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Language Choice and Students' Performance in Mathematics and Science: Evidence from Pakistan's Multilingual Context

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ABSTRACT

In Pakistan's post-colonial multilingual context, language in education remains sensitive and complex. Most learners use their mother tongue at home, Urdu functions as the national lingua franca, and English, an official language, serves widely as the Language of Instruction (LoI) in private schools. These overlapping roles shape classroom interaction and student performance. This paper examines how language practices in Pakistani schools, particularly consistency across textbooks, instruction, and assessment, affect achievement in science and mathematics. Findings draw on a nationally representative sample of 15,391 students and 589 teachers from 153 elementary schools, using student achievement tests and classroom observations. Students exposed to consistent language use

performed significantly better than those experiencing inconsistent language use in both subjects ($p<0.001$). The results show that language consistency, alongside school systems and teaching quality, influences performance, with effects strongest in classrooms with relatively better teaching quality.

Keywords: Evidence from Pakistan, language of instruction, multilingual society, observation study, STEM disciplines, student learning, teaching quality.

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INTRODUCTION

Language policies within the realm of education have profound and enduring effects on a nation's trajectory, intricately woven into the fabric of a broader social engineering process. This process seeks to guide the populace towards objectives set forth by the state. Unfortunately, in post-colonial and Low- and Middle-Income Countries (LMICs), around 40% of students experience learning in unfamiliar languages in schools; this percentage reaches as high as 90% in some countries. A concerning 70% of students under the age of 10 face a learning crisis, unable to comprehend even the simplest of texts (Crawford & Marin, 2021). It is commonly believed that students who are taught in the language they understand are better at expressing their learning than those who express their learning in a language that is different from the one that is used as a Language of Instruction (LoI) in the classrooms (Murtaza, 2021; Crawford & Marin, 2021).

The challenge intensifies in multilingual societies, where language dynamics significantly impact classroom interactions and student performance (Cummins, 2000; García & Baker, 2007). This is particularly evident in post-colonial countries which are facing the dilemma of choosing specific languages such as a LoI.

Explaining Pakistan, as an example in this context, it is a diverse nation contending with a plethora of mother languages, the lingua franca is Urdu, and the official language is English (Fareed et al., 2019; Rahman, 2006). Such a condition compels countries to transition from familiar to unfamiliar languages which leads to challenges in learning (Heng & Tan, 2006; Nakamura et al., 2023; Wedikkarage, 2009). The struggle to choose a suitable language of instruction (LoI) is further compounded by factors such as the scarcity of resources, inadequate teaching staff, and wavering political will (Government of Pakistan, 2017; Khan & Haseeb, 2017; Piper et al., 2016; Trudell & Piper, 2013).

Navigating this linguistic complexity in educational practices involves grappling with ideological debates surrounding language's role in shaping national identity, fostering global competitiveness, and driving academic achievement (Tollefson, 2017). Conversely, a country's local language holds great significance in terms of fostering national integrity and cohesion among its citizens (Heller, 2007). The tension between prioritising English, a global language, and local languages, integral for national cohesion, often leads to a lack of uniformity in LoI across schools within the same country (Norton, 2010).

The decision-making landscape regarding LoI selection is based on three distinct perspectives. Some studies strongly support mother tongue-based education, promoting the initial use of the mother tongue as the medium of instruction. This approach is believed to yield various benefits for students' learning outcomes (Collier & Thomas, 2017; Evans & Acosta, 2021; Murtaza, 2021; Nag et al., 2019; Prinsloo & Harvey, 2020). Another perspective emphasises the significance of acquiring proficiency in postcolonial languages, particularly English, highlighting its association with socioeconomic advancement and global competitiveness (Azam et al., 2013; Coleman, 2011; Phillipson, 2001). Similarly, a third viewpoint advocates for translanguaging, a practice that involves the flexible use of multiple languages in the learning environment (Back et al., 2020; Lewis et al., 2012; Probyn, 2015).

The existing literature related to the language of instruction (LoI) primarily revolves around three key perspectives, focusing on their impact on students' performance (Fareed et al., 2019; Mahboob, 2020). However, this paper presents a unique case from Pakistan, offering insights with significant implications for the education systems of other multilingual societies. It draws on findings from a nationwide study that aimed to assess classroom teaching practices and their impact on students' learning in science and mathematics across public and private schools. During this large-scale research, an interesting trend emerged regarding language use in science and mathematics classrooms. Two distinct patterns were observed: i) consistency in language use - where there is complete alignment among the language of textbooks, assessments, and teachers' classroom instruction; and ii) inconsistency in language use - where the language used by the teacher in the classroom differs from that of the textbook and/or assessments. In

other words, language consistency refers to the use of the same language for textbooks, classroom instruction, and assessment, whereas language inconsistency indicates a mismatch among these elements. This study identified varied patterns of both consistency and inconsistency in language use across the country. These patterns are presented in Table 1 to illustrate and explain the different scenarios observed nationwide.

Table 1
Scenarios of Language Use in Pakistani Schools

Type	Textbook	Examination	Teacher instructions in classroom
Consistency in language use	English	English	English
	Urdu	Urdu	Urdu
	Sindhi	Sindhi	Sindhi
Inconsistency in language use	English	English	Urdu/Sindhi/Pushto/Balochi or other local languages
	Urdu	Urdu	Urdu/Sindhi/Pushto/Balochi or other local language
	Sindhi	Sindhi	Urdu/Saraiki/other

Note. Textbook language is decided by the policymakers of each province. As per the policy and practice, language of the examination must be the same as the textbook. However, at the classroom level, the school lead and/or class teacher decides which language to be used for teaching. The situation is applicable to both government and private schools.

