



Exploring Primary Teachers' Notions of Big Ideas in Statistics: Insights from Maharashtra, India



Jioo Nimkar

Lady Margaret Hall
Department of Education
University of Oxford

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List of Abbreviations

BI: Big Idea

CK: Content Knowledge

PCK: Pedagogical Content Knowledge

PD: Professional Development

Abstract

This study examines primary mathematics teachers' understanding of the big ideas in statistics through a sequential explanatory mixed methods design in the state of Maharashtra, India. Adopting a pragmatic perspective, the study integrates quantitative and qualitative methods to gain a comprehensive view of teachers' statistical knowledge and pedagogy. In the quantitative phase, a survey questionnaire was administered to 251 primary teachers across the state. The instrument assessed statistical content knowledge through five *big ideas* in statistics, framed within the statistical inquiry cycle. The mean score was 4.87 (SD = 2.08) out of 12, indicating overall low performance. No significant differences were found based on teaching experience, school type, or language of instruction. However, teachers with postgraduate qualifications scored slightly higher than those with only undergraduate degrees ($p < 0.01$). Teachers' confidence, measured on a Likert scale, did not correspond with their actual performance, suggesting limited awareness of knowledge gaps.

The qualitative phase involved semi-structured cognitive interviews focusing on teachers' current classroom practices, their reasoning behind survey responses, and their pedagogical content knowledge (PCK) in statistics. Analysis showed that correct answers on the survey did not necessarily reflect deep conceptual understanding. Teachers' knowledge was often context-bound; they performed better with familiar, context-specific tasks but struggled to transfer understanding to unfamiliar situations. In several cases, teachers' reasoning resembled that of early learners of statistics, indicating a persistent gap in statistical knowledge. While interviews also revealed that teachers' PCK was constrained by their limited statistical content knowledge, teachers appeared more confident when discussing the PCK task that was grounded in the classroom context. This suggests that professional development could productively begin with contextually relevant activities before expanding to broader statistical concepts.

The study highlights critical gaps in teachers' statistical understanding and awareness, providing an evidence base for targeted professional development initiatives. It underscores the need for approaches that strengthen both content knowledge and pedagogical strategies, enabling teachers to better support students' statistical reasoning.

Chapter 1: Introduction

In today's increasingly technology-driven world, the ability to engage with, interpret, and critically evaluate data has become essential not only to participate in the democratic process as a responsible citizen but also to make autonomous, informed decisions in everyday life. From understanding medical statistics to interpreting election results or reading economic indicators, individuals constantly interact with data in both personal and societal contexts. As a result, developing statistical literacy, defined as the ability to understand, assess, and use statistical information in decision-making (Wallman, 1993), has become a fundamental educational goal. The American Statistical Association defines statistics as the science 'of learning from data, and of measuring, controlling and communicating uncertainty' (Davidian & Louis, 2012, p.1; Davidian, 2014), and given the increasing presence of statistics across disciplines and professions, developing statistical understanding is no longer limited to advanced levels of education but is now considered important from the early years of schooling.

Many education systems across the world have recognised the importance of this and responded by integrating data handling and statistical reasoning from the early years of schooling (Ben-Zvi & Garfield, 2005) and research in this area has likewise expanded (Watson et al., 2018; Friedrich et al., 2024). Early engagement with statistics allows children to classify, represent, and analyse information using basic tools such as tables, graphs, and measures of central tendency informally, thus forming a conceptual foundation for later formal statistical learning. Furthermore, working with real data supports the development of critical thinking, argumentation, and problem-solving skills that are widely acknowledged as key 21st-century competencies (OECD, 2018).

In India, statistics was introduced into school mathematics nearly two decades ago (Ramanujam et al., 2006; NCERT, 2005), yet it remains a relatively neglected area in both curriculum development and classroom practice. A close examination reveals at least three key gaps that hinder the effective integration of early statistics education in the Indian education system. The first gap lies within the curriculum itself. While the National Education Policy (NEP) 2020 and the National Curriculum Framework (NCF) 2023 both articulate a vision of fostering analytical thinking, data interpretation, and reasoning through real-life data (Ministry of Education, 2020; NCERT, 2023; Zaidi & Ali, 2019),

these aspirations are not consistently operationalised in the curricular goals of primary mathematics. Curricular goals regarding statistics are completely missing from the primary mathematics curriculum. Instead, elements of statistical inquiry appear under subjects like environmental studies and science, where students are expected to hypothesise and interpret patterns (NCERT, 2023, p. 200). As a result, students are expected to apply data-related skills in other subjects, when the mathematics curriculum lacks goals focused on developing skills like hypothesis formulation or data-supported reasoning at this stage.

The second gap appears at the level of textbooks and corresponding learning outcomes. Although most primary mathematics textbooks include chapters on statistics (or data handling), studies have identified a misalignment between textbook content and the learning outcomes they claim to address (Thatte & Nimkar, 2022; Nimkar & R, 2024). In India, textbooks carry significant weight as they are distributed free of charge by the government and serve as the primary instructional resource in most classrooms (Mahapatra, 2012). The examination system, which remains largely content-driven and summative, reinforces this reliance by testing students directly on textbook material (Kumar, 1988; Muralidharan & Singh, 2021). This has led to what Kumar (1988) calls a *textbook culture*, where teaching is confined to the scope and structure of the textbook, with minimal space for teacher autonomy. In such a context, misalignments between textbook content and learning outcomes are not trivial, as they directly affect how statistics is taught and understood in classrooms.

The third and less visible gap is pedagogical. While research documenting classroom practices in statistics at the primary level in India is limited, it is reasonable to infer a disjunction between intended learning outcomes and enacted classroom teaching. This inference is supported by vague curricular goals and a dominant textbook culture that limits teacher autonomy. Consequently, teachers are accustomed to following prescribed instructions, and the responsibility of interpreting and implementing statistics-related content often falls on them, something they may not be adequately prepared for. Further, many Indian primary teachers face challenges due to insufficient content knowledge and limited pedagogical training in mathematics (Banerjee & Stacey, 2025; Kithan & Pal, 2024; Das, 2019; Selvaraj et al., 2015).

In the case of statistics, a conceptually demanding and often misunderstood domain (Garfield & Ben-Zvi, 2008), this lack of preparation becomes particularly concerning. As

a result, data handling is frequently marginalised or reduced to superficial exercises involving graph plotting, table reading and calculating central tendencies, without opportunities for further engagement or reasoning.

These three gaps (curricular ambiguity, textbook misalignment, and pedagogical limitations) suggest that the quality of statistics education at the primary level is highly dependent on the knowledge, beliefs, and practices of individual teachers. However, there is currently little empirical understanding of how Indian primary teachers conceptualise the aims of teaching statistics, what content knowledge they hold, what beliefs shape their teaching of statistics, and how they approach instruction in practice. Without this understanding, efforts to improve the teaching of statistics through teacher education, curricular reform, or policy interventions lack a clear starting point.

This study, therefore, aims to investigate primary teachers' understanding of the big ideas in statistics through the lens of Content Knowledge and Pedagogical Content Knowledge (Shulman, 1987). It further seeks to examine whether and how these understandings vary across different teacher backgrounds. By generating a baseline of current teacher knowledge and practice in this domain, this research intends to inform the design of targeted professional development and contribute to the broader conversation on strengthening statistical literacy from the early years of schooling.

I begin by establishing a strong theoretical foundation on teacher knowledge, followed by a review of literature on statistics education from both teacher and student perspectives, leading to the research questions (Chapter 2). Chapter 3 outlines my positionality as a researcher, the mixed-methods design, data collection, and analytical approaches. Chapter 4 presents quantitative findings, which inform the qualitative phase, followed by qualitative results. In Chapter 5, findings are integrated and discussed in relation to the research questions, with implications, limitations, future recommendations, and the conclusion.

Chapter 2: Literature Review

This literature review begins by exploring the concept of *teacher knowledge* to establish a theoretical foundation for analysing teachers' understanding of statistics. Teacher knowledge has been conceptualised in various ways, and it is necessary to discuss these frameworks before narrowing the focus to *statistical* teacher knowledge. Drawing on one such framework that distinguishes between content knowledge and pedagogical content knowledge of teachers, I then review relevant global and Indian studies that explore these domains in the context of statistics education. Through this review, I discuss key insights as well as gaps in the literature. I conclude by proposing three research questions to address this gap within the Indian context that focus on: (1) statistical content knowledge (2) pedagogical content knowledge for statistics and (3) current classroom practices in teaching statistics

2.1 Theoretical and Knowledge Frameworks

Understanding how teachers engage with statistical ideas in the classroom requires careful consideration of the nature and structure of the knowledge they draw upon in their teaching. Since statistics differs from mathematics as a discipline, I begin by exploring broader, foundational framework of teacher knowledge. I then consider a framework specific to mathematical knowledge for teaching, which builds on this foundation, and reflect on its relevance to statistics education. Finally, I briefly touch upon an alternative foundational framework of teacher knowledge to offer a more complete perspective.

2.1.1 Frameworks of Teacher knowledge

Shulman (1987) introduced pedagogical content knowledge (PCK) to capture the unique blend of content knowledge (CK) and pedagogy that teachers require to make subject matter comprehensible for students. While CK refers to a deep understanding of the subject itself (its structures, rules, and facts), PCK encompasses knowledge of how to represent these concepts in ways that are accessible to learners. It includes anticipating student misconceptions, selecting appropriate analogies or examples, and adapting content to diverse classroom contexts. Shulman argued that teaching involves both the *what* and the *how*, and that PCK is the knowledge that bridges them. For example, in statistics education, teachers must balance encouraging informal inferential reasoning (Makar & Rubin, 2009) with introducing statistical tools that may be unfamiliar to young learners (Callingham & Watson, 2011). PCK is therefore

more than CK or general pedagogical knowledge, it is a situated, topic-specific form of professional expertise focusing on both subject matter and student thinking.

Building upon this idea, Ma (1999) provides a knowledge framework that is specifically for mathematics. She offered the notion of ‘profound understanding of fundamental mathematics’ (p.125) characterised by what she called knowledge packages. These are well-organised, internally connected structures of content knowledge, with four defining features that support strong mathematical teaching. Table 2.1 outlines these features with illustrative examples from statistics education. The existence of clear examples for each feature coming from statistics education suggests that Ma’s framework, though developed for mathematics, can be meaningfully extended to support the teaching of statistics as well.

Table 2.1
Features of knowledge packages (Ma, 1999)

Feature	Description	Example from Statistics Education
1.Connectedness	To link concepts and present them as part of a coherent structure.	Connecting mean, median, and mode while teaching as measures of central tendency.
2. Multiple Perspectives	To explain ideas in varied ways to deepen student understanding.	Representing mean as a numerical value or a line on a graph showing distribution
3. Basic Idea	Highlight core principles that cut across different topics.	Framing data as a way to represent and make sense of real-world variation
4. Longitudinal Coherence	To connect current content with prior and future learning.	Connecting early ideas of likelihood and chance to later concepts of probability and odds.

The distinction between CK and PCK, as proposed by Shulman, is useful to draw attention to the specialised nature of teacher knowledge. However, McEwan and Bull (1991) argue that this dualistic framework can be conceptually inadequate, as it treats pedagogic thinking as separate from disciplinary understanding. Drawing on Dewey (1916), they instead suggest that all knowledge is pedagogic in nature, constructed through interaction, reflection, and the intent to communicate. This view positions teacher knowledge not as a fixed body of content or skills, but as dynamic, responsive, and situated in specific contexts of teaching and learning. According to McEwan and Bull (1991), knowledge emerges through the teacher’s engagement with learners, shaped by the immediate demands and purposes of instruction. What matters is not only what the teacher knows, but how this knowledge is activated, adapted, and reconstructed in response to students’ ideas, questions, and contexts. This makes teacher knowledge fundamentally interactive, what Dewey (1916) refers to as a *continuity of experience* where meaning is constantly negotiated.

Yet, Shulman's distinction between CK and PCK remains analytically useful, particularly when the aim is to assess and structure teacher knowledge. This clear separation allows for the development of measurable indicators: the factual and conceptual nature of CK lends itself to assessment through questionnaires, while the more descriptive and contextual nature of PCK requires interactive, qualitative approaches. Aligned with the pragmatist paradigm guiding this study (Discussed in the methodology chapter), Shulman's framework provided a practical basis for methodological decisions and helped structure both the quantitative and qualitative phases of data collection.

When combined with Ma's framework, which emphasises the depth, and connectedness of content knowledge through knowledge packages, these two models offer a complementary and robust analytical lens. While Shulman conceptualises teacher knowledge as an integration of multiple domains (content, pedagogy, curriculum, and learner understanding), Ma focuses more narrowly on the internal structure and quality of CK. Yet, both underscore the foundational role of strong CK in effective teaching. In the context of Maharashtra, where curricular guidance on statistics is often vague and textbooks inconsistently aligned (Thatte & Nimkar, 2022), teachers frequently rely on their professional and academic judgement. Given the lack of research on teachers' current understanding of statistics, examining both CK and PCK offers an appropriate starting point for establishing a clear baseline.

