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Misconceptions in Basic Scientific Concepts: A Case Study of Primary School Learners in South Punjab, Pakistan

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Abstract

This manuscript examined misconceptions in basic scientific concepts among primary school learners in South Punjab, Pakistan through a qualitative case study conducted in Bahawalpur district. Conceptual errors in early science learning were treated as stable misunderstandings shaped by interactions among cognitive development, language accessibility, pedagogy, and assessment practices. Data were drawn from semi-structured interviews with primary learners and science teachers and analyzed using thematic analysis. The case evidence indicated that misconceptions clustered strongly around abstract and invisible concepts (air/pressure, force, energy, magnetism) and process-based phenomena (water cycle, evaporation, photosynthesis). A central pattern was that learners expressed difficulty describing how and why scientific processes occur, often relying on memorized statements rather than articulated understanding. Teacher accounts emphasized that learners could decode textbook text while failing to grasp meaning, suggesting that language complexity and limited conceptual scaffolding functioned as major misconception drivers. Instructional routines were mainly textbook-centered, with constrained access to models, charts, kits, and practical opportunities. The findings were interpreted through a conceptual framework linking student cognitive readiness and prior knowledge with teacher pedagogical content knowledge, medium-of-instruction barriers, and limited formative assessment. The manuscript argues that addressing misconceptions in South Punjab primary science requires systemic shifts: bilingual scaffolding where needed, low-cost experiential learning, routine diagnostic questioning and feedback cycles, and sustained teacher development aligned to classroom realities. These reforms can better align curriculum intentions with classroom implementation, reducing long-term accumulation of misconceptions that hinder later STEM learning.

Keywords: *scientific misconceptions, primary school learners, science learning difficulties, teaching strategies in science*

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1. INTRODUCTION

Misconceptions in the basic scientific concepts are not just "wrong answers." Often, they are internally consistent models that children use to interpret experience and propositional form that can continue long after learners are able to recite correct definitions. Within primary schooling, such misconceptions affect whether science becomes an accessible way of defining the world, or a subject withered into the process of memorization and exam preparation. In Pakistan, based on the descriptive evidence, it is already clear that elementary learners experience conceptual challenges in general science emergencies but more particularly when content is abstract and cognitively challenging (Akram et al., 2022). Mixed-method evidence similarly reports the lack of conceptual difficulties due to pedagogy and context served as a constraint of how the learners interact with science ideas (Akram et al., 2023). Where the misconceptions are not addressed, the subsequent learning is fragile because the concepts of science build sequentially, so that if there is an error in the foundation model then the learning in the middle and secondary grades could become unstable.

Within South Punjab, the issue has a certain educational texture, derived from the inequalities of resources, uneven instructional support and language complexity. A recurring structural strain is the medium of instruction and implementation of the same in the classrooms. English-medium science teaching, particularly government, can contribute to the addition of linguistic load in the competition with concept formation, especially if teachers and learners are not proficient or have limited support resources (Mukhtar et al., 2021). Debates on language policy and the use of mother tongues in Pakistani education appears to indicate that access and understanding lie at the heart and not at the periphery of learning quality, at least for the early grades (Khan et al., 2020). The introduction of standardized reforms like the Single National Curriculum has made the policy discourse more focused on the learning standards, although there is also scholarship to identify the ideological and linguistic concerns that can be manifested in the classroom complexity rather than conceptual clarity (Khan & Mehak, 2024). However, without classroom-level interventions, policy reform cannot be a reliable way to reduce misconceptions.

The present manuscript is based on an empirical account of the misconception problem by using a qualitative case study dataset drawn from Bahawalpur district (South Punjab). The evidence indicates that the presence of misconceptions is clustered around the invisible (air/pressure), forces (force and magnetism), and abstract quantities (energy) and natural phenomena involving processes (water cycle and evaporation). These patterns are in line with what Pakistani work has documented about widespread conceptual difficulties in general science at elementary level (Akram et al., 2022) and what has been done on how inappropriate conceptual understanding of science leads to misconceptions in science learning at secondary level, where the early conceptual difficulties could become persistent misunderstandings (Majeed, 2023). In addition, assessment and feedback cultures is important as misconceptions are not usually corrected without explicit diagnostic work. Formative assessment and feedback processes have often been highlighted as the key to fostering improvements in learning as well as conceptual clarity (Kausar, 2022; Qadir et al., 2020; Rahman, 2024), but unfortunately evaluation is inherently oriented to recall and grading, not to diagnosis of misconceptions (Zafar et al., 2024). This research study answers the following research questions following a Scopus-indexed journal standard of clarity and empirical contribution:

a) What misconceptions and conceptual difficulties are most prominent in basic scientific concepts among primary learners in South Punjab (Bahawalpur case)?

b) What classroom and contextual factors appear to generate or sustain these misconceptions (language, pedagogy, resources, assessment practices)?

c) What reforms (pedagogical, assessment-based, language-supportive, and resource-sensitive) are indicated by the case evidence?