In the existing literature, there is hardly any discussion regarding the consistency of language across textbooks, teachers' instructions, and assessments. Hypothetically, the inconsistency in the use of language across the three media can pose a significant challenge for the students in terms of their academic progress. This is particularly evident in science and mathematics education, where complex concepts are often conveyed through specialised vocabulary and abstract reasoning (Schleppegrell, 2001). When students are not fully proficient in the LoI, they may struggle to grasp these concepts, leading to gaps in their understanding and academic achievement (Gracia & Baker, 2007). On the other hand, if the students are taught in a local language but their exams are carried out in another language (language of textbook) then it becomes challenging for students to comprehend the questions and pencil the answer. With this backdrop, this paper delves into the role of the consistent use of language in science and mathematics education, intending to bridge the gap in the existing literature that is confined to the choice between adopting 'trans-languaging', a local language, or an official post-colonial language for effective teaching in schools. More specifically, the paper brings forth intriguing findings related to the consistent use of language and its impact on

students' learning outcomes in the subjects of mathematics and science. This paper responds to the following research questions:

1. Is there a significant difference in the academic performance of elementary school students exposed to consistent language use compared to those with inconsistent language use in the subjects of mathematics and science in Pakistan?
2. Do language consistency and school system have independent and interactive effects on the academic performance of students in mathematics and science, within elementary schools in Pakistan?
3. Do language consistency and teaching practices exert separate and interactive effects on the academic performance of elementary-grade students in mathematics and science in Pakistan?

CONTEXT OF THE STUDY

Pakistan, being a multilingual society, has grappled with this dilemma since its inception. Some schools prefer using the local language as a LoI, while many others opt for English. Among these, a major proportion of private schools predominantly choose English as the medium of instruction; however, some of the government schools attempt to adopt this policy without fully understanding it. This phenomenon gives rise to a lack of uniformity, where students within the same country may not be studying the same language as a LoI. Arguably, most of those who opt for English usually struggle to comprehend it fully. In Pakistan, this lack of uniformity is further exacerbated by the varying levels of English proficiency among teachers (Manan et al., 2016). This can result in a shift to the local language for instruction even when English is claimed as LoI, and even when the textbooks are in English. Furthermore, when teachers have a strong command of the LoI, students may still struggle to comprehend the content due to differences in their English proficiency levels (Cummins, 2000). Therefore, schools, including both government and private sectors, have been struggling to align with this approach.

In the Pakistani education system, a noticeable linguistic divide exists between Urdu and English medium schools. Government schools primarily use Urdu as the LoI, while private schools prefer English. This division is exacerbated by economic disparities, contributing to competency differences between students from lower-income households and those from affluent backgrounds (Shamim & Rashid, 2020). Although evidence suggests some government schools are transitioning to English as LOI, internal mechanisms reveal that English is often limited to textbooks and assessments, with students experiencing teaching in Urdu and/or a regional language. This raises concerns about efforts to ensure consistency in medium of instruction in schools claiming English as the LoI, as inconsistencies

in teaching and assessment hinder effective learning and comprehension, irrespective of the school system (government or private schools). This disparity among students ultimately translates into differences in their competency levels, creating divisions within the student population of the same country.

To address this and ensure uniformity in education, a single national curriculum framework was introduced in Pakistan in 2021. This curriculum aims to eliminate biases among citizens and unify them around a single education system by standardising the medium of instruction. This assumes that using a language familiar to students as a LoI is crucial to facilitate better comprehension. However, the imposition of a single national curriculum has faced criticism, with concerns raised about the difficulty of completely transitioning students from an English-based medium of instruction to Urdu and vice versa. This raises questions about whether students truly receive instruction in English in schools that claim it as a LoI.

LITERATURE REVIEW

Language has been a fundamental medium for communication throughout human history, holding immense significance, especially in education (Mustafaqulova, 2022). It serves as the cornerstone of educational instruction, enabling teachers to effectively convey knowledge to students. In post-colonial multilingual cultures, the necessity for different languages arises from diverse linguistic backgrounds and colonial influences. Despite having numerous local languages and communally used national languages, English is often considered a globally accepted language (Coleman, 2011).

On the global landscape, countries grapple with diverse approaches to the Language of Instruction (LoI), shaped by their national philosophies and socioeconomic imperatives. The language dilemma persists prominently in post-colonial nations like Pakistan, India, Sri Lanka, and various African countries, where the choice between local, national, or post-colonial languages as the LoI remains a crucial decision. Governments often justify adopting English for science and technology education, viewing it as pivotal for socioeconomic advancement and global competitiveness (Brock-Utne, 2012; Heng & Tan, 2006; Sah, 2022). Conversely, countries like Japan, China, and Korea lean towards using their local languages for instruction, reserving English education primarily as a language-learning component (Mustafa, 2021a). The positioning of English as a second language stems from historical periods of colonisation, leaving enduring influences on language emphasis (Mustafa, 2021a).

Advocates for English as the LoI draw a direct correlation between proficiency in English and socioeconomic mobility, advocating for early exposure to international post-colonial languages in schools (Azam et al., 2013; Coleman, 2011; Sah, 2022). Similarly, the elevation of English as the language of science

and technology in post-colonial and LMICs is a recurring theme, often influenced by donors and elite groups maintaining the hegemony of ex-colonial languages (Brock-Utne, 2012).