2.1.2 Frameworks of Students' Statistical Thinking

In addition to frameworks on teacher knowledge, it is equally important to consider frameworks of how students learn statistical ideas, as this has implications for how teachers' CK can be understood and assessed. Wild and Pfannkuch (1999) describe statistical thinking as a cyclical process involving five key components (PPDAC): problem identification, preparing for data collection, data handling, analysis and conclusion drawing. This statistical-inquiry cycle focuses on the importance of contextual reasoning, iterative questioning, and interpretation (Wild & Pfannkuch, 1999) all while dealing with uncertainty, competencies that are often underdeveloped in teacher knowledge and classroom practices (Ben-Zvi et al., 2012).

Additionally, Konold et al. (2004) identified three early points of view that learners often take when encountering data: pointers, where data serve as reminders of the event without direct reference to the data itself; case values, which focus on individual data points, such as extremes; and classifiers, which involve grouping cases with similar values, emphasising frequency patterns like the mode. These perspectives, while developmentally appropriate for learners, if

observed in teachers, can indicate limitations in their conceptual understanding. Therefore, student-centred frameworks can serve as diagnostic tools for understanding and identifying gaps in teachers' statistical CK.

Together, these frameworks provide a strong foundation for this study. While Shulman (1986) and Ma (1999) offer a grounding to examine the structure and application of teacher knowledge, the student-centred models of Wild and Pfannkuch (1999) and Konold et al. (2004) help uncover potential gaps in teachers' content understanding. Drawing on these perspectives, I aim to investigate how primary teachers in Maharashtra understand and teach statistics, data handling, and information processing.

2.2 Teachers' Content Knowledge of Statistics

This section examines the literature on primary teachers' statistical content knowledge. I organise statistical CK around five key conceptual areas based on the statistical inquiry cycle (Wild & Pfannkuch, 1999). I define these *Big Ideas* as:

- (1) Defining statistically investigable questions,
- (2) Collecting data and sampling,
- (3) Describing data,
- (4) Understanding central tendencies, and
- (5) Interpreting and predicting from data.

I will also use these categories later in this study to develop an assessment and analyse data.

1. **Statistically Investigable Question:** Formulating statistically investigable questions (Arnold, 2012) is a key step in any statistical inquiry. However, this area is often underdeveloped in both school curricula and teacher knowledge. A well-formed investigable question requires students to collect data, analyse it, draw conclusions, and support findings with evidence (Chin & Kayalvizhi, 2002; Arnold, 2012). Wild and Pfannkuch (1999) emphasise that the quality of the question shapes the rest of the statistical process. Yet, research suggests that teachers often struggle to frame questions that can result in statistical enquiry (Makar & Rubin, 2009) and tend towards closed (Allmond & Makar, 2010) or deterministic questioning. This challenge may be greater in primary classrooms, where teacher training in statistics is usually limited. In the Indian context, textbooks rarely support the development of meaningful, investigable questions. Activities often provide fixed or vague prompts. E.g., grade 2 textbook instructs: 'Ask the children the date and month of their birthday and note it down... Answer the following questions' (Balbharati, 2019/2022,

p. 65). There is no clear purpose for collecting this data. Follow-up questions focus only on isolated data points, like how many students have a birthday in a certain month. Without a guiding question, data collection lacks purpose, ending the statistical inquiry at its outset.

2. **Data Collection:** Data collection directly depends on the previous big idea as a poorly framed question can lead to irrelevant data and not useful conclusions. Research shows that teachers often have a procedural rather than conceptual understanding of sampling. Groth and Bergner (2005) found that many pre-service elementary teachers viewed samples as a *collection of objects* or *part of a whole* without considering key ideas like representativeness or bias. Garfield (2003) reported low scores among teachers on sample variability, indicating limited understanding that smaller samples tend to vary more and can produce extreme values. In India, sampling is usually introduced only in later stages of schooling (NCERT, n.d.) and is mostly absent from primary-level teacher training as these teachers rarely face tasks that involve sampling. If teachers are to carry out informal statistical inquiry in early grades, more attention is needed to strengthen their understanding of sampling, as it directly affects their teaching using small sets of data collected by students.
3. **Describing Data:** Describing data involves viewing it as an aggregate to summarise patterns, distributions, and variability using visual and numerical tools. However, research shows that pre-service primary teachers often struggle with this. They tend to treat graphs as end products rather than tools for data description, and face difficulty linking graph-based insights to context (Bruno & Espinel, 2009; Burgess, 2011; Batanero et al., 2011; González et al., 2011). This prevents engagement with data and informal inferential reasoning (Makar & Rubin, 2009). Burgess (2011) also found that teachers' classroom use of graphs was mostly procedural, focusing on making and reading graphs rather than analysing them. Textbooks in India support this pattern by asking questions about single data points (e.g., extremes), rather than broader trends (Thatte & Nimkar, 2022). As a result, teachers may not be equipped to guide students in viewing data as aggregated information, which is at the core of inferential statistics (Konold et al., 2004).
4. **Central Tendency:** Understanding measures of central tendency are a compact tool for describing data. There has been plenty of research about teachers' statistical knowledge of mean, median, and mode, which indicates that teachers often rely heavily on procedural knowledge. Jacobbe and Carvalho (2011) showed that while many teachers could compute averages correctly, few demonstrated a comparative understanding of when and why each measure should be used, e.g., preference towards choosing the median over the mean in skewed distributions was rarely observed. Leavy and O'Loughlin (2006) reported that pre-

service teachers often perceived mean as simply a *fair share* or a *balancing point*, which the authors describe as a superficial and non-statistical understanding of the concept. This points towards a lack of connection between conceptual and procedural knowledge. Similarly, in India, though curriculum includes central tendencies, the emphasis is on calculations using formulae (Thatte & Nimkar, 2022). The idea that these measures produce an indicator of *typicality* is rarely addressed, potentially influencing both teachers' and students' understanding

- 5. Interpreting and Predicting from Data:** Interpreting and predicting from data involve using multiple statistical concepts such as central tendency, variation, and sampling. Unlike describing data, this big idea requires going beyond the data itself to using it as evidence for making inferences or predictions (Makar & Rubin, 2009). It also involves revisiting earlier big ideas, reconsidering the initial question, recognising sampling limitations, and using descriptive summaries with caution. A sound understanding of probabilistic and uncertain language is crucial for making both informal inferences (Ben-Zvi et al., 2012). Ben-Zvi and Garfield (2005) argue that this is one of the most cognitively demanding aspects of statistical reasoning, involving a shift from describing data to reasoning about what it suggests, something many teachers may struggle with due to gaps in their own education.

Thatte et al. (2025) highlight challenges specific to the Indian context, showing that students face difficulty with uncertain language during data investigations in local languages, such as interpreting the word *about* in Marathi. Teachers, too, often lack the linguistic and conceptual confidence to support this kind of reasoning (Reinhart et al., 2019). Many languages lack formal statistical vocabulary, which adds to the challenge (Thatte et al., 2025). While professional development can help, persistent misconceptions remain without sustained and language-sensitive support (Groth, 2017).

2.3 Teachers' Pedagogical Content Knowledge in Statistics

Pedagogical Content Knowledge (PCK), introduced by Shulman (1986), refers to the integration of subject knowledge and pedagogy required for effective teaching. In statistics, particularly at the primary level, PCK involves more than procedural knowledge. Teachers must also make visible to students' conceptual structures through connectedness and multiple perspectives (Ma, 1999). Statistical PCK also includes designing developmentally appropriate lessons and enabling students to reason using data (Callingham & Watson, 2011; Callingham et al., 2016). Further, it must include an understanding of the epistemological nature of

statistical knowledge and the influence of context and uncertainty in drawing conclusions (Godino et al., 2011)

Teachers' beliefs play a crucial role in shaping how statistics is taught (Garfield & Ben-Zvi, 2008; Schreiter et al., 2024). Estrada et al. (2011) found that many teachers view statistics as either difficult or less important than other areas of mathematics. These perceptions often stem from their own schooling experiences, where statistics was taught procedurally rather than conceptually. Such beliefs can lead to teachers avoiding open-ended tasks or data explorations, limiting students' exposure to reasoning with data (Pierce & Chick, 2011). Addressing these beliefs is important to improving teachers' PCK and supporting classroom practices.

One reason for this discomfort may be the role of uncertainty in statistical reasoning. Unlike other areas of mathematics education, which focus on deductive and definitive answers, statistics involves probabilistic thinking and approximations. Teachers must be comfortable using and modelling language that reflects uncertainty. Makar and Rubin (2009) highlight that many teachers struggle to promote probabilistic reasoning, especially when the rest of the curriculum reinforces certainty and exactness. This becomes more challenging in multilingual contexts, where local languages may lack terms that express uncertainty clearly (Thatte et al., 2025). Developing statistical PCK, therefore, must involve building both conceptual understanding and linguistic comfort with uncertain language, enabling teachers to guide students through exploratory dialogue.

Another important aspect of statistical PCK is the ability to choose and use appropriate representations. This reflects Ma's (1999) idea of multiple perspectives, as not all graphs or visuals highlight the same features of data. Some, like bar graphs, show frequency well but may not show proportions or variation. Godino et al. (2011) emphasise the need for teachers to understand both what a representation shows and what it hides. Yet, González et al. (2011) found that teachers often select graphs based on familiarity, not on their alignment with the learning goal, which may prevent further engagement with data. A strong pedagogical decision would involve aligning the representation with the statistical concept being taught.

A further marker of effective statistical teaching is the ability to support students in moving from data description to informal inference. This includes helping students generalise from samples, notice patterns, and make plausible conjectures (Makar, 2013). However, many teachers stop at descriptive work and do not extend tasks towards inferential reasoning. Thatte et al. (2025) show that in multilingual classrooms, this shift requires careful scaffolding of both

reasoning and language. Teachers with strong PCK would support this transition using real-world contexts, appropriate uncertain language, and classroom dialogue that helps students identify and describe trends in aggregate data.

Professional development is critical in supporting the growth of statistical PCK. Lee and Hollebrands (2011) recommend programmes that involve working with authentic data, reflecting on student thinking, and developing specific teaching strategies. Pfannkuch and Ben-Zvi (2011) also advocate for sustained, inquiry-based teacher education that integrates content and pedagogy through cycles of practice and reflection. In India, such structured and sustained opportunities are still limited (Zaidi & Ali, 2019). This highlights the need for teacher education that is responsive to local languages and contexts, enabling teachers to develop the confidence and skills necessary for effective statistics instruction.

2.4 Current Practices in Teaching Statistics

Understanding teachers' knowledge of statistics is ultimately important because it influences how statistical ideas are taught in classrooms. The broader purpose of research (beyond this study) (Swann & Pratt, 2004, p.179) should not just be to study teachers' understanding in isolation, but to use that understanding as a basis for improving classroom practices. Therefore, it is important to examine what existing research says about how statistics is currently taught, and the challenges and opportunities that shape classroom practices.

Teaching statistics requires a distinctive approach. On the one hand, using real-world contexts can make statistical learning more meaningful for students. Makar (2013) argues that when students engage with authentic data drawn from their lives, they are more likely to reason meaningfully about statistical concepts. On the other hand, authentic data can also be complex or messy, making it difficult to illustrate concepts clearly (Fergusson et al., 2025; Kjelvik & Schultheis, 2019). This means that teachers need to find a balance and make constant pedagogical decisions to navigate conceptual clarity and real-world relevance while teaching statistics.

Although curricular frameworks in many countries, including India, emphasise inquiry-based and contextually meaningful approaches to statistics (NCERT, 2023), actual classroom practices often fall short of these ideals. Studies suggest that teaching statistics remains largely procedural, focusing on reading values from charts, with limited attention to interpretation or reasoning (Makar, 2013; Nimkar & R., 2024). Indian mathematics textbooks, also tend to prioritise computation and formulae over interpreting trends or making inferences (Thatte &

Nimkar, 2022). Teachers frequently follow textbook examples closely, which in the Indian context are often highly structured (Chowdhuri, 2022), leaving little scope for open-ended exploration. This influences not only how students engage with statistics but also how teachers plan and deliver lessons.

Systemic challenges further make it harder to adopt exploratory, reasoning-based teaching practices. Many Indian teachers have limited access to professional development specifically focused on statistics. Additionally, an overloaded curriculum and assessment systems that reward correct answers over reasoning make it difficult to implement teaching approaches which focus on conceptual understanding (Muralidharan, 2019; Sarkar, 2012; OECD, 2020). Thatte et al. (2025) show that in the Indian context, when children speak a different dialect of the instructional language, they often struggle to grasp ideas like uncertainty or central tendency at an informal level. This makes teaching in multilingual classrooms (a common scenario in India) even more challenging.

Despite these challenges, some positive shifts have been observed in the global north where teachers are supported through sustained professional learning. For example, Groth (2017) documents cases where teachers began to incorporate data collection, student discussions, and informal inference into their teaching through iterative design-based research. While being resource demanding, this example shows that when teachers are provided with contextualised, reflective professional development, they shift from procedural to concept-oriented instruction.

In summary, while many teachers currently deliver data handling through rule-based, textbook-driven methods in India, there is a growing need to engage students in authentic, exploratory work with data. However, bringing about this shift in practice requires not only better resources and training but also a structured, deep understanding of teachers' current knowledge and classroom practices.

