriculum-saturated; in addition to referencing the NCP 2022–23, it reproduces the full Grade 6 outcome sequence in unit design and thus achieves full formal alignment. At the same time, its alignment is characterized by selective reduction. The textbook is strongest when outcomes require explanation, classification, representation, comparison, and guided application, and weaker when they require learner-controlled inquiry, controlled-variable investigation, original engineering design, reflective or affective response, explicit safety procedure, and systematic performance evidence. The most accurate description of the case is therefore strong curriculum-saturated alignment with selective reduction in independent inquiry, design agency, and performance assessment. Crucially, the gaps are enactment-depth gaps rather than coverage gaps—there are no weak or omitted topics.

#### **5.2. Relationship to prior alignment research**

This pattern is consistent with, and extends, the international and Pakistani alignment literature. The finding that content coverage and cognitive labeling are easier to achieve than depth-of-knowledge and inquiry alignment echoes Webb's (1997, 2007) and Polikoff's (2012) warnings that surface coverage can mask cognitive-demand differences, and it mirrors science-textbook studies reporting strong content but thinner higher-order and inquiry provision (Alemneh & Mengistie, 2023). It aligns with Pakistani secondary-level studies that found textbooks emphasizing content and lower-order activities relative to curriculum ambitions (Bhatti et al., 2015; Hashmi et al., 2018; Bhutto et al., 2022), and with evidence that realizing the reform's twenty-first-century aims depends on resources and teacher capacity as much as on curriculum text (Mansoor & Din, 2023). The present study, however, is notably strong on formal and content alignment—stronger than some earlier Pakistani findings—suggesting that the explicit, SLO-anchored design of the NCP 2022–23 and its reproduction in the textbook's unit-opening outcomes has improved coverage fidelity. What has not yet been solved is the harder problem: carrying scientific practices and design into enacted, assessable learning opportunities.

#### **5.3. Why the reductions cluster where they do**

The reductions are not random. They concentrate on the two genuine create-level design outcomes (solar water heater, solar oven), on controlled-variable investigations (electrical brightness/speed factors), on affective/reflective outcomes (Halley's Comet), and on outcomes requiring learners to infer conclusions rather than receive them (digestion transport/egestion). These

are precisely the kinds of results where a textbook, as an idealized form of written communication, will tend to replace guided participation with inquiry because it provides the method, the result, and the pathway to evidence. This is an inherent characteristic of textbook science rather than an odd feature of this particular textbook, which is why it needs to be addressed through conscious design decisions.

#### **5.4. The role of visual pedagogy and guided participation**

Two factors explain the textbook's high level of alignment and its inherent limitations. First, there is the visual pedagogy. With the help of about 130 illustrations, representation is used as a tool for enactment, contributing to a high level of content-cognitive alignment by helping students grasp abstract concepts without overreliance on textual language and thereby promoting the conceptual orientation of the curriculum. Second, there is guided participation. The textbook provides learners with many activities; however, it always gives them a procedure, a diagram, a list, a teacher prompt, and a form of response. Guided participation is a strength in terms of coverage, accessibility, and classroom manageability – especially valuable when teacher capacity and lab facilities are inconsistent. However, it is also the mechanism by which open inquiry and learner-designed investigation are subtly constrained. Understanding these two mechanisms as the sources of the textbook's strengths and weaknesses makes the improvement agenda manageable: the goal is not to eliminate guidance and visual elements, but to overlay them with a layer of learner-owned inquiry and design.

#### **5.5. Implications for the reform and for equity**

Given that the textbook is the operational curriculum in most Balochistan classrooms, enactment-depth gaps have direct implications for equity. If inquiry, design, and performance assessment are under-specified in the textbook, learners with less access to well-equipped teaching will be the most likely to have science taught to them as guided description rather than as investigation and design – precisely the outcome the reform aims to prevent. Strengthening the textbook's inquiry and design provisions, therefore, is not a cosmetic fix but a means of ensuring equitable access to the higher-order aims of the curriculum. The strong visual and contextual alignment already achieved in the textbook provides a good basis for such improvements.