1.1 Theoretical and Conceptual Framework

A misconceptions analysis of Scopus quality requires a conceptual clarity (one in which observed classroom evidence is related to mechanisms for why misconceptions arise and why they persist). In the literature provided from Pakistan, four clusters of mechanisms are repeated again: Cognitive development and readiness, Language and epistemic access, Pedagogy and teacher knowledge, Assessment/Feedback ecosystems.

- The first mechanism is learner cognitive development and the ability to process abstraction. While the references provided are not classic texts of developmental psychology, it is empirically reinforced by the fact that cognitive development levels influence the way in which learners deal with conceptual demand in science learning. Research work on cognitive development for learning chemical at secondary level shows how the constraints of development may

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influence the conceptual understanding (Nazir and Kanwal, 2025). Although there is a difference between the group of learners, the underlying logic is relevant: Concepts that become abstract and multi-step are prone to conceptual error unless instruction is developmentally responsive. In the rural learning scenario in Punjab, cognitive science framing has also been applied to understand the learning environment interaction with cognitive factors (Rehman, Khan, & Zia, 2023). For primary science, this means that non-visible entities (air/pressure) and intangible constructs (energy) need concrete bows and scaffolded structures, to prevent misconception formation as much as possible.

- A second mechanism is that of language as an access condition. English-medium instruction can transform the learning of science from meaning-making to decoding, especially when students do not know the conceptual vocabulary and teachers lack the positionality to facilitate language learning as necessary during teaching (Mukhtar et al., 2021). Scholarship on mother tongue education emphasizes the fact that language policy for early learning is connected to comprehension and conceptual clarity (Khan et al., 2020). In practice though, this implies that misconceptions may arise as the learners memorize unfamiliar terms in English that take the form of strings of sound and spelling, rather than as terms related to concepts and experience. This concern is acute in the case of curriculum reform contexts as standardized curricula have the potential to move language and content expectation more rapidly than the classroom capacity and teacher preparation (Khan and Mehak (2024).
- A third mechanism refers to pedagogy (the teacher pedagogical content knowledge). Empirical work suggests that conceptual difficulties of learners are linked to the way that science is taught and whether the way it is taught employs instruction methods that create understanding and are away from recall (Akram et al., 2022; Akram et al., 2023). Intervention-oriented studies in Pakistan indicate toward usefulness of analogy-based teaching in learning chemistry (Saleem, 2022) and concept maps as formative assessment tools in learning biology (Choudhary, 2022). These examples are secondary-level contexts, but nevertheless they throw some light on the logic of a mechanism: under conditions in which the process of instruction actively supports relational reasoning and visualization, misconceptions will be brought more readily to light and corrected. Teacher knowledge about the nature of science is also important because misconception about science content can be quite persistent when scientific reasoning, explanation and evidence are not foregrounded in classroom practice (Rana et al., 2023).
- A fourth mechanism is system of assessment and feedback as a misconception control system. Feedforward processes are usually conceived to play a central role in learning improvement (Rahman, 2024), while formative assessment is both associated with learning outcomes as well as with academic achievement (Kausar, 2022). In the discussions related to engineering education, formative assessment and feedback are highlighted as important levers towards effective learning (Qadir et al., 2020). If primary science assessment continues to be recall oriented, then misconceptions can become stable because memorization rather than correction of non-scientific mental models is reinforced to the learners. More general evaluation practices in education can support or oppose conceptual learning practice based on whether they place emphasis on reasoning and clarity (Zafar et al., 2024).

The conceptual framework below is a synthesis of these clusters of mechanisms and related to misconception outcomes and possible intervention sites of South Punjab primary science.