2.5 Gaps in Research

Although there is growing international interest in statistics education, research that specifically focuses on the teaching and learning of data handling in primary classrooms, particularly in the Indian context, remains sparse. The limited studies that do exist tend to either address general mathematical knowledge or focus on secondary education, with primary statistics receiving only marginal attention.

One significant gap is the lack of empirical work exploring teachers' understanding of statistical content and pedagogical strategies. While global research by researchers like Watson (2001), Garfield and Ben-Zvi (2008), and Groth (2017), etc. provides useful insights into common misconceptions of teachers and their instructional challenges, these findings may not fully translate to the Indian context, where the curriculum, language, and classroom realities differ considerably. The few available Indian studies (e.g., Chowdhuri, 2022; Thatte & Nimkar, 2022; Nimkar & R, 2024; Thatte et al., 2025) are small-scale and point to structural issues such as the mismatch between curriculum objectives and textbook content. They do not systematically investigate teachers' content or PCK in statistics, which can reflect the current state of statistics education. Furthermore, there is limited research on how teachers understand and implement statistical inquiry in multilingual or socio-economically diverse classrooms (scenarios that are common in India) when professional development support in these areas remains minimal.

2.6 Conclusion

This literature review has examined research on primary teachers' CK, PCK, and classroom practices related to data handling, structured through the lens of five key big ideas. It reveals that while international research has addressed specific components such as misconceptions, instructional strategies, and statistical reasoning, these are often fragmented and rarely situated within primary-level classrooms, especially in the Indian context. Studies from India point to curriculum-textbook mismatches and teaching practices focusing on procedural knowledge but offer little insight into teachers' own statistical understanding or their pedagogical reasoning. Together, these findings establish a clear research gap: the need to investigate how primary mathematics teachers in India understand and teach statistical ideas. To address this gap, the study aims to explore teachers' CK, PCK, and classroom practices through a coherent approach. Accordingly, the research questions are as follows:

- 1. Content Knowledge:** How do primary mathematics teachers in Maharashtra demonstrate knowledge of key statistical concepts such as uncertainty, central tendency, variation, and data aggregation at an informal level?
- 2. Pedagogical Content Knowledge:** How do primary teachers in Maharashtra describe teaching statistical ideas in the classroom, and how do they report analysing and scaffolding students' statistical reasoning?
- 3. Current Practices:** What are the current teacher-reported practices for teaching statistics in primary classrooms in Maharashtra? What challenges do these teachers report facing?

Chapter 3: Methodology

3.1 Introduction

In this chapter, I will outline the methodological framework for investigating primary teachers' understanding of statistics. I will discuss my philosophical positioning, sampling and recruitment strategies, and data collection instruments. The research is guided by the following key research questions:

1. **Content Knowledge (CK):** How do primary mathematics teachers in Maharashtra demonstrate knowledge of key statistical concepts such as uncertainty, central tendency, variation, and data aggregation at an informal level?
2. **Pedagogical Content Knowledge (PCK):** How do primary teachers in Maharashtra describe teaching statistical ideas in the classroom, and how do they report analysing and scaffolding students' statistical reasoning?
3. **Current Practices:** What are the current teacher-reported practices for teaching statistics in primary classrooms in Maharashtra? What challenges do these teachers report facing?

3.2 Positionality

For this study, I adopt a pragmatist approach outlined by Creswell and Clark (2018), which emphasises the selection of methods based on their capacity to effectively address the research questions rather than adherence to a single paradigmatic and, consequently, methodological position. This approach offered me methodological flexibility, ensuring the chosen methods best address the research questions (Brierley, 2017; Biesta, 2010).

My personal experience as both a student of education and mathematics, as well as a student teacher, has shaped my understanding of the challenges associated with teaching statistics (referred to as data handling/information processing in Indian primary curricula) in Indian classrooms. I have observed that the teaching of statistics in primary classes often reduces to basic *mathematical* ideas, such as counting, comparison or ratios, rather than the fundamentals of statistics. I believe that this is a missed opportunity, as early exposure to statistical thinking can greatly support students' learning in later years. Addressing this issue requires a better understanding of the current state of statistics education and studying teachers' understanding of statistics (in terms of CK and PCK) and the associated classroom practices can provide

valuable insights. Thus, this research draws on practical questions and the needs of educators. As a result, I prioritise the consequences and practical outcomes of this research over strict adherence to any single research paradigm, which aligns with a pragmatist framework and informs my choice of methodology (Creswell & Clark, 2018; Brierley, 2017; Pring, 2015). While there is an ongoing debate about whether pragmatism qualifies as a distinct paradigm due to its loosely defined ontology and epistemology (Johnson & Onwuegbuzie, 2004), I see this flexibility as an advantage in the present study. The pragmatist, question-driven approach has allowed me to adapt methods to the demands of the research questions (Punch & Oancea, 2014), than focusing on the philosophical underpinnings of the knowledge produced.

3.3 Research Design

I followed an explanatory sequential mixed methods design (Creswell & Clark, 2018), which involved two distinct phases: a quantitative phase followed by a qualitative phase. The primary objective of the quantitative phase was to assess teachers' informal CK of statistical concepts. Given the scale of Maharashtra's education system with over 51,000 primary schools and approximately 149,000 primary teachers (Ministry of Education, 2024), it was necessary to use a quantitative approach to capture a broad and somewhat representative understanding of teachers' CK across the state.

The results from this phase then informed the structure and focus of the subsequent qualitative phase. The qualitative phase aimed to explore the reasons, justifications, and thought processes behind the teachers' responses in the quantitative phase. Furthermore, I also captured some aspects of teachers' PCK of statistics and glimpses of their classroom practices through semi-structured, cognitive interviews. The qualitative phase not only helped explain the quantitative findings but also contributed to generating additional insights, about the challenges teachers faced and the strategies they used when teaching statistics. Therefore, although this study followed the structure of an explanatory sequential design, where the qualitative aspect was primarily expected to explain the quantitative data (Creswell & Clark, 2018), it also took on an exploratory dimension. Table 3.1 outlines the methods used for each research question.

Table 3.1
Mapping Research Questions to Corresponding Methods

Method	Research Questions
Question based Survey*	RQ1: Statistical Content Knowledge
	RQ1: Statistical Content Knowledge
Semi-structured, Cognitive Interviews**	RQ2: Statistical Pedagogical Knowledge
	RQ3: Teacher reported practices

*Note:**Quantitative Phase,**Qualitative Phase

3.4 Quantitative Method

3.4.1 Sampling Strategy

In the quantitative phase of the study, I recruited primary mathematics teachers ($n = 259$, valid $n = 251$) from Maharashtra, India, to participate in an online survey questionnaire using convenience sampling (Clark et al., 2021). The sample size was targeted to ensure that the dataset included sufficiently large sub-samples for meaningful statistical analysis. This included aiming to secure at least 30 participants in key sub-groups, such as independent categorical variables like school type (private, government schools, etc.), to allow for valid analysis (VanVoorhis & Morgan, 2007).

I identified and contacted the participants through informal WhatsApp teacher communities in Maharashtra, with permission obtained from the group moderators. Since these groups had a limited representation from the eastern (Vidarbha region) and south-western (Konkan region) of Maharashtra, I contacted some teachers with strong professional connections in these regions personally to improve geographical representation. Consequently, I obtained a small portion of the sample through snowball sampling (Clark et al., 2021) to capture a more geographically representative sample (Gorard, 2001). Exclusion criteria were applied to maintain the focus on the target population. Teachers who teach mathematics but not in primary grades, as well as those who do not teach in Maharashtra, were excluded from the study. No protected characteristics (e.g., age, disability, gender) under the Equality Act 2010 (BERA, 2018) were used as exclusion criteria, ensuring that the study maintains ethical and inclusive research practices (See [Appendix C](#)). The [Appendix F](#) includes a flowchart of participant access with key figures.

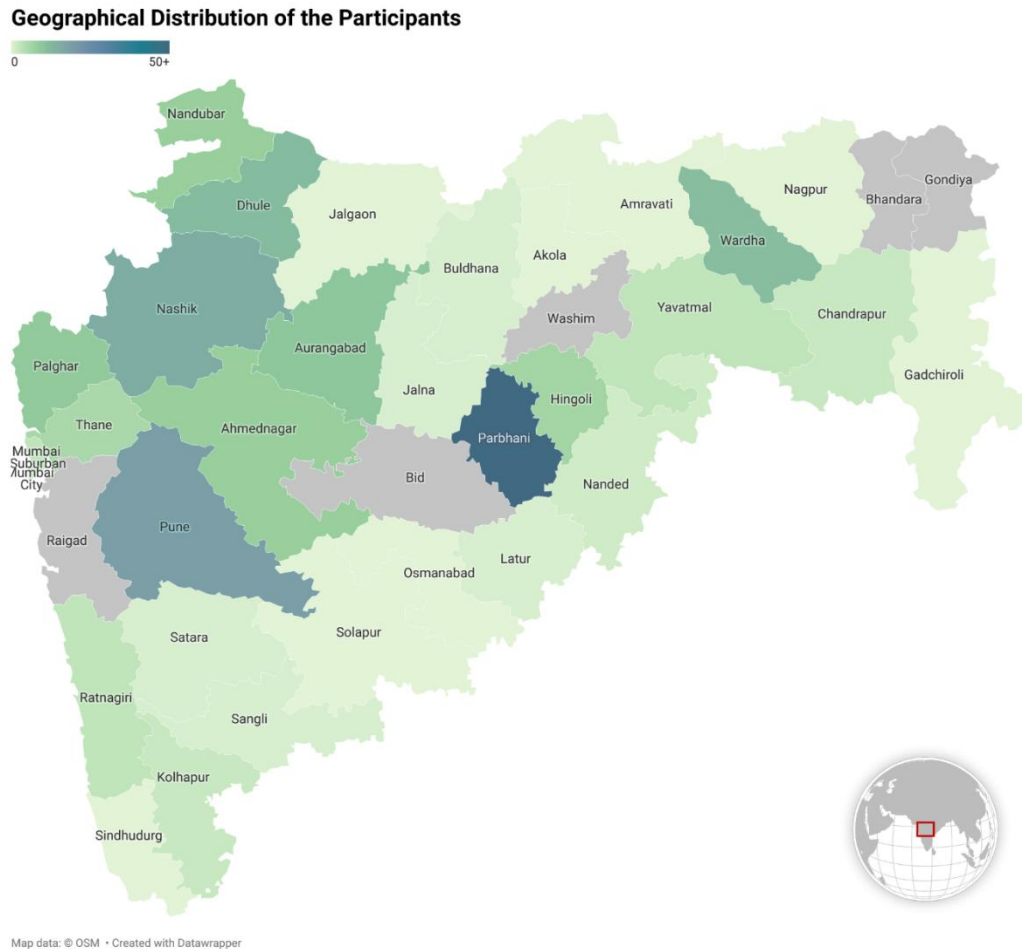
Out of a total of 6,024 data points across the statistical questions, confidence ratings, and background variables, only 43 were missing (0.7%), indicating a very low amount ($< 3\%$) of missing data (Cohen & Cohen, 2003, p.432). Unanswered statistical questions were treated as incorrect and assigned a score of zero. For the correlation analysis, only complete observations were included (through pair-wise deletion) to ensure the reliability of results. Given the minimal amount of missing data, I did not perform any imputation (Field, 2018; Pallant, 2020).

3.4.2 Sample Characteristics

A total of 259 teachers participated in the quantitative phase by completing the survey; however, 8 responses were excluded due to not meeting the inclusion criteria or being duplicate submissions. Geographically, participants were from a broad cross-section of Maharashtra. Out

of 36 districts, 32 were represented by at least one participant, with the highest concentration from Parbhani (25.1%). This overrepresentation can be attributed to the use of snowball sampling within the district. Pune (10.0%) and Nashik (8.0%) were the next most represented districts. Bhandara, Bid, Gondiya, Raigad, and Washim had no participant representation (See Figure 3.1).

Figure 3.1



In terms of school type, 68.52% (n = 172) of teachers were employed in government schools. This category included Zilla Parishad schools (n = 159) and municipal/metropolitan schools (n = 13). The remaining 31.48% (n = 79) of participants taught in private schools, comprising aided ashram schools (n = 3), aided private schools (n = 51), and unaided private schools (n = 25). Due to the small and unequal group sizes within these categories, school type was recategorised as government (n = 172) versus private (n = 79) for subsequent analysis. This distribution aligns closely with the actual proportion of school types in Maharashtra, where

approximately 67.05% of primary schools are funded by the state and rest are privately funded (Ministry of Education, 2024).

Regarding teaching experience, most participants, 72.5% (n=182), reported having over 15 years of professional experience, while the remaining 27.5% (n=69) had between 0 and 15 years of experience. This distribution reflects demographic trends in the teaching workforce in Maharashtra, particularly within government schools, where formal recruitment has been limited since approximately 2010 (Tirodkar, 2019; Sarangapani et al., 2024). The majority of participants reported Marathi as their medium of instruction (70.9%), while a smaller proportion indicated English (29.1%).