### **6. Recommendations for Strengthening the Textbook**

These recommendations are a direct response to the authors' request for feedback and are specifically aimed at addressing the enactment-depth gaps in the pilot textbook. They are designed to preserve the textbook's strengths – complete coverage, strong visuals, and abundant context from daily life – while aligning it more closely with the concept-based, inquiry-oriented, and twenty-first-century-oriented aims of the curriculum.

#### **6.1. Build the full inquiry cycle into activities**

The clearest weakness was that very few tasks require the full inquiry chain: question, hypothesis, method, data, conclusion, and improvement. In units with investigation outcomes—especially Matter as Particles, Electricity, Mixtures, and Reproduction in Plants—activities should be reframed from confirmatory demonstrations into short structured investigations. A simple, repeatable activity template can be added to the book's design: ask a question –predict –plan the method –record data in a given table –conclude the data –suggest one improvement. For the electricity brightness/speed outcome, for example, learners should vary one factor at a time (number of batteries, number of bulbs, wire type, length, thickness), record measurements, and interpret a simple results table—turning a partial outcome into a strong one.

#### **6.2. Restore genuine design agency to STEAM outcomes**

The two create-level outcomes (solar water heater, solar oven) and other STEAM tasks are the most vulnerable to becoming instruction-following. The next edition should present these as open design challenges with criteria and constraints rather than as step-by-step recipes: state the goal and the constraints (materials, cost, size), ask learners to sketch and justify a design, build and test it, measure performance against a stated criterion, and redesign once. Providing a design brief and a short evaluation rubric—rather than a finished procedure—preserves the create-level demand the curriculum intends.

Add explicit performance-assessment criteria and rubrics

The written exercises were systematic, but there were no criteria for practical, design, or inquiry activities that would elicit and assess the desired performance. Every practical or project activity needs a short rubric (three or four criteria) for what a good investigation, model, or product looks like. This is particularly important for the units on microscopy and slide preparation (Unit 1), separation methods (Unit 7), electromagnet building (Unit 10), and technology projects (Unit 11).

### 6.3. Make safety a visible, routine feature

While the safety aspect is highlighted in the curriculum framework, safety procedures have not been explicitly stated for biological samples, slides, heating and burners, glassware, food preparation, and electricity. A clearly labeled safety box needs to be provided for each activity, including hazard recognition and safety precautions, to make safety a routine part of scientific activity. This will help support microscope, mixtures, energy, and technology topics.

### 6.4. Shift selected conclusions from supplied to inferred

For many outcomes, including, notably, the digestive transport/egestion outcome (Unit 4) and the particle arrangement explanation (Unit 5), the book provides the scientific conclusion rather than having learners draw it based on evidence. A slight modification, giving the observations first and having learners conclude before it is stated, would maintain the intended reasoning requirement and better align these moderate outcomes.

### 6.5. Strengthen affective, reflective, and source-evaluation tasks

Affective or reflective outcome clauses (such as Halley's Comet in Unit 12) and secondary-source research outcomes (contributions of satellites) require response frames that include a brief reflection prompt with starter sentences, and, in the case of research outcomes, a source evaluation checklist. This would transform the current partially aligned outcomes into fully aligned ones.

### 6.6. Correct pilot-edition anomalies and prepare for twenty-first-century skills

Numbering, language, and source quality issues common in a pilot edition must be rectified during revision, and subject-matter experts must evaluate scientific accuracy and language concerns. In general, for equipping learners with practical skills for future success in life, the next edition must incorporate the skills needed for the twenty-first century into the curriculum in the form of critical and creative thinking, communication, collaboration, and problem-solving skills through tasks such as group projects which will involve planning, presentation, and argumentation of conclusions.