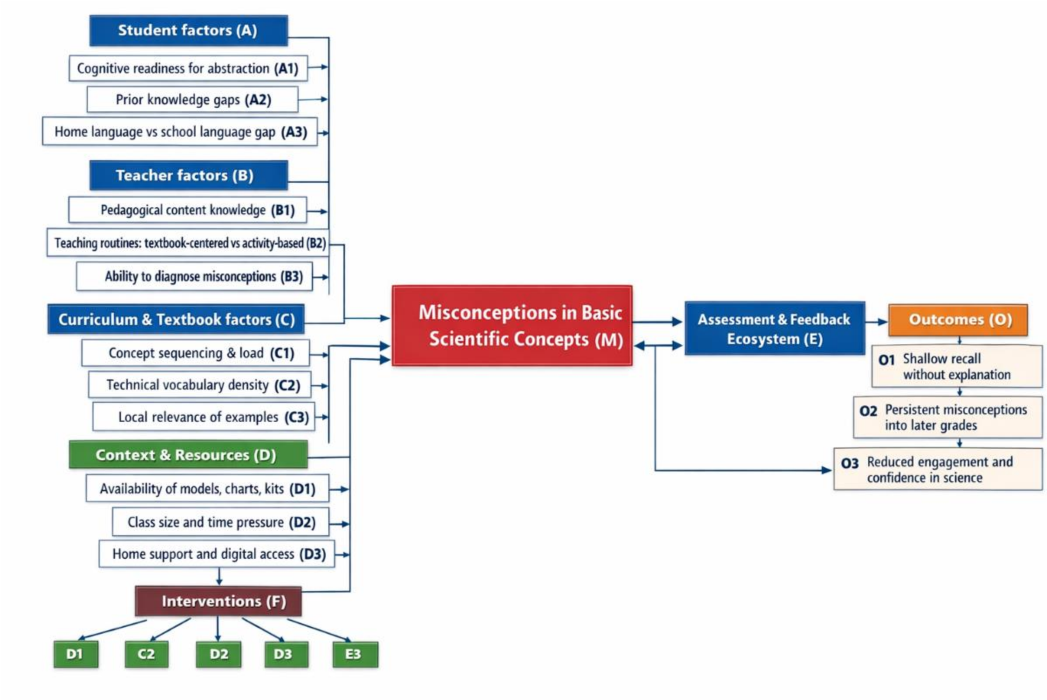

Figure 1: Framework

This framework informed the Findings and Discussion sections because misconceptions are treated as an outcome of this system and not an isolated learner error.

2. LITERATURE REVIEW

Research done in Pakistan and similar contexts clearly illustrates how conceptual understanding in science is tenuous when learning environments have little to do with science takes on a focus on recall, reduces experimentation, and offers little to no opportunities for learners to express reasoning. At elementary level in Pakistan, the application of descriptive research has highlighted conceptual difficulties on general science as a main obstacle of learning quality (Akram et al., 2022). A sequential explanatory mixed-method study also records conceptual difficulties among primary learners and indicators towards systemic causes which include instructional design, context of the learner, and the little use of structured inquiry (Akram et al., 2023). These studies offer a scholastic anchor for the interpretation of the South Punjab case: primary misconceptualizations are embedded within instructional ecosystems, not only found within individual learners.

Misconceptions in science are also prevalent in research within specific disciplines. At secondary level, a specific Pakistani study directly looked at the common misconceptions in chemistry that were found, with the main point of the study being that misconceptions do not disappear without specific instructional intervention (Majeed, 2023). While the age group is different, the implication is transferable: if a student has false beginnings, it can easily be set in stone as he progresses, especially if he is given "definitive assessment" that rewards memorization more than conceptual explanation. The significance of diagnosis and correction is added by intervention work based on analogy-based teaching which has been proven to be effective in improving chemistry learning by establishing a connection between an abstract concept and a familiar pattern (Saleem, 2022). Similarly, concept maps have been documented to be effective as formative tools in biology learning because they enable learners to visualize the relationships between concepts in Biology learning rather than isolated facts. (Choudhary, 2022). Both approaches demonstrate practical methods that can be modified for use in primary science in less complex versions of these techniques (e.g., picture-based concept maps; teacher guided analogies).

A major recurrent theme across the references provided has been language as an instructional gatekeeper. Teachers' perception research in government higher secondary schools from Sindh area report difficulties, related to the medium of instructions of English, from which it can be observed that language problems can distort the learning process and can reduce conceptual access (Mukhtar et al., 2021). Language policy debates on mother tongue education make similar arguments that early education is beneficial when learners are able to construct concepts in accessible language, as opposed to having to grapple with unfamiliar linguistic structures (Khan et al., 2020). In addition, the single national curriculum debate poses ideological and linguistic issues that can influence the understanding and learning quality in classrooms or learning parity (Khan & Mehak, 2024). Together, these studies set the issues of language not as an aspect of "support," but as a mechanism that affects whether learners develop scientific concepts or memorize labels.

The learning environment in rural Punjab has also been explained based on cognitive science, including contextual constraint affecting learning preparedness and achievement (Rehman et al., 2023). Such contextual constraints cross over into the technologies of instruction and access to digital learning technologies. Research on online learning for mass audiences during the objectives of the period of covid-19 pandemic outline key considerations for effective real time knowledge transfer (Utunen, Tokar, Arabi, & Gamhewage, 2022). Although not an intervention study of schools, it does argue in favor of a larger argument: multimedia resources and structured digital lessons can help to visualize and understand when experimentation in a classroom is limited. Complementary evidence from digital game-based learning shows that digital supports such as structured digital strategies can markedly improve engagement and learning processes, reinforcing the premise that digital supports may help to reduce misconceptions were aligned to instructional goals (Bakhsh et al., 2022). A Socrative-based homework case study in Vietnam also suggests that structured digital tools cannot only support learning outcomes, if it is used in a guided and a purposeful way (Ánh and Thanh, 2023). These sorts of works together point at the importance of carefully designed technology, rather than technology itself, to support conceptual understanding.