In terms of academic qualifications, 125 participants had obtained a bachelor's degree, with the majority holding a BA (n = 93), followed by BSc (n = 27) and BCom (n=5). A total of 112 participants held a postgraduate degree, primarily an MA (n = 103), with a smaller number holding an MSc (n=7) and a PhD (n=2). For the purposes of analysis, categories were combined to account for the variability in qualification pathways. Table 3.2 summarises the newly formed categories.

In terms of professional qualifications, 116 participants held the Higher Secondary Certificate with a Diploma in Education (HSC D.Ed.), which is broadly equivalent to A-levels combined with a teaching qualification. A further 94 teachers reported holding a Bachelor of Education (B.Ed.), a degree typically pursued following or with undergraduate studies. Additionally, 29 participants had completed the Secondary School Certificate with a Diploma in Education (SSC D.Ed.), an award comparable to GCSEs, followed by a professional qualification, generally permitting teaching at the primary level only. 12 participants reported not holding a recognised professional teaching qualification; this group either had no formal teacher education or held academic degrees in education, such as an MA in Education.

Table 3.2
Recategorised Demographics

Recategorised Demographic Variables	Frequency	Percentage(%)
School Type		
Government schools	172	68.5
Private schools	79	31.5
Teaching Experience		
0-15years	69	27.5
15+years	182	72.5
Medium of Instruction		
Marathi	178	70.9
English	73	29.1
Highest Academic Qualification		
Postgraduate degree	112	44.6
Undergraduate degree	125	49.8
SSC/HSC* level diploma	14**	5.6
Professional Qualification		
Bachelor's in education (B.Ed.)	94	37.5
HSC* Diploma in Education	116	46.2
SSC* Diploma in Education	29	11.5
No professional degree	12**	4.8

Note: *equivalent to GCSE/A-levels examinations, **Given the small sample size, these categories were excluded from the subsequent analysis

3.4.3 Instrument Development and Design

The objective of the quantitative phase was to assess teachers' statistical CK using *big ideas* in statistics. These big ideas were based on the statistical enquiry cycle conceptualised by Wild and Pfannkuch (1999), and included defining statistically investigable questions, collecting data and sampling, describing data, understanding central tendencies, and interpreting and drawing inferences from data. Since no existing instrument adequately assessed primary teachers' CK across all these big ideas, a new tool was developed, informed by both theoretical frameworks and practical considerations. I used an online multiple-choice questionnaire (MCQ) to collect data efficiently across a large geographical area of Maharashtra (Oc & Hassen, 2025). While shared via existing teacher communities, without direct access to potential participant lists, this was a *non-list-based web survey* (De Leeuw et al., 2012, p.267). *close ended* (p.148) MCQ allowed for more objective scoring, providing some insights into

teacher statistical CK at the population level. More importantly, it provided insights into teachers' thinking through carefully designed distractors. These distractors served a diagnostic purpose, as they were not merely incorrect alternatives but indicators of possible underlying misconceptions (De Leeuw et al., 2012). They also gave rise to detailed discussions during the semi-structured interview.

Items were drawn and adapted from three main sources: the Saksham test (Nimkar & Thatte, 2022/2024), the LOCUS question bank (LOCUS, 2025), and the instrument developed by Garfield (2003). The Saksham Test, originally designed in the Marathi language for students, required significant modification to reflect teachers' knowledge levels and to strengthen distractors. Questions from the LOCUS bank and Garfield's instrument, both in English, were adapted and translated into Marathi. Where gaps remained (e.g., areas such as formulating investigable questions), new items were developed. These new questions were informed by my own experiences in classrooms and by literature on common misconceptions or possible weaknesses in statistical understanding (e.g., Konold et al., 2004; Thatte et al., 2025).

Each question in the instrument was designed to address one of the five big ideas (Outlined in [Appendix A](#)), which shows the distribution of questions, objectives, and their sources. All questions were grounded in the principles of informal inferential reasoning, where teachers were required to choose claims that extended beyond the data, were supported by the data as evidence, and were expressed with a degree of uncertainty (Makar & Rubin, 2009). No questions involved formulae or calculations; instead, they focused on observing and interpreting data. Particular emphasis was placed on concepts such as central tendency and inference, which are often underrepresented in the current textbooks (NCERT, n.d.) but are fundamental competencies in statistics and essential for real-world data interpretation.

In addition to content-focused items, the instrument included six 4-point Likert-scale questions to assess teachers' confidence in their statistical knowledge, aligned with the five big ideas. This allowed analysis of the relationship between self-perception and actual performance (Harrell-Williams et al., 2015; Li & Copur-Gencturk, 2025). The online survey was carefully formatted to ensure clarity and minimise cognitive load, allowing for smooth and consistent navigation.

3.4.4 Translation and Language Considerations

The instrument was originally developed in English, primarily for supervisory feedback and ethical review. However, to ensure contextual and cultural relevance, as well as linguistic accessibility for participants, I undertook a rigorous translation process using the multi-step TRAPD method (Willis et al., 2010) and translated the survey into Marathi. This process was completed with a pilot study. I collaborated with a Marathi-speaking researcher with expertise in statistics education to ensure accuracy and relevance. The translation process involved several stages: initial *translation* of the items by me, *review* by the local expert, *adjudication* involving the expert, my supervisor, and myself, and *pretesting* through a pilot study. During the pilot, participants engaged in brief interviews and provided detailed feedback on the clarity and accessibility of the translated items. All versions, changes, and feedback were thoroughly *documented*.

Translation decisions were shaped by both linguistic and cultural considerations. For example, terms such as *random*, *typical*, and *statistically investigable* did not have direct equivalents in Marathi. In such cases, we adopted bilingual phrasing or explanatory terms. We also avoided formal or Sanskritised vocabulary that is not commonly used in classroom settings. These choices were guided by the principle of functional equivalence (Landman & Robinson, 2009), ensuring that the conceptual fidelity was prioritised over literal translation and linguistic demands remained consistent across items after translation. Involving a domain expert with contextual and linguistic knowledge improved clarity and ensured alignment with teachers' real-world experiences, increasing both cultural validity and psychometric reliability (Hosseinizadeh et al., 2022).

3.4.5 Pilot Study (Quantitative Phase)

As the survey was developed from scratch, I conducted a pilot in February 2025 to assess clarity, language, and structure. With ethical approval, 8 conveniently sampled participants from the district of Palghar, sharing backgrounds with the target group, completed the developed survey with 12 CK items and six confidence Likert questions. I held 10-20-minute-long online Teams interviews, with verbal consent obtained and detailed notes taken. Participants found the survey engaging but time-consuming (20-30 mins). Based on their feedback, the following modifications were made to improve the survey (question-wise summary in [Appendix A](#)).

1. **Removing problematic questions:** One question related to understanding central tendencies was removed, as all eight participants found it difficult to understand. The confusion stemmed from the Marathi translation of *typical number*, which became *representative number* an unfamiliar term for day-to-day language. The question was replaced with one that addressed the same big idea but used more accessible language.
2. **Strengthening distractors:** Three questions were revised to increase their diagnostic quality. Original distractors were too simplistic and failed to reveal misconceptions. In response: (A) some purely numerical options were replaced with choices that paired numbers with plausible justifications; and (B) overly obvious distractors were redesigned to include more nuanced, contextually relevant alternatives.
3. **Improving clarity:** Five questions were edited for better alignment with everyday language. Statistical terminology was simplified without losing sight of the Big Idea and the objective (De Leeuw et al., 2012). For example, a double-barrelled question with complicated terminology (Gorard, 2001) was restructured for clarity (See [Appendix A](#)). This was clarified with minor linguistic adjustments.
4. **Reducing cognitive load:** To ensure consistency and ease of understanding, all questions followed a standardised format (De Leeuw et al., 2012, p.276-279). Confidence-level items were included uniformly, and consent information was translated into Marathi in a clear and accessible manner to build trust and encourage honest responses.

After these revisions, the updated survey was reviewed by my supervisor and the Marathi-speaking researcher to ensure linguistic accuracy and contextual relevance. The pilot study helped refine the survey tool, ensuring it was culturally appropriate, clear, and methodologically sound for assessing statistical CK of primary teachers.

3.5 Qualitative Methods

The qualitative phase aimed to gain an understanding of the reasoning behind teachers' survey responses, their current practices, and statistical PCK. I used semi-structured cognitive interviews with primary mathematics teachers to explore how they think about and engage with statistical concepts. Combining semi-structured questions with cognitive techniques like think-aloud and probing (Collins, 2003; Richardson, 2002, p.45) allowed flexibility in follow-up while maintaining consistency. This method also aligned with the pragmatist orientation of this study, offering the opportunity to capture context-specific (Gillespie et al., 2024), qualitative

insights that would not have been apparent through a structured survey questionnaire alone. The open-ended format encouraged teachers to share experiences and classroom examples (Denzin & Lincoln, 2018, p.579), resulting in long interviews (around 50 minutes). The data also highlighted how Marathi language and local educational contexts shape teachers' understanding and teaching of statistics.

3.5.1 Participants

Six participants were selected for the qualitative phase using purposive sampling (Clark et al., 2021), with the aim of exploring their survey responses in greater depth and capturing diverse thought processes. Selection was guided by three criteria: total survey score, performance on six selected survey items, and willingness to participate in follow-up interviews.

These six items in the survey showed strong diagnostic potential during the quantitative analysis. In each case, one or more distractors had been selected by a significant number of participants. To explore both possible misconceptions and accurate understanding, I included teachers who had either chosen these distractors or answered the items correctly. Additionally, I aimed for a range of overall performance levels, from low to high CK scores in the survey, to capture varied perspectives. Since none of the independent variables, such as teaching experience, school type, etc., showed a statistically significant association with scores, they were not prioritised during sampling, although the final sample still reflected diversity across these factors. After applying the criteria, I reached out to 28 teachers. Six who responded were included in the qualitative sample (See [Appendix F](#)). These participants scored between 3 and 9 out of a maximum of 12 on the survey. Except for one item (Q22), which was selected for the interview, all other questions had at least one correct response and at least one selection of the most common distractors.

3.5.2 Interview Structure

At the start of each interview, I obtained oral consent from participants and gave them an opportunity to ask questions (Fowler, 2014). Each interview was organised into three sections:

1. **Current Practices:** I began by asking about teachers' current approaches to teaching statistics including how they use textbook activities, their views on the goals of statistics education at the primary level, and the challenges they face in the classroom.
2. **Cognitive Probing of Survey Responses:** I revisited six key survey questions identified during quantitative analysis. Teachers were shown their original responses

and asked to explain their thinking using the think-aloud technique (Collins, 2003). This helped reveal their reasoning processes and any conceptual gaps in their statistical knowledge. To support their reflection, I provided the original MCQ items and graphs. I used open, non-leading follow-up prompts when needed (See [Appendix B](#) for English and translated Marathi questions).

3. **Pedagogical Task:** I presented a classroom-based scenario involving a statistical graph. Teachers were asked to interpret the graph through their students' point of view and describe how they would address the situation if they were teaching it. This task aimed to elicit both their PCK and CK by exploring how they interpret student thinking and explain concepts like variability and central tendency. The task was inspired by Ma's (1999) *knowledge package* concept, which highlights how well-structured CK supports recognising subtle features in teaching. Teachers were encouraged to reason from their students' perspectives, offering insight into how their CK and PCK interact in practice.

3.5.3 Translation and Language Considerations

The interview questionnaire was developed in English and translated into Marathi. Unlike the survey, the conversational nature of interview questions did not require exact linguistic equivalence, so a formal multistep translation was not undertaken. However, the English version was reviewed by my supervisor for clarity and alignment with research aims and translations were reviewed by the local researcher with expertise in Marathi and statistics education to ensure linguistic and cultural appropriateness. Although interviews were conducted in Marathi, participants often switched between Marathi and English, especially for technical terms. This common form of code-switching in Indian classrooms was accommodated without any interference.

3.5.4 Pilot Study (Qualitative Phase)

A brief pilot was conducted in April 2025 before the qualitative phase. Two teachers, not involved in either the quantitative or qualitative sample, were selected using convenience sampling. They first completed the full survey and then participated in the cognitive interview. Each pilot interview lasted approximately 40 minutes.

The purpose of the pilot was: (1) to test the structure, clarity, and pacing of the interview, and (2) to assess the clarity of language. Feedback from the pilot participants indicated that the questions were clear but recommended simplifying some instructions and replacing overly formal words with terms more familiar in everyday teaching contexts. Unlike the survey

instrument, which demanded precise terminology and cognitive equivalence across items, the interview questions were inherently more flexible. As a result, fewer adjustments were needed. The main changes involved minor rewording of instructions and ensuring that prompts were conversational yet focused.