Table 10 links each recommendation to the finding it addresses and the outcomes most affected, so that revision effort can be prioritized where alignment is currently moderate or partial.

**Table 10: Recommendations Mapped to Findings and Priority Units**

| Recommendation                                     | Finding addressed                       | Priority units/outcomes                |
|----------------------------------------------------|-----------------------------------------|----------------------------------------|
| Build the full inquiry cycle into activities       | Open inquiry is the clearest weakness   | Units 5, 7, 9, 2                       |
| Restore genuine design agency.                     | Original design selectively reduced.    | Units 8, 11 (solar heater, solar oven) |
| Add performance rubrics and criteria.              | Assessment uneven for practical/design  | Units 1, 7, 10, 11                     |
| Make safety a routine feature.                     | Safety is an alignment condition.       | Units 1, 3, 5, 8, 9, 11                |
| Shift conclusions from supplied to inferred.       | Learner-generated inference is limited. | Units 4, 5                             |
| Strengthen affective and source-evaluation tasks.  | Affective and research evidence thin    | Unit 12; satellite research            |
| Correct pilot anomalies; embed 21st-century skills | Pilot-edition quality flags matter      | Whole book                             |

## 7. Limitations and Future Research

The study was limited in several aspects. Firstly, it used document-to-document mapping, focusing on writing curriculum requirements and the opportunities in textbooks, but did not consider how they were implemented in classrooms, nor the gaps that teachers could fill in their practices. Secondly, the textbook used was a Pilot Edition for the Academic Year 2026. third, alignment judgments were qualitative and interpretive rather than psychometric scores, and assessment evidence was based on textbook exercises and tasks rather than official examinations. Finally, scientific accuracy and language flags noted during coding require specialist subject review beyond the scope of an alignment study.

These limitations point to productive future research. Classroom observation and teacher-interview studies could test whether the identified enactment-depth gaps are compensated for, widened, or reproduced in practice, particularly in low-resource Balochistan schools. Cross-case comparison with textbooks aligned to earlier curricula (NC 2006, SNC 2020) or with other

provinces' NCP-aligned textbooks would show whether the curriculum-saturated-with-selective-reduction pattern is general. Learner-outcome studies could examine whether strengthening inquiry and design provision in a revised edition improves higher-order performance. Second-coder reliability studies would further strengthen the dependability of the coding frame.

## 8. Conclusion

This study analyzed the alignment between the National Curriculum of Pakistan 2022–23 Science curriculum and the Balochistan Textbook Board's Grade 6 General Science Pilot Edition through a transparent, multi-step directed qualitative content analysis of all 81 Grade 6 Student Learning Outcomes across eight dimensions. The textbook demonstrated complete formal mapping and strong overall alignment: 76.5% of outcomes were strongly aligned, 18.5% moderately aligned, 4.9% partially aligned, and none weakly aligned. Alignment was strongest in content coverage, visual support, guided explanation, and daily-life context, and weakest in independent inquiry, controlled-variable data production, original engineering design, direct performance assessment, explicit safety protocols, and reflective evidence.

The most accurate characterization of the case is a curriculum-saturated textbook with selective reduction in inquiry, design agency, and performance assessment. Its alignment gaps are enactment-depth gaps, not coverage gaps—a meaningful and encouraging result for a first-generation reform textbook, and one that points to a clear, achievable improvement agenda. Because the book is a pilot edition whose producers have invited feedback, the recommendations offered here—building the full inquiry cycle, restoring design agency, adding performance rubrics, making safety routine, shifting selected conclusions from supplied to inferred, strengthening affective and source-evaluation tasks, and embedding twenty-first-century skills—can be implemented in the next edition without restructuring the book. Doing so would allow the textbook to move from strong formal fidelity toward full realization of the curriculum's concept-based and twenty-first-century aims, and would help ensure that learners in Balochistan encounter science not only as knowledge to be understood but as practice to be enacted.

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