Assessment and feedback are constantly repeated as critical elements of learning improvement. A study on formative assessment techniques on university level found a relationship between formative assessment and learning and academic achievement (Kausar, 2022). In the context of engineering education, formative assessment and feedback were expressed as powerful levers for effective learning if they were anchored to conceptual understanding (not grading-based) [Qadir et al., 2020]. Work that is located on reading readings and feedback is like how feedback practice influences learning trajectories (Rahman, 2024). In evaluation-focused scholarship, evaluation notions and practices are presented as being central to educational processes thus implying that the design and function of assessment can either render misconceptions visible or can hide them in a mask of memorized performances (Zafar et al., 2024). Applied to primary science, this implies that misconceptions become long lasting if mechanisms for articulating understanding, providing feedback and addressing conceptual gaps are not routinely included in classrooms.

Finally, knowledge and professional capacity of teachers are important. Research on science teacher's understanding about the nature of science suggests that shortcomings in teacher's understanding can affect the way that science is represented in classroom instruction (Rana et al., 2023). Additional work on curriculum-based development of critical thinking through science points to the perception of teachers as an important factor with respect to shaping the implementation (Younis, 2022). If the primary teachers lack the training, the confidence around the content and the diagnostic skills, there are chances that the misconceptions will be passed or left uncorrected particularly the contexts where resources are scarce and the time pressure dominate the decision about instruction (Akram et al., 2022; Akram et al., 2023).

Taken together, the scholarship provided supports a coherent argument: misconceptions in basic science make the most sense because of cognitive, linguistic, pedagogical as well as assessment conditions. The evidence of the case is therefore interpreted in this manuscript through those intersecting dimensions.

3. METHODOLOGY

A qualitative research design of case study to understand misconceptions and conceptual difficulties in general science in primary learners in Bahawalpur district (Southern Punjab). The setting has been hampered as selected schools in Bahawalpur district The demographic table in the source case study document described the setting as being in Bahawalpur and bilingual practices in teaching (Urdu/English) and home language patterns used alongside English in schooling which had Urdu and Saraiki (Source case study document, 2025).

Participants included students who were primary learners and science teachers. A statement of delimitation in the source document indicated that: "The participants consisted of forty students from Grades 4 and 5 as well as eight science teachers". The abstract excerpt had furthermore indicated semi-structured interviews with forty

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students and eight teachers. Demographic table explained the composition of the teachers as n = 8 with bilingual language medium and mixed experience, and the number of students as n = 40 with the gender distribution of 22 girls and 18 boys. Purposive sampling was employed when participants were selected to be able to give information in-rich form to conceptual difficulties and teaching practices. Semi-structured interview protocols were used, one for students and one for the teachers. Such interview structures are in line with qualitative methods that seek to collect data that is meaningful, rather than just performance oriented. The dataset was analysed with the help of thematic analysis.

4. RESULTS AND FINDINGS

The Findings are reported as thematic patterns of misconceptions and misconception generating conditions. Verbatim extracts from the source case study document are included, in the form of direct evidence and are clearly marked.

4.1 Misconception Cluster Around "Invisible Science": Air/Pressure, Force, Energy, and Magnetism

A consistent pattern in the data set was difficult in concepts that the learners were unable to observe directly. These ideas are not only "difficult topics," but common locations for the stabilization of misconceptions because learners cannot rely on concrete anchors to guide them and rely on everyday intuition. A direct extract from the results stated: "The students always ranked air, force, magnetism, energy and the water cycle as the hardest science concepts to figure out."

The use of teacher evidence perpetuated this misconception cluster. Out of the 20 topics where students had the lowest scores, teachers directly reported that students had the most trouble with "air pressure, energy, force, magnetism, and photosynthesis," which present these as invisible, with reasoning. A teacher excerpt identified an important mechanism of misconceptions, that vocabulary can displace understanding: "They learn the words but can't make the links to real things." (Source case study document, 2025). The conceptual issue here is, however, not only "lack of information," but poor mapping between language labels and experiential meaning.