3.6 Data Analysis

3.6.1 Quantitative Analysis

The quantitative data, primarily teachers' responses to the developed survey instrument assessing statistical CK, were analysed using inferential statistical methods. I used one-way ANOVA, independent sample t-tests, and multiple linear regression (Field, 2018) to explore associations between total survey scores (dependent variable) and independent variables such as school type, medium of instruction, general education, professional education, and teaching experience. With a large sample size ($n = 251$), key assumptions for parametric tests were met. Missing data were minimal. To assess whether teachers' self-perceived confidence aligned with their actual performance, Spearman's correlation (Clark et al., 2021) was used to examine the relationship between confidence ratings (4-point Likert scale) and total scores. This approach is supported by prior work in mathematics education that examines the link between perceptions and performance of teachers and students (Li & Copur-Gencturk, 2025; Alshehri & Youssef, 2022; Ayotola & Adedeji, 2009). The combination of these methods allowed for robust exploration of performance predictors while acknowledging the complexity of teacher knowledge and confidence.

Each survey question was analysed individually. I examined item responses using basic principles from Item Response Theory (IRT) (Field, 2018). Graphs depicting item characteristic curves (ICCs) helped me identify items with poor discrimination, extreme response clustering (Secolsky & Denison, 2017, p.194). Such items were further explored in the qualitative phase (See [Appendix D](#))

3.6.2 Qualitative Analysis

The qualitative data, derived from semi-structured cognitive interviews (Denzin & Lincoln, 2018) with a purposive subsample of six teachers, were analysed thematically using both inductive and deductive strategies (Braun & Clarke, 2012). This dual approach allowed the data to speak organically while also allowing coding aligned with the study's conceptual framework, both teacher knowledge (e.g. Shulman, 1987; Ma, 1999) and statistical frameworks (e.g. Konold et al., 2004; Pfannkuch & Wild, 2004).

The six-phase thematic analysis process involved familiarisation with audio recordings of the interviews, generation of initial codes, search for themes, theme review, definition, and final writing (Braun & Clarke, 2012). The coding was done using direct audio recordings of the interview. This ensured authenticity and rigor, as transcripts are considered only a partial representation of the data (Ingram & Elliott, 2019, p.189) and important linguistic nuances may be lost in translation. Coding was performed manually, and memoing (recording my own assumptions and reflections during analysis (Richardson, 2002, p.176)) and iterative listening of the interview recordings ensured rigour and depth in theme development. This hybrid inductive-deductive framework enabled a nuanced understanding of both various level of statistical understanding and systemic influences on teachers' statistical instruction.

While reporting the findings, I use non-verbatim, free translation to ensure participants' intended meanings are conveyed accurately, as literal translation can risk losing nuance while free translation preserves contextual clarity (Rabiah-Mohammed et al., 2024). Culturally relevant translation is vital for interpreting educational experiences (Temple & Edwards, 2002), especially in this study, where teachers use probabilistic, uncertain language to express their context dependent understanding of statistical concepts in Marathi. Translation decisions have therefore prioritised meaning over exact wording to preserve conceptual equivalence across languages (Van Nes et al., 2010).

3.7 Ethical Considerations

Voluntary participation and informed consent were carefully managed. As teachers were approached through Marathi-dominant community networks, many might not be comfortable with English; hence, I translated the information sheets and consent forms into Marathi (See [Appendix C](#)), ensuring transparency about the study's purpose, rights, and confidentiality in line with survey research ethics guidelines (Fowler, 2014, p.141). After the online survey and interviews, each teacher was also given the opportunity to request removal of specific sections if they wished. Data privacy and anonymity were maintained throughout. Some teachers expressed concern about unintentionally mentioning specific names or examples during interviews. I reassured them that such parts could be removed on request and that secure storage and anonymisation would be applied. These steps upheld ethical standards and strengthened participants' trust in the research process (BERA, 2018).

Another key ethical concern I encountered arose from relying on teacher self-reports, which were susceptible to social desirability bias, recall bias, and self-report bias (Dunning et al.,

2004). Social desirability could have led participants to over-report best practices or under-report challenges, affecting data validity (Krumpal, 2013; Podsakoff et al., 2003). See [Appendix C](#) for ethical approval, original English ethics documents, and Marathi translations.

3.8 Rigour of the Research

3.8.1 Quantitative Rigour

As I developed the survey instrument for this study, traditional psychometric validation was not possible. Content validity was established through expert review by a local Marathi-speaking specialist in statistics education, who assessed the relevance, clarity, and cultural appropriateness of items. This participatory approach to validation aligned with principles of cultural validity and functional equivalence (Hosseinizadeh et al., 2022).

I could not formally test reliability, as the tool was administered only once. Internal consistency checks like Cronbach's alpha (Clark et al., 2021) were not used due to the limited number of items (12) and low variability across the five big ideas. However, pilot testing contributed to clarity and informal psychometric strength. Feedback from the pilot helped identify problematic items and improved consistency in interpretation.

Although the sample was not randomly selected, participants from across the state of Maharashtra completed the survey. Given the sufficient variability across independent categorical variables, I expect the findings to be reasonably generalisable across the state. As the tool was both newly created and culturally specific, it followed a flexible, evolving process grounded in the specific context and language (Tracy, 2010; Lincoln & Guba, 1985).

3.8.2 Qualitative Rigour

Thematic analysis followed Braun and Clarke's six-step process, which supported a transparent and systematic approach to coding and theme development (Braun & Clarke, 2012). I increased credibility through sustained and critical engagement with participants' responses from the cognitive interviews. I used triangulation by comparing patterns across multiple interviews to check for consistency or variation in how similar survey items were interpreted (Flick & Flick, 2014, p.30). Transferability was supported through detailed descriptions of the school contexts and the purposeful selection of teachers from various backgrounds, allowing others to assess the relevance of findings to similar educational settings. Dependability and confirmability were addressed through reflexive memoing and by carefully documenting coding steps and theme development.

3.8.3 Mixed Methods Integration and MMAT

Table 3.3
MMAT framework for rigour (Lorenzini et al., 2024)

MMAT Criterion	Description and Status
Clear justification for MM approach	Provided via question driven, explanatory sequential design
Quality of quantitative strand	Ensured via expert review and pilot testing
Quality of qualitative strand	Ensured via thematic analysis, triangulation
Integration strategy	Sequential: qualitative phase elaborated on quantitative results
Meta-inferences	Derived from integrated themes, e.g., teacher reasoning

The MMAT framework (Lorenzini et al., 2024) guided a critical reflection on the coherence and quality of the mixed methods design (See Table 3.3). I found the explanatory sequential approach necessary, as the survey responses, while offering an overview of teachers' statistical CK, could not reveal the reasoning, justifications, or pedagogical thinking behind answers. The qualitative phase was not merely confirmatory but added interpretive depth by offering insight into teaching-learning practices. For instance, while the quantitative data highlighted that a specific distractor attracted a high number of incorrect responses, the interviews revealed the underlying misconceptions that led teachers to choose that option. In this way, the quantitative strand informed the design of the qualitative strand, which in turn helped interpret and extend the survey results (Flick & Flick, 2014, p.34). This strategy enabled meta-inferences that were both situated and grounded. For example, teachers' statistical CK, which emerged as a key factor influencing all three research questions, was shaped by curricular expectations, the linguistic framing of survey items, etc. Integration was iterative rather than linear. Although no strong contradictions were found, alignment between strands extended my understanding of teacher knowledge and helped avoid reductive interpretations. As detailed earlier, I aimed to maintain rigour in both strands through context-sensitive validation and transparent analysis processes. The MMAT offered both a diagnostic and developmental structure to ensure consistency and robust interpretation. The study's pragmatic orientation further supported meaningful integration during analysis (Lorenzini et al., 2024; Creswell & Clark, 2018).

Chapter 4: Analysis and Findings

4.1 Quantitative Findings

4.1.1 Introduction

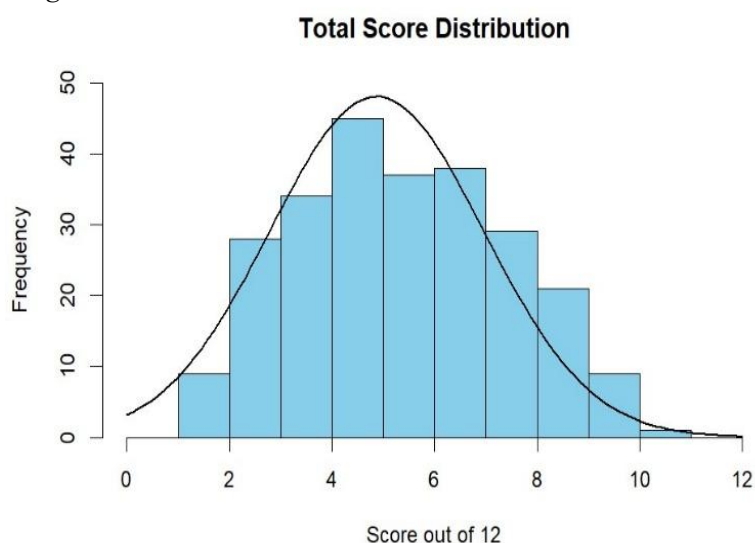
In this section, I present the quantitative findings of the study, which aimed to investigate teachers' statistical content knowledge through a multiple-choice questionnaire, to answer the first research question of this study. A total of 259 responses were collected, and 251 valid responses were analysed, with a focus on descriptive statistics, distribution of scores, and performance on individual items. I employed statistical tests, including independent t-tests and ANOVAs, to investigate potential differences across demographic variables such as teaching experience, school type, and medium of instruction, among others. Additionally, item response patterns were used to inform the subsequent qualitative phase through item characteristic curves (Secolsky & Denison, 2017).

4.1.2 Descriptive Statistics

Total Score Distribution

The questionnaire comprised 12 multiple-choice items focusing on statistical CK, with a maximum possible score of 12. The overall mean score was 4.87 (SD = 2.08, min = 1, max = 10), indicating a modest level of performance across the sample. The score distribution demonstrated slight positive skewness (0.14) and moderate negative kurtosis (-0.81), suggesting a concentration of scores toward the lower end of the scale. This was visually confirmed through a histogram of total scores (Figure 4.1.1).

Figure 4.1.1



To examine domain-specific understanding, the items were grouped into five conceptual categories or *big ideas* in statistics: (1) defining statistically investigable questions, (2) collecting data and sampling, (3) describing data, (4) understanding central tendencies, and (5) interpreting and predicting from data. These categories were developed based on the PPDAC inquiry cycle described by Wild and Pfannkuch (1999), which is discussed in detail in Chapter 3. Each subscale consisted of two or three items. Participant performance varied across the five domains. The mean scores in *interpreting and predicting from data* ($M = 1.35$, $SD = 1.02$) and *collecting data and sampling* ($M = 1.25$, $SD = 0.73$) were the highest. In contrast, the lowest performance was recorded for *defining statistically investigable questions* ($M = 0.55$, $SD = 0.57$) and *describing data* ($M = 0.60$, $SD = 0.63$) (See Table 4.1.1).

Table 4.1.1
Descriptive Statistics

Variable	n*	No. of Questions**	Min	Max	Mean	SD	SE
Total Score	251	12	1	10	4.87	2.08	0.13
By Big Ideas							
Defining Statistically investigable Question	248	2	0	2	0.55	0.57	0.04
Collecting data & Sampling	251	2	0	2	1.25	0.73	0.05
Describing Data	249	2	0	2	0.6	0.63	0.04
Understanding central tendencies	241	3	0	3	1.18	0.8	0.05
Interpreting & Predicting from Data	242	3	0	3	1.35	1.02	0.07

Note: *missing answers were marked 0, **No. of questions=possible maximum score (e.g.,12=12 marks)

4.1.3 Analysis

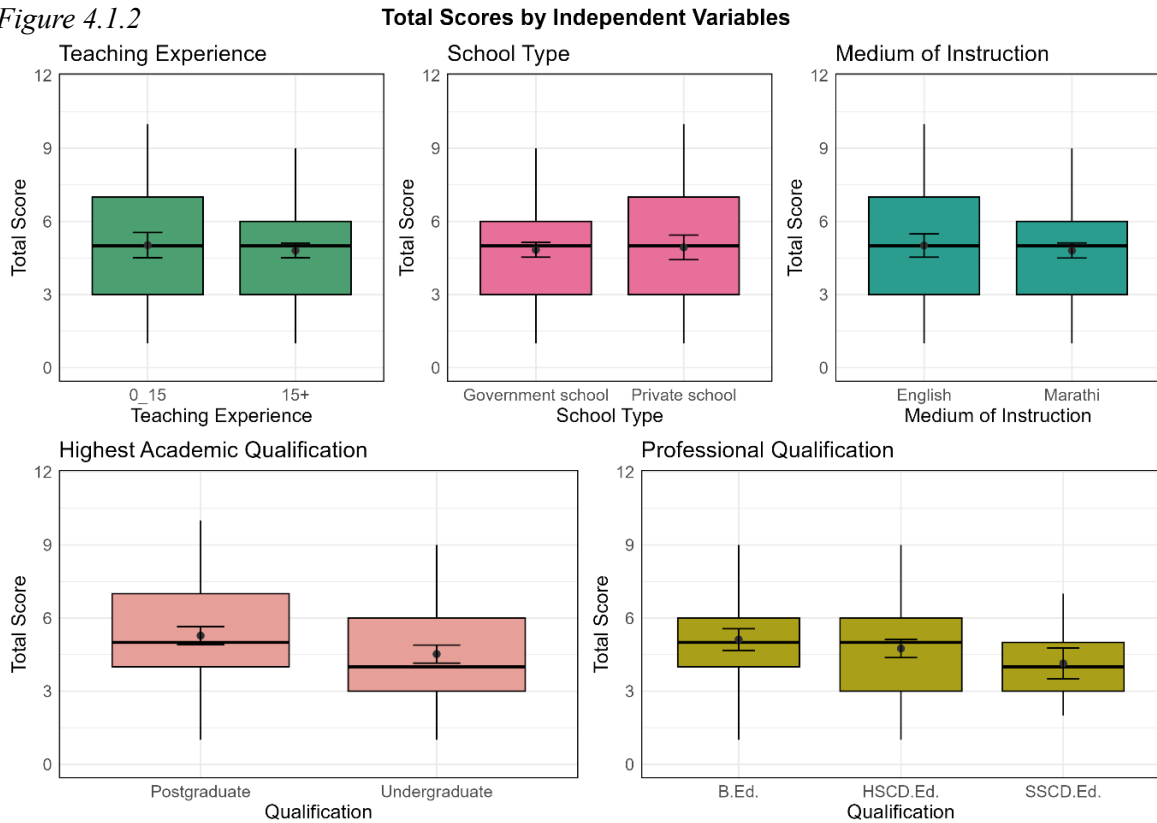
Assumptions

Before conducting the t-tests and ANOVA, key statistical assumptions were checked. Levene's test indicated that the assumption of homogeneity of variances was met across all independent variables. In addition, the distribution of the dependent variable (total score) was assessed for normality within each level of the independent variables. Visual inspections of histograms and values for skewness and kurtosis suggested that the distributions approximated normality in all

cases (See [Appendix D](#) for details). Therefore, the assumptions required for conducting the parametric tests were satisfied (Full statistical details and graphs are in the [Appendix D](#)).