The experiences of countries adopting English as the medium of instruction reveal a spectrum of outcomes. In Bangladesh, the endeavour to embrace English for global competitiveness faced challenges such as inadequate teacher training, resource constraints, and a lack of proficiency, leading to suboptimal results (Mustafa, 2021; Rahman et al., 2019). A parallel scenario unfolded in Nepal, where a shift from Nepali to English as the medium of instruction was pursued to bolster global competitiveness, despite associated educational costs and benefits. Similarly, in the Kenyan context, the use of a second language, whether it be the national language or English, is found to have negative effects on students' learning as well as on teachers' morale (Mose, 2019). Evidence indicates that countries opting for English as the medium of instruction encounter difficulties in effectively delivering content and fostering meaningful student learning, with the proficiency of teachers in the English language emerging as a critical factor (Khati, 2016; Milligan & Tikly, 2016).

Conversely, the use of familiar and widely spoken local languages has demonstrated efficacy in certain Western European countries and some post-colonial Asian nations, contributing to improved student learning outcomes and enhanced socioeconomic development (Brock-Utne, 2017; Prah & Brock-Utne, 2009). Various scholars contend that employing local languages as the LoI proves to be beneficial not only for learning a secondary language but also for enhancing student understanding across various subjects (i.e., Genesee et al., 2006; Rolstad et al., 2005; Slavin & Cheung, 2005). However, an overemphasis on teaching in an unfamiliar language, as observed in some cases, leads to diminished performance in science subjects (Brock-Utne, 2012). Additionally, it results in only average proficiency in both languages - the primary and/or secondary language or ex-colonial language (Palmer & Lynch, 2008). These nuanced experiences underscore the multifaceted challenges and outcomes associated with the choice of language as the medium of instruction in education.

The choice of the LoI significantly influences students' cognitive growth and overall academic performance. Introducing a language unfamiliar to students as the LoI diminishes the likelihood of effective cognitive development, while instruction in a language students understand correlates with enhanced cognitive skills (Murtaza, 2021; Crawford & Marin, 2021). Systematic reviews (e.g., Evans & Acosta, 2021; Nag et al., 2019) stress the importance of teaching children in languages they speak and comprehend well for optimal learning outcomes. An in-depth assessment comparing native English speakers to those for whom English is a second language reveals substantial disparities in their academic results (Kieffer et al., 2009). Concerning science and mathematics education, the selection of a language as the LoI becomes even more critical, as these subjects require expert

teachers to convey complex concepts effectively. The language in which scientific concepts are taught significantly impacts learners' comprehension, with difficulties arising for those who are not taught in their mother tongue (Brock-Utne, 2012; Prinsloo & Harvey, 2020). The ability to grasp any concept or discourse, including scientific ones, is heavily reliant on the language competencies of the learners. Teaching science in a familiar language, utilising familiar terminologies, proves to have a positive impact on student learning compared to using unfamiliar and scientific language (Brock-Utne, 2012; Brown & Ryoo, 2008).

Globally, there is a compelling perspective that advocates bilingualism and translanguaging as natural modes of communication for multilingual individuals. The roots of research on this topic are traced back to the 1980s in Bangor, North Wales, where Cen Williams and associates explored teaching methods enabling students to use both Welsh and English within a single class. The term "trawsieithu," describing the process of reading or hearing something in one language and expressing it in another, was coined. It was further translated into English and popularized as "translanguaging" (Lewis et al., 2012). The concept of translanguaging was expanded beyond pedagogical strategies, viewing it as a process employed by bilinguals and multilinguals to gain insights, reshape experiences, and make sense of their bilingual environments.

In contrast to avoiding learners' native tongues, the intentional use of learners' language through "pedagogical translanguaging" has proven to be beneficial (Probyn, 2015). Translanguaging challenges the traditional hierarchical relationship between teachers and students, creating a safe space for co-learning (Tai & Wei, 2021). It is also considered a valuable tool for addressing issues related to social justice and equity (Heugh et al., 2017). Furthermore, proponents argue that it enhances classroom participation and contributes to reducing behavioural problems among learners stemming from language-related fears and dissatisfaction (Back et al., 2020). This comprehensive perspective underscores the diverse benefits of embracing translanguaging in educational settings. However, the problem related to post-colonial multilingual contexts like Pakistan is inconsistency in translanguaging; it remains confined to instruction only. Translanguaging may yield better results if maintained through teaching, textbooks, and assessments.

The literature review highlights a gap in research concerning the outcomes of employing a single language consistently in science and mathematics books, teaching, and assessment in multilingual post-colonial contexts. It emphasizes the importance of aligning the LoI with the language familiar to students for optimal understanding. Alignment between the language of textbooks, teaching, and assessment is crucial and achievable through a massive policy and practice level decisions; however, such decisions must be backed by robust evidence. This paper

not only generates such evidence but also takes forward the discourse of the impact of language use on students' learning in science and mathematics.