4.2 Process-Based Misconceptions: Water Cycle, Evaporation, and Photosynthesis as "Steps to Memorize"

Process-based content, evaporation, photosynthesis, water cycle, was linked to repeatedly confusion because of causal sequencing mental modeling. The section on the results of student interviews explained that learners deemed evaporation, air pressure and energy especially difficult because these processes are "hard to imagine" (Source case study document, 2025). Teachers have also indicated that they had consideration of photosynthesis as challenging given its many steps and unfamiliar terminology (Source case study document, 2025). This is consistent with the misconception literature in general in Pakistan which states that the misconceptions do not go away if there is no need to push learners to link steps in causal explanations (Majeed, 2023), or if there are no teaching tools such as analogy or concept mapping (Saleem, 2022; Choudhary, 2022).

4.3 Language-Driven Misconceptions: Reading Without Meaning

Language barriers became a major cause of misconceptions. The results of this teacher interview explicitly placed language as a mechanism that causes memorization. The teacher excerpt was: "They don't get big science words, so they just memorize them."(Source case study document, 2025). Another quotation that was more specific regarding successfully decoding without the aspects of comprehension was: "Students can read the words but don't understand the meanings." (Source case study document, 2025). These statements align closely with more general evidence on challenges associated with English medium instruction in Pakistan, in which language may act as a barrier to meaning making, and may push students to rote strategies (Mukhtar et al., 2021). They are also supporting policy-oriented arguments that perhaps early education requires more mother tongue or bilingual scaffolding to support conceptual learning (Khan et al., 2020).

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4.4 Pedagogical Conditions: Textbook-Centered Instruction and the Weak Presence of Diagnostic Practice

Evidence from the case suggests that pedagogy too often favoured coverage and recall. While it was noted in the Findings narrative that the learners had interests in science, it was strongly related that classroom engagement was associated with teaching methods and opportunity for activity-based learning (Source case study document, 2025). A student excerpt from a case study recorded the motivational and conceptual cost of textbook-only delivery: "When the teacher just reads, it gets boring." (Source case study document, 2025). This type of lesson environment holds the potential to continue, indirectly, the perpetuation of misconceptions because of the lack of structured opportunities for learners to test beliefs, explicate mechanisms of cause and effect, or experience science phenomena. The pattern is in line with the Pakistani scholarship which stresses upon linking conceptual comprehension to instructional strategy (Akram et al., 2022; Akram et al., 2023).

Teacher evidence revealed that misconception detection tended to rely primarily on classroom observation, rather than on the use of systematic forms of diagnosis. The source document contained information that the teachers realized that misunderstanding was realized through blank answers, partial answers, and repeated errors and then tried to re-explain in simpler terms and using vocabulary of daily life (Source case study document, 2025). However, time pressure was specifically listed as an obstacle for continued clarification (Source case study document, 2025). This condition is compatible with encompassing evaluations that are concerned with the impact of assessment ecosystems on teaching priorities because they can often cause emphasis on surface correctness rather than conceptual explanation (Zafar et al., 2024). It also directs at the relevance of formative assessment and feedback cycles as a misconception control mechanism (Kausar, 2022; Qadir et al., 2020; Rahman, 2024).

4.5 Resource Constraints and the Misconception-Reinforcing Absence of Practical Work

A key structural cause for misconceptions in this case was lack of materials and limited opportunities for demonstrations. For example, teachers explicitly explained shortage of teaching tools and the consequent reliance on textbooks and explanation from the board. The source document explained that the lack of laboratory facilities, models and visual aids limited the ability of the students "to visualize and grapple with concepts" (Source case study document, 2025). Teacher narratives also pointed to the use of visual and demonstrations, if any, as helping to increase retention: "When they are looking at something happening, they remember it better". (Source case study document, 2025). Another excerpt taken from a teacher affirmed the importance of the learning activity being learner-centered for the concept to stick: "If children are doing it themselves, then they don't forget." (Source case study document, 2025). Such classroom-based statements are in line with broader evidence that there is advantage to interactive teaching and guided activity in improving learning outcomes (Zai, Ajmal, & Nudrat, 2021) and others that focus on the benefits of structured strategies in supporting engagement and learning effectiveness (Bakhsh et al., 2022; Utunen et al., 2022;Ánh & Thanh, 2023).

4.6 Descriptive Chart: Prominence of “Difficult Concept” Terms in the Results Narrative

The nature of the dataset was primarily qualitative, so the source document did not contain numerical frequency count data of misconceptions by concept. In order to offer an evidence-based descriptive visualization, but not over-claim the analysis, a simple term frequency scan was performed of the Results chapter text from the source case study document. This chart shows the frequency of the key concept terms that were used in the Results narrative (student and teacher sections combined). These counts can best be interpreted as "prominence within reporting," rather than direct participant mention counts.

Table 1: Difficult Concept Terms

Term (Results chapter)	Count of appearances in Results narrative
Air	8
Pressure	7
Force	5
Energy	4
Photosynthesis	4
Magnetism	3
water cycle	2
Evaporation	2

A simple visual representation of these Results-section term appearances is provided below.