T-test and ANOVA Results

Figure 4.1.2



Independent samples t-tests and one-way ANOVA were conducted to examine differences in total scores across key demographic variables. No statistically significant differences were observed based on school type, $t_{[136.25]} = -0.33$, $p = .74$; teaching experience, $t_{[117.37]} = 0.73$, $p = .46$; or medium of instruction, $t_{[136.82]} = 0.71$, $p = .48$. These findings suggest that teachers' performance on the assessment was not influenced by these background factors.

However, a statistically significant difference was found with respect to the highest academic qualification. Participants with a postgraduate degree ($M = 5.28$, $SD = 1.99$) scored significantly higher than those with only an undergraduate degree ($M = 4.52$, $SD = 2.09$), $t_{[234.08]} = 2.85$, $p < 0.01$, with a small to moderate effect size ($d = 0.37$) (Cohen, 1977). This may reflect the role of advanced academic training in increasing conceptual understanding of statistical ideas assessed through the survey instrument.

In contrast, professional teaching qualifications did not yield a significant effect, although there was a trend approaching significance, $F_{[2, 236]} = 2.65$, $p = .07$. Participants with a B.Ed. had a

mean score of 5.12 (SD = 2.17), while those with an SSC diploma had a mean score of 4.14 (SD = 1.66). Figure 4.1.2 presents boxplots of the total scores across different independent variables and their respective categories, along with the mean values and the 95% confidence intervals. Table 4.1.2 summarises the results of the statistical tests.

It is important to note that categories with very small sample sizes, specifically those holding only SSC or HSC-level diplomas under academic qualifications, and those without formal professional training, were excluded from this analysis to maintain the reliability of statistical testing (Field, 2018 p.534). The lack of significant differences may reflect the generic nature of existing PD programmes, which often overlook subject-specific needs (Singh & Sarma, 2025). This suggests a need for targeted professional development focused specifically on statistics education to create impact.

Table 4.1.2
Description and t-test, ANOVA outcomes

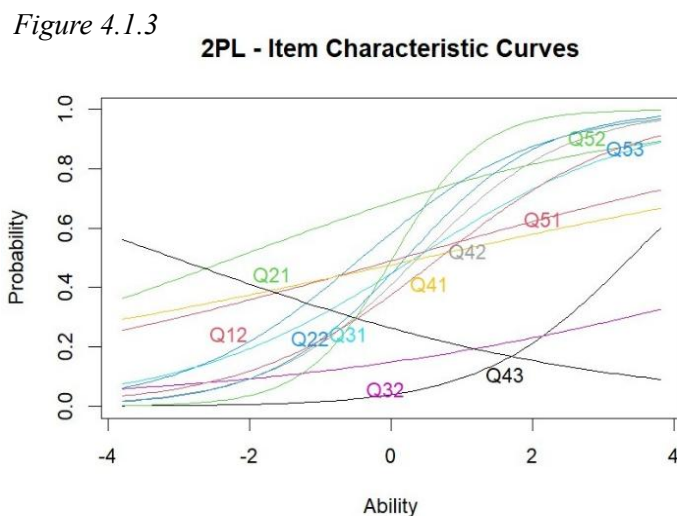
Variables & Categories	n	Mean	SD	SE	t(df)	p-value
School Type						
Government schools	172	4.84	2	0.15	-0.33(136.25)	0.74
Private schools	79	4.94	2.26	0.25		
Teaching Experience						
15+ years	182	4.81	2.16	0.26	0.73(117.37)	0.46
0-15 years	69	5.03				
Medium of Instruction						
Marathi	178	4.81	2.1	0.16	0.71(136.82)	0.48
English	73	5.01	2.05	0.24		
Highest Academic Qualification						
Postgraduate degree	112	5.28	1.99	0.19	2.85(234.08)	0.005**
Undergraduate degree	125	4.52	2.09	0.19		
Professional Qualification						
Bachelor's in education (B.Ed.)	94	5.12	2.17	0.22	F _[2, 236] =2.65	0.07
HSC Diploma in Education	116	4.75	2.04	0.19		
SSC Diploma in Education	29	4.14	1.66	0.31		

*Note: **p<0.01 (statistically significant)*

4.1.4 Item-level Response Distribution: Informing the qualitative phase.

Following the analysis of total scores, I conducted an item-level examination to explore how participants responded to each of the 12 multiple-choice questions. Given the deliberate design of each item and its distractors (See [Chapter 3](#)), this analysis offered deeper insights into patterns of teachers' statistical understanding and misconceptions. Response accuracy varied substantially across items, ranging from as low as 6% to as high as 68% correct responses. This variation is illustrated in Figure 4.1.4, which uses pie charts to depict the proportion of correct versus incorrect answers.

Additionally, item characteristic curves (ICCs) were plotted for each question (Figure 4.1.3). In these plots, the x-axis represents participants' overall ability (as indicated by their total scores), and the y-axis shows the probability of answering a given item correctly. Together, these graphical representations helped identify items with atypical response patterns or unexpected behaviour. Based on this combined analysis, six questions were selected for further exploration during the qualitative phase (*Qxy*: *x* = big idea number, *y* = question number within that idea)



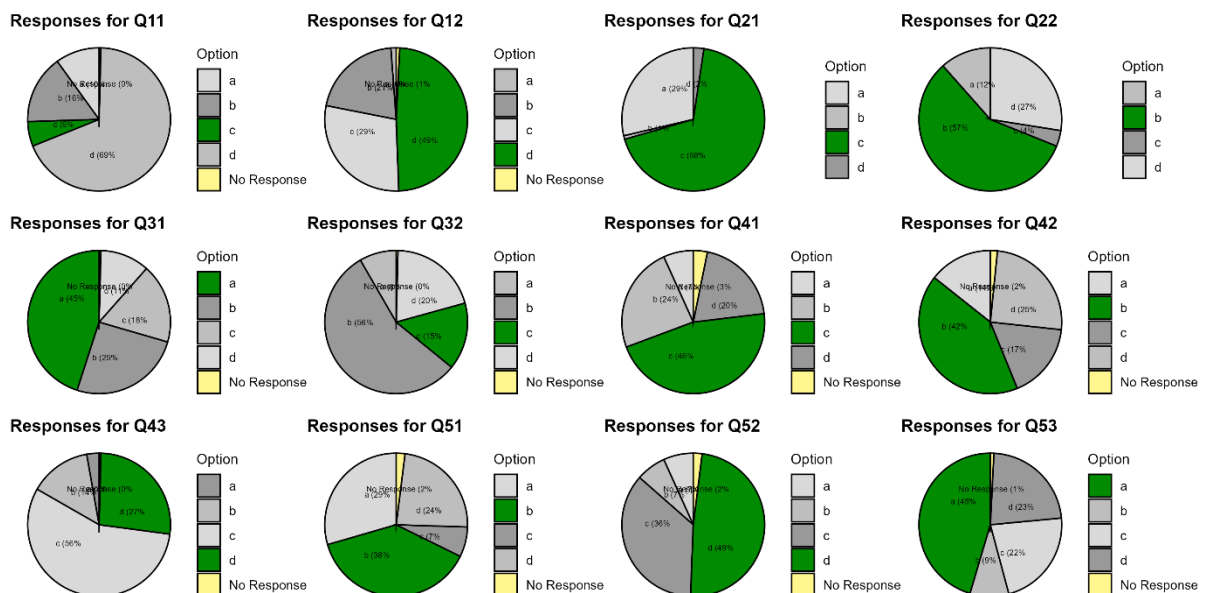
1. **Questions Q11, Q32, and Q43:** These items did not display the expected S-shaped ICCs (Secolsky & Denison, 2017). Instead, the curves were irregular, and very few participants answered these items correctly. More notably, a single distractor attracted many incorrect responses; hence, these questions were chosen for further exploration.
2. **Questions Q11 and Q12:** Although both belong to the same big idea (Defining Statistically Investigable Questions), there was a large disparity in correct response rates: only 6% answered Q11 correctly, compared to 49% for Q12. Despite Q12's ICC

appearing normal, the contrast in performance justified its inclusion for further discussion.

- Questions 22 and 52:** While both showed appropriate S-shaped ICCs, the incorrect responses were not evenly distributed among distractors. In each case, one distractor overwhelmingly accounted for most of the wrong answers. In the case of Q52, the most frequently chosen distractor was especially surprising as I considered it an *obvious no* while creating the question.

These six items were therefore flagged for detailed follow-up during the qualitative phase to better understand the reasoning processes and potential misunderstandings behind participants' choices or the potential flaws in the questions themselves.

Figure 4.1.4
Distribution of responses within each question



Note: Green indicates the proportion of participants who answered correctly.

4.1.5 Confidence Levels

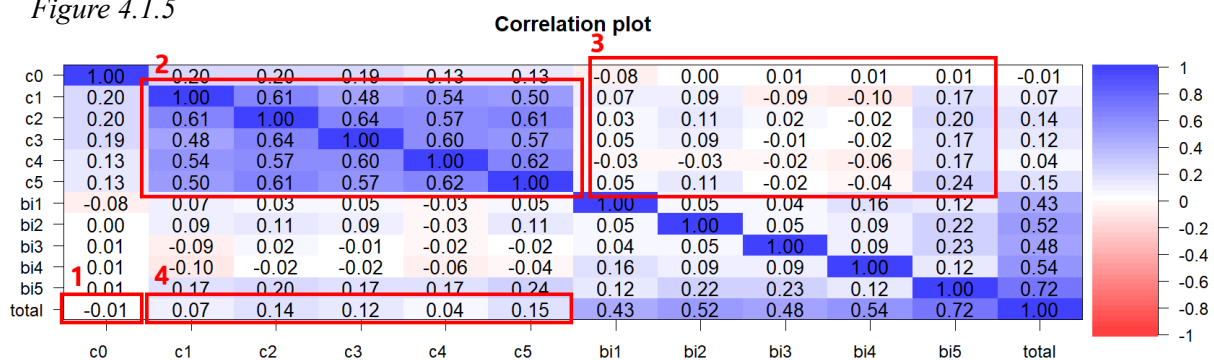
Alongside the statistical questions, I also collected data on teachers' confidence. Specifically, participants were asked to indicate whether they felt confident that they had answered the questions correctly within each big idea (Harrell-Williams et al., 2015; Li & Copur-Gencturk, 2025). To explore the relationship between confidence and performance, I conducted a correlation analysis. Distribution of responses can be found in [Appendix D](#).

The results showed no significant correlation between overall confidence (asked through a Likert scale question at the start of the survey) and total score (Figure 4.1.5, red rectangle 1),

suggesting that teachers' general sense of confidence did not align with the teachers' actual performance. Interestingly, the correlation matrix (red rectangle 2) showed moderate to strong correlations between confidence ratings across the five big ideas. This indicates that teachers who felt confident in one area tended to feel confident in all areas, while those who lacked confidence in one area generally lacked confidence across the board. In other words, teachers did not perceive any specific concept as particularly more difficult or more approachable than others. Here, the presence of the word *confidence* in the question may have acted as a priming cue, potentially shaping the teachers' responses (Double & Birney, 2019).