RESEARCH METHOD

This paper is extracted from a nationwide study that examined the relationship between the quality of classroom teaching and students' learning outcomes across Pakistan (Bhutta & Rizvi, 2022). For the nationwide study, a cross-sectional survey was conducted in 153 schools (78 public, 75 private) across six regions of Pakistan, namely Punjab, Sindh, Khyber Pakhtunkhwa, Balochistan, Gilgit Baltistan, and Azad Jammu & Kashmir. These schools were randomly selected from 25 districts using a multistage cluster sampling technique. In the first stage, districts were selected based on population size and geographical diversity. In the second stage, three public and three private schools were randomly chosen per district, ensuring representation of girls', boys', and co-education schools. All pupils in grades 5, 6, and 8 from selected schools were invited to participate, resulting in a total sample of 15,391 students. All science and mathematics teachers of grades 5, 6, and 8 were sampled for classroom observation. In total, 589 teachers participated in this study. The sample size was deemed adequate based on established guidelines and exceeded the threshold recommended by Krejcie and Morgan (1970) for large populations, ensuring strong generalisability.

Two types of instruments were used in the study. First, a 3-point Classroom Observation Scale (COS) was applied to observe one lesson from each mathematics and science teacher. Second, students' performance in both subjects was assessed using achievement tests specific to each grade, namely, the Science Achievement Tests (SATs) and Mathematics Achievement Tests (MATs). The tests were available in three languages: English, Urdu, and Sindhi. Additionally, demographic information about teachers (e.g., qualifications, gender, age, experience) and classroom (class size, lesson duration, language of textbook, language of teaching, and language of assessment) as well as students (e.g., gender, age, parents' qualifications) was collected through items included in both tools, aligned with the theoretical framework. Both instruments were developed and validated in previous research. For achievement tests, the reliability measured by Cronbach's alpha, ranged from 0.60 to 0.78, indicating acceptable internal consistency.

Table 2
Reliability of the Tests

Test	G5	G6	G8
Science	0.60	0.82	0.69
Mathematics	0.70	0.72	0.66

Similarly, teaching practices of the participating teachers were observed using a structured 3-point observation tool – Classroom Observation Scale (COS) - adopted from previous research (Bhutta, 2011). The benchmarking of this three-point observational scale was conducted across three categories (weak = 1.0-2.0; moderate = 2.01-2.50; good = 2.51-3.0) to classify teachers' teaching practices. COS validity and reliability have been established in various studies undertaken in the context of Pakistan (e.g., Bhutta, 2011; Bhutta & Rizvi, 2022; Chang, 2018). COS was employed to observe one lesson for each of the sample teachers in science and mathematics.

The COS is made up of 15 items that measure different aspects of classroom quality. Of the seven items in the teaching learning methods, two items are defined as checklists to capture a variety of active methods (e.g., questioning, demonstration, role-plays) and classroom management strategies (e.g., whole class, group/pair work) used during the observation. The rubric consists of three anchoring points for each descriptor, and specific guidelines are provided on each item for observers. In addition, a demographic questionnaire was administered to collect information on various relevant variables related to teachers, including gender, class size, experience, and qualification in three main constructs. The COS also helped to record the language instruction used by the teacher during classroom teaching. In this study, the values of Cronbach's Alpha were found to be within the acceptable range for both COS-science (0.79) and COS-mathematics (0.69). Therefore, the COS was reliable for this study. The study was approved by the institutional Ethical Review Committee (ERC). The project was funded by the Higher Education Commission's National Research Program for Universities.

For this paper, data from the science and mathematics achievement tests - under both scenarios of consistent and inconsistent language use - were analysed separately at the school system level and the classroom teaching quality level to address the aforementioned research questions.

The data analysis encompasses multiple steps. First, the CRQs were marked using pre-developed rubric after establishing inter-rater reliability. The MCQs were marked through SPSS. The mean percentage scores of student achievement tests and classroom practices were used for the analysis. After meeting all the key assumptions of parametric tests (normality and equality of variance), an independent t-test was employed to compare the mean scores. Furthermore, the magnitude of differences was also estimated by computing effect size (r). Benchmarks for effect size were determined as small (r =0.1), medium (r=0.3), and large (r=0.5) (Field, 2017). Finally, a two-way ANOVA was run to see if the two independent variables (consistent use of language interacts with the school system; consistent use of language interacts with teaching practices) have an interaction effect on the dependent variable (students' scores in SATs and MATs).

For the two-way ANOVA, both independent variables (language inconsistency=0 & language consistency=1; government school system=1 & private school system=2) were categorised into two groups. The categories for language consistency and school system were straightforward. However, the categories for teaching practices were determined based on benchmarking the classroom observation scale. The mean score of teachers' classroom observations on a 3-point scale was computed and categorised into three bands as weak practices (1.00 to 1.50), moderate practices (1.51 to 2.50), and good practices (2.51 to 3.00). Since teachers' practices did not reach the benchmark for good practices, only two categories (weak=1 & moderate=2) can be seen in the analysis.

FINDINGS

Demographic Characteristics of the Sample

Out of the total 15,391 students included in the study, a system-wise breakdown revealed a larger proportion of students from government schools (n=9270; 60%) participated in the study compared to those from private schools (n=6121; 40%). Additionally, when examining the distribution by student gender, the results revealed nearly equal representation, with slightly higher participation of boys (n = 7,968; 52%) compared to girls (n = 7,423; 48%). The variation in gender distribution reflects the higher enrolment rate of boys in the country (NEMIS, 2019; UNESCO, 2021). Moreover, the frequency analysis demonstrated that most private school students (75%) experienced inconsistent use of language, whereas their public school counterparts were taught with consistent use of language across textbooks, classroom instruction, and assessment. On the other hand, notably, slightly less than half of the government school students (40%) encounter inconsistency in language across textbooks, classroom instruction, and assessment.