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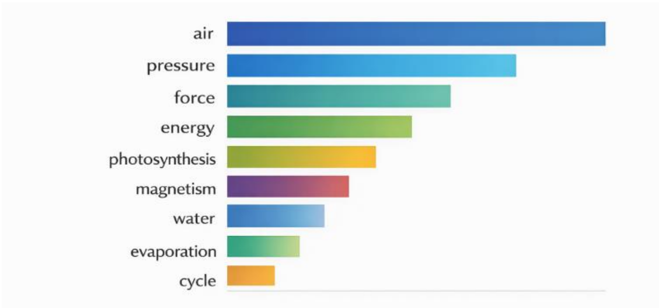

Table 2: Visual Presentation of Difficult Concept Terms

This descriptive pattern accords with the thematic interpretation reported in the Findings, namely that misconceptions and conceptual difficulties were most visible in terms of invisible and abstract concepts, and conceptual difficulties in terms of process-based topics.

5. DISCUSSIONS

The South Punjab case evidence supports a strong contention: that misconceptions in primary science were concentrated in the areas where concepts were invisible, abstract or process-driven and perpetuated by instructional routines and language barriers that encouraged memorization. This is very close to work by Pakistani on difficulties in understanding elementary science concepts (Akram et al., 2022) and mixed-method work conceive of conceptual difficulties as constrained by instruction and the context rather than weakness in learners per se (Akram et al., 2023). In particular, the reoccurring issue of "words without meaning" is one of a known vulnerability of English-medium science delivery where learners can decode text while failing to conceptualise content (Mukhtar et al, 2021). When such a misalignment is made, the misconceptions are solidified for the learner, because there is no way for him or her to test ideas through demonstrations, no way to express understanding in accessible language and no assessment that reveals misunderstanding.

The case evidence also shows the pervasive influence of the assessment ecosystem in shaping misconceptions and go unnoticed. Where implied classroom practices focus on note taking and recall, there is often a surface appearance of performance which conceals misconceptions. Formative assessment and feedback (found to play a role in learning improvement) are not extras; they are learning mechanisms responsible for correction of concepts (Kausar, 2022; Qadir et al., 2020; Rahman, 2024). In the scholarship of evaluation, assessment practices are conceptualized as an integral part of educational meaning-making, which means that misconception correction is in part an evaluation design issue (Zafar et al., 2024). For primary science, the implication is that for control of misconceptions to be effective, there needs to be routine diagnostic questioning, feedback, and learning that requires explanation, rather than copying.

The results also indicate that teacher capacity is a structural variable. Under-resourced and under-trained teachers teach reading textbooks and leave misconceptions untouched. Studies that investigate science teachers' knowledge about the nature of science have proposed that the teacher understanding and orientation correlate with classroom representation of science concepts and reasoning (Rana et al., 2023). Teacher perceptions of the development of critical thinking by science also implies the need for conceptual learning which requires teacher support in addition to syllabus coverage (Younis, 2022). The case submitted by the South Punjab is evidence suggesting the importance of training needs and availability of resources, Source case study document, 2025.This, therefore, seems to be in line with a larger Pakistani pattern: Conceptual improvement requires sustained training of teachers as opposed to one-time workshops.

6. IMPLICATIONS AND RECOMMENDATIONS

One of the standards for Scopus-indexed education research is that recommendations need to be properly coherent both in theory and in the context of implementation. The recommendations below are thus in tandem with the findings in the case and are underlined by the scholarship provided.

The curriculum and textbook implication are that of language scaffolding and conceptual load. Where learners can read but are unable to grasp meaning (Source case study document, 2025) and perhaps "simpler words" are not the solution - it is intentional bilingual scaffolding and explanation of concepts, in accessible language, which will then be reflected into the English vocabulary. This is consistent with evidence on the perception of teachers regarding the challenges of English-medium teaching (Mukhtar et al., 2021) and arguments on mother tongue accessibility in early education (Khan et al., 2020). In the context of the Single National Curriculum, the ideological and linguistic concerns ought to be translated into the design practices concerning readability, contextual relevance and clarity of sequence (Khan & Mehak, 2024).

A pedagogical implication is in the form of structured experiential learning. The case evidence supported retention (Source case study document, 2025): Demonstrations and "seeing something happening" helped with retention, Learner's associate boredom and difficulty with reading only instruction (Source case study document, 2025). This suggests that low-cost demonstration routines can be used as misconception breakers, particularly for air/pressure, force, magnetism and energy. Interactive teaching methods, such as activity-based teaching practices, have been recorded to be effective in enhancing learning and engagement (Zai et al., 2021). While not all schools can develop labs, demonstration kits can be developed using materials that are locally available and lesson plans can incorporate short "concept conflict" demonstrations to challenge the naive interpretations.