At the same time, no statistically significant correlations were found between performance and confidence within each big idea (red rectangle 3), except for big idea 5, where some weak correlation can be observed. This may be partly explained by the limited variability, particularly the limited range of scores within each big idea (e.g., only 0-2 or 0-3 points possible), and the use of a 4-point Likert scale for confidence ratings. Yet very weak positive correlations were observed between total score and confidence in a few specific big ideas (rectangle 4), suggesting some alignment between confidence and ability, though not consistently.

Figure 4.1.5



Note: c0 = overall confidence, bi = big idea, c1- c5 indicate confidence in Big Ideas 1-5.

4.1.6 Summary

This section reports the quantitative findings from a survey of 251 teachers, focusing on their performance on a 12-item statistical reasoning task. Descriptive statistics showed moderate overall performance, with no significant differences based on school type, teaching experience, or medium of instruction. A significant difference was found between teachers with postgraduate and undergraduate academic qualifications. Item-level analysis revealed variability in performance and highlighted six items with unusual response patterns or strong distractors, which were selected for further exploration in the qualitative phase. Confidence ratings showed no significant correlation with actual performance, although confidence across

different statistical ideas was strongly interrelated. Minimal missing data were observed, and complete case analysis was used in correlational tests. The quantitative results provide an overview of how teachers engage with the various stages of the statistical inquiry cycle and inform the design of the next phase of the study, in which selected items will be explored further through interviews. However, teachers' understanding of each big idea will only become clear through the qualitative findings.

4.2 Qualitative Findings

4.2.1 Introduction & Participants

This section presents the qualitative findings of my study, which aimed to explore primary pedagogical practices and teachers' statistical knowledge, extending the quantitative findings. These findings build on the survey data analysed earlier and offer insight into teachers' reasoning, classroom practices, and their understanding of children's engagement with statistics. Semi-structured interviews were conducted with a purposive sample of participants selected from the survey pool. The interviews were divided into three parts, aligning with the study's research questions. Findings are presented accordingly: teacher-reported practices, statistical CK, and statistical PCK.

The six teachers selected for interviews represented a range of professional backgrounds, language contexts, school types, and total scores on the survey. More importantly, all participants had answered the six selected survey questions, either choosing the commonly selected distractor or answering correctly (in most cases) (See [Appendix F](#)). Their varied total scores enabled an exploration of different reasoning patterns. Each participant had experience teaching mathematics at the primary level. Interviews were conducted in Marathi, although code-switching into English was accepted when initiated by the teacher. Table 4.2.1 outlines relevant background information for each participant.

Table 4.2.1*Backgrounds of the participants*

No.* ¹	Professional Qualification	Highest Academic Qualification	Years of Experience	School Type	Medium of Instruction	District	Total Score (/12)
T1	B.Ed.	Ph.D.	15+	Gov.**	Marathi	Parbhani	3
T2	HSc D.Ed.	B.A.	15+	Private	Marathi	Kolhapur	4
T3	B.Ed.	M.A.	0-15	Private	English	Pune	6
T4	B.Ed.	M.A.	15+	Gov.	Marathi	Pune	7
T5	None	B.Tech	0-15	Private	Marathi	Palghar	8
T6	B.Ed.	M.A.	15+	Private	Marathi	Mumbai Sub	9

Note: * Teachers are hereafter referred to by their assigned numbers. **Gov.=Government School,

¹All participants are anonymised using she/her pronouns.

4.2.2 Section 1: Teacher-Reported Classroom Practices

Textbooks provided by the government free of cost are the most used teaching and learning materials in Maharashtra (as discussed in Chapter 1). Hence, during the interviews, I began the conversation around the textbooks, and teachers organically spoke about what they did beyond the chapters in them. When I asked what they think are the objectives of teaching statistics in primary school, teachers offered a range of interpretations. Their responses can be grouped into the following three categories.

1. **Unrelated to statistics:** T1 mentioned that interpreting data is the main objective, but when asked to exemplify, she gave a completely unrelated example of being able to divide students into equal groups, say while playing sports. T2 said that students should get knowledge of everyday transactions, like calculating the total amount using rates in a shop. This response indicates a conflation of objectives with general mathematics education objectives. The objectives articulated by the teachers are unrelated to statistics, and probably these teachers have misinterpreted some words in the question, like *Sankhyiki* (statistics) or *Mahiti Vyavasthapan* (data handling) (University of Cambridge, 2025), which are not used in colloquial Marathi and have been coined for curricular purposes. Both these teachers are from the lowest band of scores on the survey instrument.
2. **Focused on the visual representation:** T2 and T4 suggested teaching proportions, specifically scaled representations like ‘1 house = 20 houses’ on the y-axis, as a major statistical learning outcome. While this may be considered a prerequisite for creating a visual representation, treating it as a core statistical objective is far-fetched. While T4 also

emphasised constructing graphs and representing large numbers through graphs, T3 suggested interpreting data by reading the graph to be the major objective. These explanations suggest that teachers have a strong procedural orientation focusing on mathematics rather than statistics, which may result in losing sight of the larger goal.

3. **Based on the statistical enquiry:** T5 and T6 reflected a closer engagement with statistical enquiry, where T5 mentioned drawing conclusions and making predictions, and T6 emphasised data collection for decision-making. These latter responses aligned more closely with curricular expectations (NCERT, 2023).

To build on this discussion, I then presented the learning outcomes (LOs) stated in the curriculum. All, except T1, expressed that there was limited direct alignment between the stated LOs and the textbook activities. T1 mentioned (See [Appendix E](#) for original Marathi quotes),

“Yes, of course, these activities are sufficient. Basically, all these things are taken into account while making the curriculum. The curriculum and the content in the textbook are determined according to the objectives. Therefore, the content and the activities in the textbooks fulfil the objectives”

This response shows almost blind faith in what is provided in the textbooks as described in Kumar’s (1988) idea of textbook culture. Other teachers described the LOs as “broad”, “idealistic, or “crude”, while critiquing the associated activities as “insufficient in number”, “disconnected from students' lived contexts” (particularly those from rural backgrounds) or “incomplete”. E.g., T6 noted,

“Textbooks contain crude data, and students are expected to answer the question based on that data. If you do not read the [learning] outcomes, you will not be able to teach properly. [Textbooks do not expect] to go beyond the given data and draw some conclusions.”

This suggests that the teachers were aware of the gap between the textbook and curriculum. Consequently, nearly all reported conducting supplementary activities beyond what is provided in the textbooks. All teachers, including T1, highlighted the need to contextualise learning by incorporating examples from students’ immediate environments. T2, T5, and T6 further mentioned that these additional activities were important for achieving the intended LOs, but they found it difficult to practice this idea due to time constraints.

When presented with a specific textbook activity and asked how they would implement it, all teachers contextualised the task within their own classrooms. For instance, in response to a

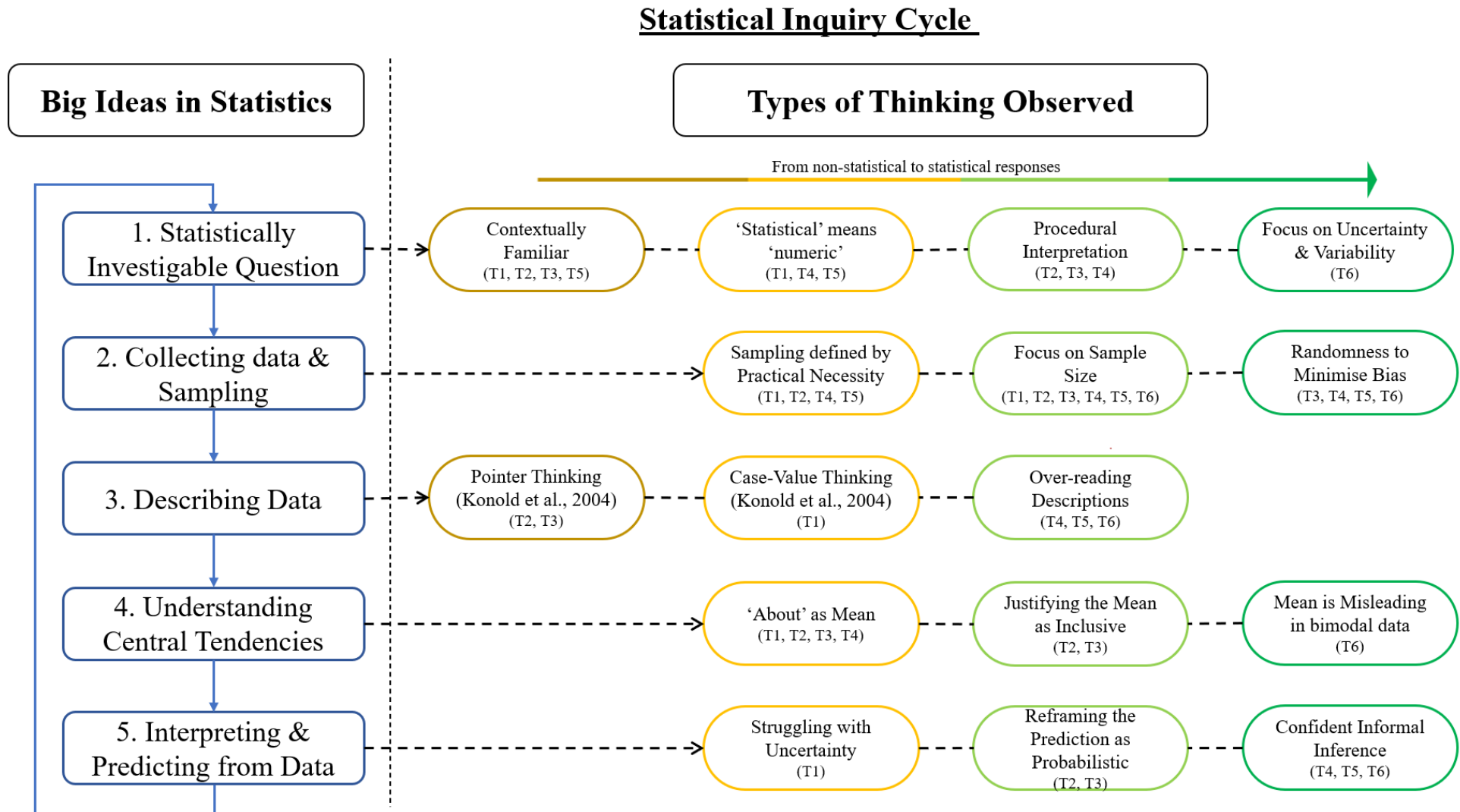
textbook task asking students to interpret data on children's Sunday evening activities, T5 decided to collect data directly from students instead of using the ready-made data from the textbook. T2, in a similar activity, adapted the task by creating context-relevant categories. T4 suggested asking questions not given in the textbooks and encouraging students to frame their own questions based on data. However, the questions suggested by T4 remained comparative in nature. Though, useful as a starting point, such questions should focus on data as an aggregate and encourage students to identify patterns, interpret trends, and draw conclusions, which is the core purpose of graphical representation.

While these adaptations demonstrated creativity and contextual responsiveness (McEwan & Bull, 1991), teachers did not necessarily engage with all five *big ideas* of statistics based on the statistical enquiry cycle (Wild & Pfannkuch, 1999). All teachers focused on actual data collection, followed by creating visual or tabular representations. But, except for T5 and T6, their data interpretation focused on individual data points or basic comparisons. This suggests a tendency toward *case value* (Konold et al., 2004) type reasoning, without any engagement in aggregate-level reasoning. T5 and T6 focused on data as aggregate and gave students opportunities to draw conclusions or make predictions. Only T6 consistently emphasised clarifying the purpose of each statistical activity and articulated the guiding question for data collection, touching upon all five big ideas

All teachers also reported a lack of targeted support or training in statistics-specific pedagogy or content knowledge. To address this, they employed various strategies: T4 referred to the teacher handbook, T1 drew on their own school education, T3 sought support from colleagues, and T6 used student test results to inform teaching. Teaching multilingual classrooms, supporting children with SEN, and a lack of time were among the most mentioned challenges. T2 and T5 also noted that learning statistics requires strong prerequisites, including number sense, comparison, ratios, and language skills to interpret questions. These are often underdeveloped in students, which creates difficulties in teaching.

To summarise, teachers actively adapted and went beyond the textbook tasks, recognising the existing gaps. However, their practices largely remained procedural, with limited focus on statistical enquiry. This disconnects between the teacher-reported objectives and classroom practice likely stems from a lack of targeted professional development, despite teachers' willingness to do more.