Students' Performance between Consistent and Inconsistent Use of Language

The results of the independent t-test, shown in Table 3, revealed that those students who have experienced consistent use of language across the textbooks, classroom instruction, and assessment have significantly outperformed their counterparts in both subjects ($p<0.001$) with a small magnitude of difference.

Table 3
Comparison of Students' Performance in Science and Mathematics by Language Consistency

Subject	Consistency of Language	n	Mean (SD)	t	p	Effect size
Math	Consistent	5702	28.1 (15.4)	-5.493	0.001	r=0.05
	Inconsistent	7096	26.5 (15.5)			
Science	Consistent	5658	34.9 (16.1)	-4.431	0.001	r=0.04
	Inconsistent	6362	33.6 (16.2)			

As discussed earlier, generally, it is assumed that the use of the mother tongue for classroom instructions would lead to better interactions in the classroom and enhanced conceptual understanding. Needless to say, this argument is undeniable as the 'familiar' medium of instruction would help students to better engage in the learning process. However, inconsistency in the language used for instructions and assessment might make it difficult for students to understand test questions and pencil in their answers. Citing here English as an example, in a majority of the sample schools, English is the official medium of instruction in textbooks and assessments. However, the classroom observations exhibited that teachers commonly used local language for instructions. Qualitative notes of the observation alluded that the students had difficulty in comprehending classroom instructions in English; therefore, the teachers used local languages instead of English.

DISCUSSION

The findings underscore a significant dependence of students' performance on the consistent use of language across textbooks, classroom teaching, and assessments, irrespective of the subject nature. Students exposed to a consistent language of instruction demonstrate enhanced comprehension and articulation compared to those facing language challenges. This aligns with Palmer and Lynch's (2008) study in a U.S. multilingual context, emphasising the necessity of maintaining consistent language in both classroom instruction and exams for better learning outcomes. Moreover, results from factorial ANOVA highlight the intricate relationship between language consistency and students' performance in mathematics and science, considering both the school system and teaching practices. These nuances, rarely explored in multicultural contexts, reveal a noteworthy interaction effect in both subjects. In mathematics, the school system,

particularly the distinction between government and private schools, plays a pivotal role, indicating that private school students benefit more from consistent language use.

This pattern extends to science, emphasising the broader influence of school systems on academic performance. Generally, the quality of private schools in Pakistan is better than that of government schools; interpreting the findings in the context clearly confirms the need to parallel efforts for improving the quality of schools along with ensuring consistent use of language, which requires efforts both at the policy and practice levels. Additionally, regarding teaching practices, the study reveals that teachers' practices modulate the influence of language consistency on student performance. Students taught by teachers with moderate practices show greater performance gains when exposed to consistent language use, underscoring the need for capacity building among educators - a crucial yet unaddressed issue in the Pakistani education system. An alternative interpretation of the findings portrays that, arguably, simply improving teaching quality without ensuring consistent use of language would not benefit students to a great extent. Therefore, a holistic development approach to professional development of teachers that is enhancing their pedagogical practices as well as transforming policy and practices towards consistent use of language would have much stronger influence.

Overall, these findings provide interesting insights into the multifaceted dynamics of language use, school systems, and teaching practices. They align with a growing body of global literature emphasising the significance of language consistency in mathematics and science education (Chikiwa & Schafer, 2016; Hansen-Thomas et al., 2019; Henderson Pinter et al., 2018). Despite this global emphasis, the importance of language consistency is less discussed in the Pakistani context, despite evidence supporting its positive impact on students' academic performance in core disciplines like science and mathematics (Aslam & Kingdon, 2011; Fareed et al., 2018; Mahboob, 2020). This study fills the gap in literature, particularly regarding the influence of consistent language use in the country's multilingual educational landscape. It is evident from the review of the subsequent National Education Policies that the language has remained a long-standing and indecisive issue in Pakistan. In other words, some governments implement English as a medium of instruction in school, while others either implement Urdu or a regional language.

In this regard, the findings of this study provide enough evidence to convince the policy makers to keep a language consistent throughout the process, no mater which language it is, as evidently it is the matter of consistent use of language that resulted in better learning outcomes across all the school systems and contexts of Pakistan. Better learning and comprehension in core subjects like science and mathematics can benefit the country in the long run, in multiple ways. First, by improving performance in these subjects, Pakistan can prepare a better labour force

that can be instrumental in socio-economic growth (Hanushek & Woessmann, 2019). Second, by ensuring consistent use of language, the country can get rid of the issue of 'learning crises' in schools (Bhutta & Rizvi, 2022; TIMSS, 2019). This study supports the idea that effective comprehension leads to effective performance in exams (Mustafa, 2021; Crawford & Marin, 2021), emphasising the importance of consistent language use.

The interaction effects between language consistency and other key factors, such as the school system and teaching practices, add further nuance to our understanding of the complex dynamics in mathematics and science education in multilingual post-colonial contexts like Pakistan. The direct impact of language consistency is evident in both school systems, emphasizing the potential role of language in affecting students' performance regardless of the school system. Despite repeated reports of better performance in private schools compared to government schools (Bhutta et al., 2024; Siddiqui & Gorard, 2017), this study suggests that the consistent use of language in private schools may contribute to their better performance, highlighting the importance of school-level resources and support structures.