One of the teacher development implications of these types of tools is the building of pedagogical content knowledge, as well as diagnostic skills. Evidence indicates that teachers may need to be developed about how to know when a misconception is present and how to redesign explanations for clarity of concepts (Source case study document, 2025). Teachers' knowledge on the nature of science is linked to representation of science reasoning and becomes a steppingstone away from memorisation, towards explaining and evidence (Rana et al., 2023). Professional development should therefore include training in diagnostic questioning and in micro-interventions that bring about corrections in misconceptions, and not just general lectures in pedagogy.

An assessment implication is necessary to build formative assessment as a routine practice in primary science. Formative assessment has been empirically related to learning and academic achievement (Kausar, 2022) and formative feedback has been framed influential in learning process improvement (Qadir et al., 2020; Rahman, 2024). For the science-talking about the science in the primary grades-for Pakistani students, simple formative tools are available such as short "explain why" questions, picture-based concept mapping tasks and tasks for peer explanations. Concept maps, which are already used successfully as formative assessment in biology contexts, give us a model for visualization used to assess learner understanding (Choudhary, 2022). Analogy based teaching evidence also indicates that strategic choices can be made to enhance the learning of abstract concepts (Saleem, 2022). These can be adapted to the early grades with the use of pictorial analogous and teacher-led analogy prompts.

A technological implication is the use of multimedia support, where this is possible. The case evidence suggested that videos and visuals had supported learners to make sense of processes where practical work was absent (Source case study document, 2025). Digital learning scholarship has suggested that structured online learning can be used to support real-time transfer of knowledge when designed with care (Utunen et al., 2022), while digital game-based learning strategies have been found to be effective in supporting engagement in learning (Bakhsh et al., 2022). In addition, based on some other research, interactive tools such as Socrative-based practices have demonstrated learning benefits in other contexts in which they are used intentionally (Ánh & Thanh, 2023). In terms of implication for South Punjab primary set ups, it is not to "digitize everything" but to create short concept-targeted, multimedia segments or teacher-led video demonstrations, for example, on water evaporation and the water cycle where visualization plays a vital role.

7. CONCLUSION

The work focused on how misunderstandings in basic scientific ideas in primary school arise and how they gradually at that stage of science learning are transformed into stable misconceptions. Evidence from the case schools in Bahawalpur indicated conceptual confusion was encountered most often around topics that deal with forces that are invisible or processes that are complex, such as air pressure, energy, magnetism, evaporation, and the water cycle. These concepts are hard for young learners to understand if they are explained primarily through textbook explanations and unfamiliar terms. A lot of students were able to recite science definitions; however, it was hard for them to explain those processes in their own words, which is a good indicator that memorization was used in place of actual concept understanding in most cases. Classroom conditions have also played an important part in the development of such misconceptions. Teaching practices heavily relied on reading and explaining from textbooks, as there weren't many days to do demonstrations, experiments or even visual learning. When there were practical examples and visuals in the lessons, there was more interest and a higher level of understanding of the topic involved. Language barriers also created additional problems in the learning process because many of the students were encountering many scientific vocabulary words in English that did not easily relate to their daily speech. In these cases, learners had a tendency of memorizing terms rather than understanding what the term means and this led to the reinforcement of the gap between remembering information and understanding scientific ideas. The results are thought to indicate that misconceptions in primary science are created by a combination of instructional practices, language difficulties and limited learning resources rather than being the result of student abilities alone. Improving conceptual understanding therefore requires teaching approaches to make natural use of explanation, observation, and discussions in place of simple recall. Providing teachers with training in the use of activity-based teaching and formative questioning, as well as use of visual demonstration and locally meaningful examples, can assist learners in constructing clearer mental models of scientific phenomena. Strengthening these classroom practices may provide a gradual shift in misconceptions and more in-depth understanding of science concepts on the primary level.

REFERENCES

Akram, M., Khan, D. A., Mahmood, W., & Sher, A. (2023). Conceptual difficulties of primary school students in learning the general science: A sequential explanatory mixed method research design. *International Journal of Social Science & Entrepreneurship, 3*(3), 313–329. https://doi.org/10.58661/ijsse.v3i3.205

Akram, M., Zafar, J. M., Aziz, S., & Asghar, M. (2022). Elementary school students' conceptual difficulties in the subject of general science: A descriptive study. *Pakistan Journal of Humanities and Social Sciences, 10*(1), 43–49. https://doi.org/10.52131/pjhss.2022.1001.0172