Similarly, the interactive effect of teachers' teaching practices emphasises the significance of classroom teaching and the consistent use of language in mathematics and science instruction. It indicates that the quality of classroom teaching significantly contributes to students' academic performance in core disciplines such as mathematics and science (Bhutta et al., 2024). Furthermore, the quality of classroom teaching is influenced by the consistency of language use, highlighting that a higher level of classroom teaching has a significantly positive effect on students' performance when combined with consistent language use. Similar views are also presented in other studies (i.e., Brown & Ryoo, 2008; Brock-Utne, 2012), which argue that teaching science subjects in a familiar language using familiar terminologies has a positive impact on students' learning than teaching it using unfamiliar and scientific language.

Conversely, the same level of teaching with inconsistent language use results in lower academic achievement among students (Malone & Paraide, 2011; Prinsloo & Harvey, 2020). This can be attributed to the fact that moderate teaching practices can better achieve the objective of developing conceptual understanding among students when their textbooks, classroom teaching, and assessments share a consistent language. In essence, students' time spent decoding and translating concepts from textbooks, classroom teaching, and assessments is minimised, while their time formulating responses is maximized, leading to better performance in core subjects such as science and mathematics.

As mentioned, there exist at least three prominent perspectives pertaining to language choice in education. The first perspective advocates for giving instructions in a primary language or mother tongue (e.g., Rolstad et al. 2005; Genesee et al., 2006; Slavin & Cheung, 2005; Brock-Utne, 2012; Palmer & Lynch,

2008). The second perspective supports teaching in a postcolonial language for socioeconomic mobility (e.g., Azam et al., 2013; Coleman, 2011). The third perspective proposes bilingualism and translanguaging (e.g., Back et al., 2020; Lewis et al., 2012; Tai & Wei, 2021). However, none of the above perspectives discuss the dynamic of language consistency across textbooks, teaching, and exams in such an intricate and systematic way as presented by this research. This could be future research agenda to explore consistent use of language in the classrooms using mother language, bilingual, and translanguaging.

Separate and Interactive Effects of Language Consistency and School System on Students' Performance in Mathematics and Science

The results of two-way ANOVA, as shown in table 4, help understand the separate and interaction effect of consistent use of language (i.e., across textbooks, classroom instruction, and assessment) and school systems for science and mathematics achievement.

Table 4

Interaction of Language Use and School System

Source	Sum of square	df	Mean square	F	p	Eta square
Mathematics (r^2=0.072)						
Language consistency	58607.4	1	58607.4	263.5	0.001	0.020
School system	209298.1	1	168226.9	940.9	0.001	0.069
Language* system	4748.8	1	1435.5	21.3	0.001	0.002
error	2846035.8	12794	222.5			
Science (r^2=0.119)						
Language consistency	78562.9	1	78562.9	340.6	0.001	0.028
School system	367582.7	1	367582.7	1593.6	0.001	0.117
Language*system	7124.6	1	714.6	30.9	0.001	0.003
error	2771701.8	12016	230.7			

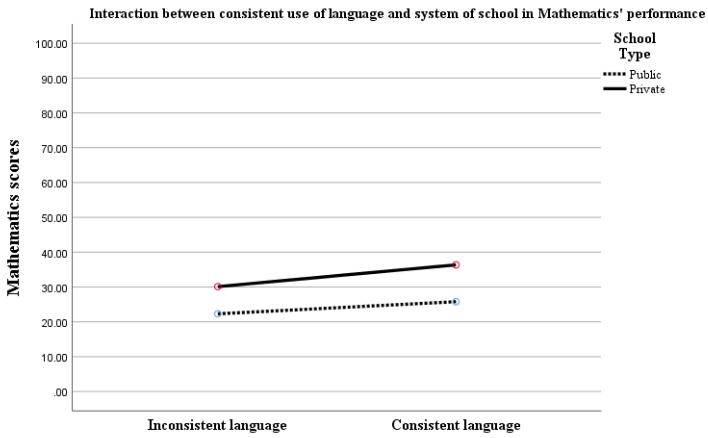
Table 4 illustrates the noteworthy findings in both subjects (i.e., mathematics and science), highlighting a strong association between language consistency and students' performance, along with the impact of the school system. The consistent use of language and the school system both demonstrated significant main effects

on students' performance, underscoring their direct influence on learning outcomes across subjects ($p<0.001$ for all). Moreover, a significant interaction effect was observed between the consistent use of language and the school system, irrespective of the subject. This interaction effect accounted for 7% and 12% of the variance in students' performance in mathematics and science, respectively.

Interaction effect in mathematics: Figure 1 illustrates the interaction effect between the system of school and the consistency of language on students' performance in mathematics.

Figure 1

Interaction between Consistent Use of Language and the System of Schools in Mathematics



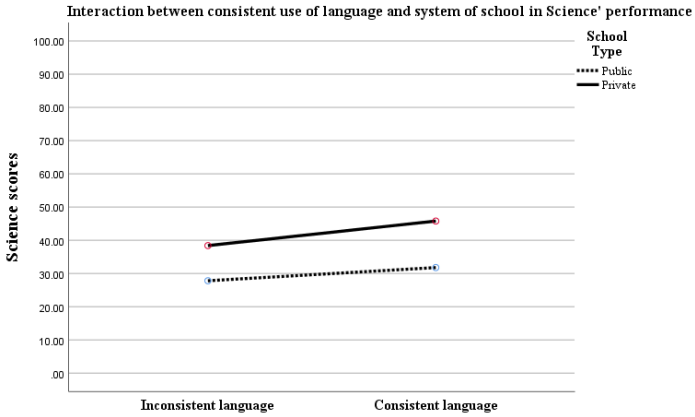
This indicates the distinct patterns of language use within each school system that contribute to the overall comprehension of mathematical concepts. The results highlight a noteworthy difference in performance based on the consistency of language use across textbooks, classroom teaching, and assessment. Students exposed to consistent language in any of the systems, government and private, demonstrated significantly better performance in mathematics compared to their counterparts experiencing language inconsistency ($p<0.001$). Importantly, the interplay between language consistency and the school system indicates that it is not solely the consistency of language that leads to variations in performance; the type of school also plays a significant role. Specifically, when language consistency is maintained across textbooks, classroom teaching, and assessment, private school students have a higher chance of achieving significantly better scores ($M=36.4$; $SD=17.1$) compared to their counterparts ($M=30.1$; $SD=16.1$), who are experiencing language inconsistency. It is important to note that this

interaction effect suggests that the gain in scores associated with consistent language use is evident across both government and private school students, but the advantage is relatively greater for private school students. These findings underscore the importance of considering both language consistency and the school system in enhancing students' mathematical performance.

Interaction effect in science: The findings from science underscore an interesting association between the consistent use of language and the school system, both exerting a significant main effect on students' performance (consistent use of language: $F = 340.589$, $p < 0.001$; system of schools: $F = 1593.560$, $p<0.001$). The graphical presentation highlights a significant interaction effect between the school system and the consistency of language in influencing students' performance in science, as shown in Figure 2.

Figure 2

Interaction between Consistent Use of Language and System of Schools in Science



This interaction emphasises the impact that the pattern of language use within each school system has on overall science performance. The language pattern revealed that students exposed to consistent language use, whether in government or private schools, demonstrated significantly better performance in science compared to their counterparts experiencing language inconsistency across textbooks, classroom teaching, and assessment ($p < 0.001$). The intricate interplay between language consistency and the school system underscores that variations in performance are not solely attributable to language consistency; the type of school equally contributes to students' learning outcomes in science. Specifically, when language consistency extends across textbooks, classroom teaching, and

assessment, private school students have a higher probability of achieving significantly better scores (M=45.8; SD=16.9) than their peers in government school (M=38.4; SD=17.1), even when encountering language consistency.

It is important to note that the gain in scores associated with consistent language use is evident regardless of the school system. However, the advantage is relatively more profound in private school students than their government counterparts. These findings emphasise the crucial role of both language consistency and the school system in shaping students' performance in science.

Separate and Interactive Effects of Language Consistency and Teaching Practices on Students' Performance in Mathematics and Science

Further analysis was carried out to respond to the third research question. The results of two-way ANOVA, as presented in Table 5, help to understand the separate and interaction effects of consistent use of language (i.e., across textbooks, classroom instruction, and assessment) and teaching practices for science and mathematics achievement. For this analysis, the mean scores of teaching practices were categorised into three levels of teaching practices based on benchmarking (weak = 1.00 to 1.50; moderate = 1.51 to 2.50; good = 2.51 to 3.00).

Table 1

Interaction of Language Use and Teaching Practices

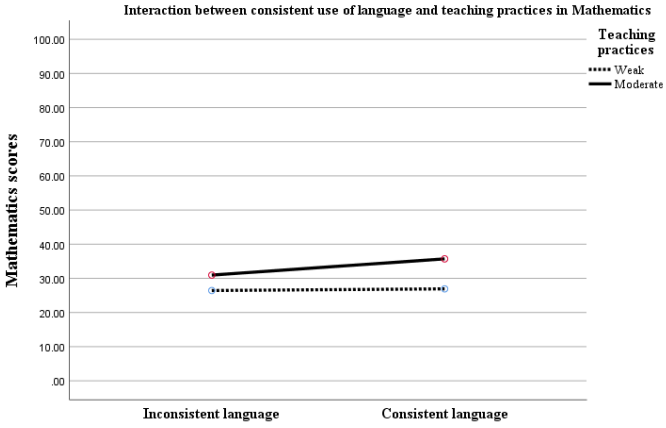
Source	Sum of square	df	Mean square	F	p	Eta square
Mathematics (r^2=0.023)						
Language consistency	9384.1	1	9384.1	39.6	0.001	0.003
Teaching practices	60639	1	60639	256	0.001	0.020
Language* teaching	6240.1	1	6240.1	26.3	0.001	0.002
error	2930742.9	12375	236.8			
Science (r^2=0.021)						
Language consistency	19779.1	1	19779.1	77.3	0.001	0.006
Teaching practices	57316.4	1	57316.4	224	0.001	0.018
Language* teaching	14930.7	1	14930.7	58.3	0.001	0.005
error	3043259.7	11889	255.9			

The results revealed a strong association between language consistency and students' performance in mathematics and science, along with the direct effect of teaching quality. The consistent use of language and the quality of teaching practices both demonstrated significant main effects on students' performance, underscoring their direct influence on learning outcomes across subjects ($p<0.001$ for all). Moreover, a significant interaction effect was observed between the consistent use of language and teaching quality, irrespective of the subject. This interaction effect accounted for 2% of the variance in students' performance in both subjects.

In mathematics: Figure 3 illustrates the interaction effect between the consistency of language and teaching practices, explaining their combined influence on students' performance in mathematics.