Ánh, T. T. N., & Thanh, P. N. (2023). Effects of Socrative-based online homework on learning outcomes in Vietnam: A case study. *International Journal of Interactive Mobile Technologies (iJIM), 17*(05), 182–199. https://doi.org/10.3991/ijim.v17i05.37513

Bakhsh, K., Hafeez, M., Shahzad, S., Naureen, B., & Farid, M. F. (2022). Effectiveness of digital game based learning strategy in higher educational perspectives. *Journal of Education and e-Learning Research, 9*(4), 258–268. https://doi.org/10.20448/jeelr.v9i4.4247

Choudhary, F. R. (2022). Concept maps as an effective formative assessment tool in biology at secondary level. *Journal of Education and Educational Development, 9*(1), N/A. https://doi.org/10.22555/joeed.v9i1.454

Kausar, F. N. (2022). Relationship between formative assessment techniques, students' learning and academic achievement at university level. *Pakistan Languages and Humanities Review, 6*(III), N/A. https://doi.org/10.47205/plhr.2022(6-iii)26

Khan, M. S., & Mehak, M. (2024). Single National Curriculum: A historical context of ideological and linguistic concerns and policies. *The Journal of Cultural Perspectives, 3*(1), N/A. https://doi.org/10.63672/dr1ypd62

Khan, S. N., Khan, A. K., & Khan, I. U. (2020). The efficacy of the application of mother tongues education in Pakistan. *Sir Syed Journal of Education & Social Research (SJESR), 3*(4), 257–261. https://doi.org/10.36902/sjesr-vol3-iss4-2020(257-261)

Majeed, S. (2023). An exploration of students' common misconceptions in the subject of chemistry at secondary level. *Annals of Human and Social Sciences, 4*(II), N/A. https://doi.org/10.35484/ahss.2023(4-ii)25

Mukhtar, A. A., Sahito, Z., & Siddiqui, A. (2021). Teachers' perception about English as a medium of instructions: Evidence from the government higher secondary schools of Sindh, Pakistan. *Theory and Practice in Language Studies, 11*(4), 362–371. https://doi.org/10.17507/tpls.1104.05

Nazir, M. F., & Kanwal, Z. (2025). Cognitive development of secondary school students in the subject of chemistry. *Qualitative Research Journal for Social Studies, 2*(2), 1401–1416. https://doi.org/10.63878/qrjs187

Qadir, J., Taha, A. M., Yau, K. A., Ponciano, J., Hussain, S., Al-Fuqaha, A., & Imran, M. A. (2020). Leveraging the force of formative assessment and feedback for effective engineering education. *2020 ASEE Virtual Annual Conference Content Access Proceedings*, N/A. https://doi.org/10.18260/1-2--34923

Rahman, M. H. A. (2024). The essence of giving feedback on the Saudi students' reading performance at Taibah University. *British Journal of Multidisciplinary and Advanced Studies, 5*(2), 1–24. https://doi.org/10.37745/bjmas.2022.0441

Rana, S., Zaman, T. U., & Bhatti, R. U. (2023). Evaluation of secondary school science teachers' knowledge about nature of science. *International Journal of Innovation in Teaching and Learning (IJITL), 8*(2), 107–126. https://doi.org/10.35993/ijitl.v8i2.2399

Rehman, A., Khan, S., & Zia, A. (2023). Cognitive science and learning environment in rural areas of Punjab. *Journal of Social Sciences Review, 3*(1), 222–234. https://doi.org/10.54183/jssr.v3i1.123

Saleem, A. (2022). Effect of analogy based teaching on students' chemistry learning at secondary school level. *Annals of Human and Social Sciences, 3*(III), N/A. https://doi.org/10.35484/ahss.2022(3-iii)46

Utunen, H., Tokar, A., Arabi, E., & Gamhewage, G. (2022). Online learning for mass audiences during the COVID-19 pandemic: Key considerations for real time knowledge transfer. *International Journal of Emerging Technologies in Learning (iJET), 17*(04), 112–134. https://doi.org/10.3991/ijet.v17i04.27569

Younis, N. (2022). Development of critical thinking skills of secondary school students through science curriculum: Teachers' perceptions. *Journal of Development and Social Sciences, 3*(IV), N/A. https://doi.org/10.47205/jdss.2022(3-iv)37

Zafar, J. M., Ullah, N., & Aslam, M. I. (2024). Evaluation notions and practices. *Academia International Journal for Social Sciences, 3*(2(a)), 1–131. https://doi.org/10.63056/acad.003.02.0083

Zai, S. A. Y., Ajmal, F., & Nudrat, S. (2021). Science learning through interactive teaching method: An experimental study. *Sir Syed Journal of Education & Social Research (SJESR), 4*(4), 10–17. https://doi.org/10.36902/sjesr-vol4-iss4-2021(10-17)