Figure 3

Interaction between Consistent Use of Language and Teaching Practices in Mathematics



The observed interaction provided insights into the interactive relationship between language consistency and the quality of teaching practices, particularly discernible within the spectrum of weak and moderate teaching practices. This underscores that students exposed to consistent language use, irrespective of the quality of teaching practices (whether weak or moderate), exhibit significantly better performance compared to their counterparts ($p<0.001$) experiencing language inconsistency across textbooks, classroom teaching, and assessment. This interplay highlights that variations in performance cannot be attributed solely

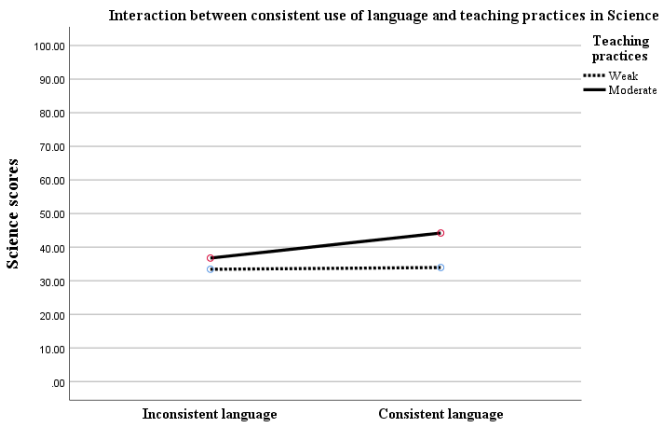
to language consistency or teaching quality; rather, the proficiency level of teaching practices also contributes to students' academic outcomes.

Specifically, when language consistency is extended (i.e., across textbooks, classroom teaching, and assessment) and students instructed by teachers with moderate levels of teaching practices demonstrated a higher chance of achieving significantly better scores (M=35.7; SD=16.2) in comparison to their counterparts (M=30.9; SD=16.3) subjected to language inconsistency. The positive impact on scores associated with consistent language use must persist across all levels of teaching practices. However, this advantage is notably more pronounced in students taught by teachers exhibiting moderate levels of teaching practices compared to those under the instructions of teachers with weak levels of teaching practices. These findings underscore the conjoined influence of language consistency and the level of teaching practices in shaping students' mathematical performance.

In science: the findings underscore an interesting association between the consistent use of language ($F = 77.270$, $p<0.001$) and the level of teaching quality ($F = 223.916$, $p<0.001$), both illustrating a significant main effect on students' performance. Figure 4 presents a visual representation highlighting a significant interaction effect between the quality of teaching practices and the consistency of language in influencing students' performance in science.

Figure 4

Interaction between Consistent Use of Language and Teaching Practices in Science



This interaction emphasises the impact that the consistent use of language within the levels of teaching quality has on overall science performance. The language pattern revealed that students exposed to consistent language use,

whether taught by teachers with weak or moderate quality of teaching, demonstrated significantly better performance in science compared to their counterparts experiencing language inconsistency across textbooks, classroom teaching, and assessment ($p<0.001$). The intricate interplay between language consistency and the level of teaching practices underscores that variations in performance are not solely attributable to language consistency; the spectrum of weak and moderate teaching practices equally contributes to students' learning outcomes in science.

Specifically, when language consistency extends across textbooks, classroom teaching, and assessment, students taught by teachers with moderate levels of teaching practices have higher chances of achieving significantly better scores ($M=44.2$; $SD=15.8$) compared to their counterparts ($M=36.7$; $SD=18.4$), who encounter language inconsistency. It is important to note that the gain in scores associated with consistent language use is evident regardless of the level of teaching practices. However, the advantage is relatively more pronounced in students taught by teachers with moderate levels of teaching practices compared to their counterparts taught by teachers with weak levels of teaching practices. These findings emphasise the crucial role of both language consistency and the level of teaching practices in shaping students' performance in science.

CONCLUSION

This research sheds light on the pivotal role of maintaining language consistency across textbooks, classroom teaching, and assessments in shaping the academic performance of students, particularly within the domain of mathematics and science education in elementary schools in Pakistan. The findings contribute noteworthy insights into the intricate dynamics of language use, school systems, and teaching practices. The study suggests the imperative need for language consistency across instructional materials, ensuring that textbooks, classroom instruction, and assessment materials in order to improve students' learning in the core subjects for better social and economic prosperity. Additionally, there is a call for contextualizing language use to local contexts. While advocating for consistency, teachers should remain mindful of the linguistic diversity within their classrooms, adapting their language use to accommodate varying levels of student proficiency. This does not necessarily entail adopting a multilingual approach but may involve strategies such as code-switching, utilizing visuals, and employing real-world examples in a language that resonates with students, whether it be familiar or unfamiliar.

Furthermore, a crucial recommendation emerges for investing in teachers' professional development with specific emphasis on effective language use in mathematics and science instruction. Teachers should be equipped with the necessary skills to identify and address language barriers, scaffold students'

language development, and seamlessly integrate consistent language use into their lesson plans and assessments. It's essential to clarify that the objective is not to teach the mother tongue or English language within the content courses of science and mathematics. Instead, the primary goal is to straightforwardly develop students' conceptual understanding of scientific and mathematical concepts.

In essence, this study not only addresses a literature gap regarding the influence of language consistency in Pakistan's post-colonial and multilingual educational landscape but also provides actionable insights for educators, policymakers, and researchers. The findings strongly advocate for the integration of consistent language practices across all educational components to optimise students' academic performance, particularly in core disciplines such as science and mathematics. Future research can build on this paper by undertaking experimental studies in various parts of the world, including Pakistan, to assess whether and to what extent consistent use of language can make any difference in students' learning in the core subjects.

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