Figure 4.2: Map of the themes of teachers' CK



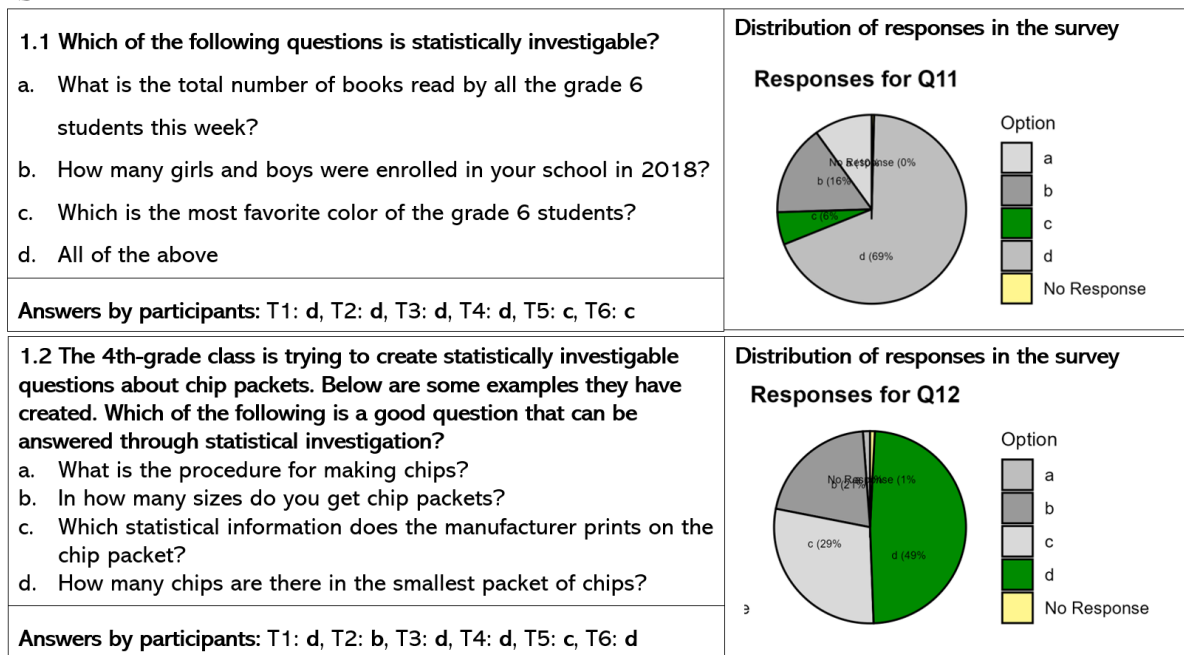
4.2.3 Section 2: Teachers' Content Knowledge

In this section, I discuss teachers' content knowledge as explored through interview conversations based on selected survey questions (selection criteria detailed in the quantitative findings section). I begin by examining responses question by question, as each item was designed to probe a specific *big idea* in statistics (as defined earlier). I identified typically 3 themes within each big idea (16 themes across 5 big ideas), each showing a natural progression in teachers' understanding of that idea, from non-statistical to more statistical. Figure 4.2 summarises these CK-based themes.

Question 1 and 2: Statistically Investigable Question

Figure 4.2.1

Question 11, 12 details



The objective of these two questions was to examine whether teachers could distinguish a statistically investigable question (one involving uncertainty and leading to a process of statistical enquiry (Arnold, 2012; Chin & Osbourne, 2008)) from other questions that might require collecting information but are closed or non-mathematical (Allmond & Makar, 2010). Figure 4.2.1 shows the original survey questions and the distribution of responses. The following were different types of interpretations of what teachers considered a statistically investigable question.

1. **Contextually familiar:** Here, teachers focused on the everyday relevance of the questions. T5, for instance, changed her response from correct to the distractor, arguing that all the questions related to a child's daily life should be considered statistically investigable. T1, T2, and T3 also mentioned the familiar context but did not build further on it. This interpretation may be influenced by the learning outcomes provided in the curriculum, which emphasise contextual familiarity while teaching statistics
2. **'Statistical' means numeric:** Some teachers focused on the term statistically and interpreted it as something to do with numbers. T1, T4, and T5 described a "statistical question" as one that has a "countable" or "numeric" answer. This interpretation may have stemmed from linguistic overlap in Marathi, where *Sankhyiki* (statistics) closely resembles *Sankhya* (number) (University of Cambridge, 2025), possibly leading to conceptual confusion between the terms *numerical* and *statistical*.
3. **Procedural interpretation:** Some teachers focused on the procedures for their interpretation. T2, T3, and T4 stated that all questions required data collection and were thus investigable. T4 added that each question could produce a graph. While reasoning for Question 1.1, she said,

"Graphs of all three [options] can be drawn. Through this, we can compare things and an answer can be found through drawing graphs."

When asked to give an example, T4 focused on the process of drawing the graph for option (a) of 1.1. She explained how student names would be on the x-axis and the number of books on the y-axis. She discussed adjusting the scale based on notebook size, etc., shifting away from the question itself. This interpretation shows a strong engagement with the fragments of the process of statistical inquiry. This type of interpretation could be influenced by the textbook activities, which also take this fragmented approach.

4. **Focus on Uncertainty and Variability:** T6 was the only teacher who answered both questions correctly in the survey. Her explanation for Question 1.1 was centred around the concepts of uncertainty and variability:

T6: "I was wondering what statistics can be done in option (a), what will be the variety in it... And again, in option (b), if we find out the total number of children, what will we do with it?"

R: "What do you mean?"

T6: "You get the answer directly in one number."

R: "You said there is no variety, can you tell me more about that?"

T6: “In option (c), if we note the favourite colour of each child and plot a graph of that [data], we can infer something about the most favourite colour of the grade six students.”

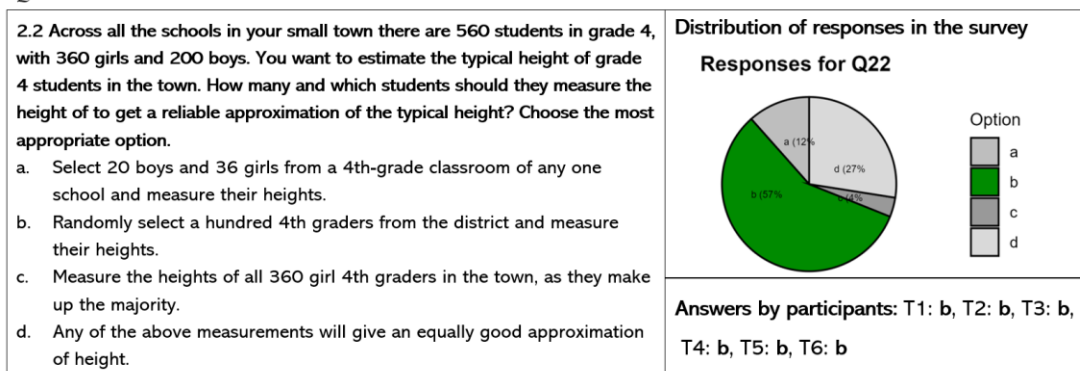
Her reasoning reflected an understanding that a statistically investigable question should involve uncertainty and should guide the purpose of statistical enquiry.

Overall, most teachers viewed closed questions (Allmond & Makar, 2010) with familiar contexts as statistically investigable. They did not realise that without uncertainty and variability, such questions become merely mathematical, with answers reduced to single values. This is in line with Makar and Rubin’s (2009) finding that teachers find it difficult to frame statistically investigable questions. T5 noted that children often lose interest in the long, repetitive data collection process. This may be due to an absence of a clear guiding question that makes statistical inquiry meaningful.

Question 3: Reasoning about Sampling

In the survey, many teachers answered the sampling question correctly. However, I intended to explore whether this was due to an understanding of randomness or influenced by the translation of *random* as *yadruchhik* in Marathi, a rarely used, coined term. I suspected the unfamiliarity of the word may have hinted at the correct answer (See Figure 4.2.2). Teachers’ explanations varied considerably: while all provided valid reasoning, the depth of their responses differed. Most teachers offered layered arguments indicating a more developed understanding of statistical sampling.

Figure 4.2.2
Question 22 details



1. **Sampling defined by Practical Necessity:** T1, T2, T4, and T5 initially justified their choice by emphasising the practicality of selecting 100 students. The focus here was not on randomness per se, but on the feasibility of data collection from a large population. T1, for instance, explained:

“Because we can't count all the students, what is easier? The easier solution is to take 100 students from all the classes in the city. Since the number is so large, 560, then instead of counting 560, we take 100 students.”

This line of reasoning reflects an understanding of a sample as a part of a whole (Groth & Bergner, 2005), with the added emphasis on practicality in collection. T1 chose the correct option because of its manageability, with no particular focus on randomness.

2. **100 is a Sufficient Sample Size:** All six teachers (T1-T6) discussed the adequacy of selecting 100 students from a population of 560, using terms such as “proportionate to the population size” and “good enough to get an estimate”. T1 and T2 argued that 100 is a good number for a sample but they neglected the need for randomness. T3 and T5 extended this by reasoning that, due to the known low variability in children’s height at that age, a sample of 100 would still yield a reliable estimate. As T3 explained:

“There is a certain amount of height growth at this age. It is very rare that a child grows a lot in height, or a child stays very short; there are examples of this, but they are very few. So, if we want an approximation, even taking 100 can work.”

Considering the population of 560, all the teachers felt that a sample of 100 was sufficiently large to offer a reasonable approximation. Even before the idea of randomness was discussed, teachers gave considerable thought to the implications of sample size, recognising that small samples could not provide reliable estimates.

3. **Randomness for Representation and Minimising Bias:** T3, T4, T5, and T6 extended their reasoning by engaging more directly with the concept of randomness. T4 described random sampling as more “standard” and “less influenced by individual preferences”. T6 highlighted its ability to include a range of heights, thus capturing variability and enabling better approximation. T5 explicitly referenced the concept of bias:

“Why take it randomly? Suppose I have some bias in my head when choosing children. Suppose I believe that the boys are taller, I may only choose tall boys, then [the height] cannot be considered representative because it will have a bias.”

These arguments reflect a stronger understanding of random sampling in improving representativeness and reducing selection bias.

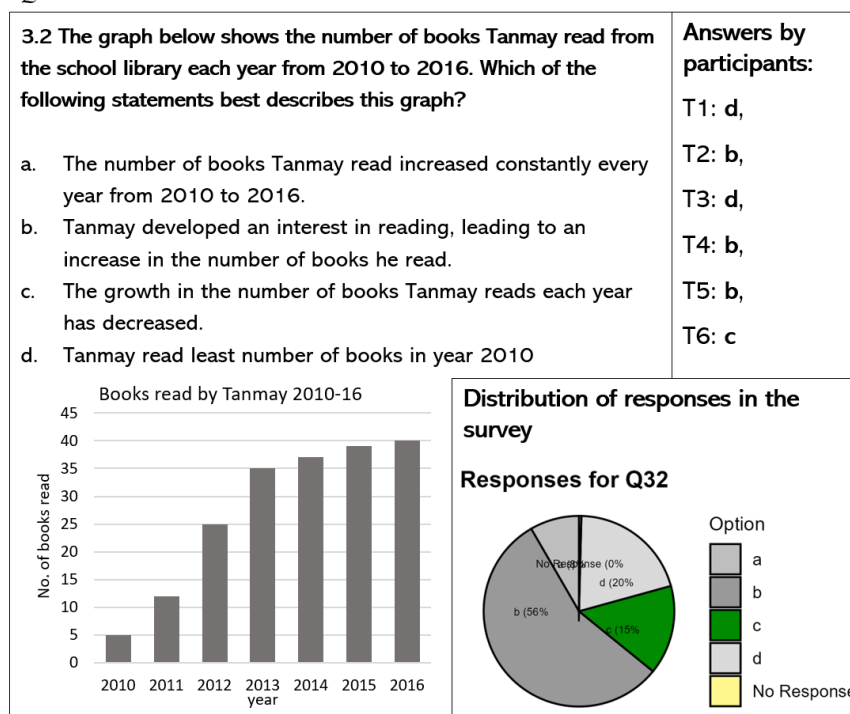
Importantly, all teachers rejected selecting students from a single classroom (though practical), arguing they must consider the entire town, not just one class. This suggests they did not view the sample as merely a part of the whole, but as something that must reflect the wider population. Contrary to earlier research findings (Groth & Bergner, 2005; Garfield, 2003),

these teachers demonstrated a more sophisticated conceptual grasp of sampling, particularly regarding size, representation, and the implications of random selection. This may also be attributed to the contextual familiarity of the question, as measuring students' height is a routine school activity that teachers have encountered frequently, making the scenario more relatable.

Question 4: Describing Data

This question, aimed at assessing understanding of the big idea *describing data*, had one of the lowest percentages of correct responses. A particularly strong distractor (option (b)) appeared to attract many teachers, likely due to a sweeping, yet familiar, claim. *Children should develop an interest in reading* is a commonly stated objective in educational documents in Marathi. Interestingly, teachers' explanations aligned well with the types of early statistical thinkers identified by Konold et al. (2004), but an additional category also emerged, where teachers tended to overread graph descriptions.

Figure 4.2.3
Question 32 details



1. Pointer: T2 and T3 both selected option (b), and while they described the graph, their reasoning extended beyond the data into assumptions about the context, particularly about Tanmay's personal interest in reading. T2, who initially selected option (d), changed it during the discussion, stated:

“The number of books has increased, which means his reading has increased. The reason why something increases is because we like it... So, this is

applicable especially for students because ‘interest’ is most important in education. Without it, you can’t learn anything even if you have the capability.”

This response reflects more than the typical *pointer* thinking, where data is ignored altogether. Here, teachers did refer to the data but relied more heavily on contextual and causal reasoning drawn from the background situation, rather than strictly describing the graph.

- 2. Case-Value:** T1 chose option d, which did not refer to the entire graph, despite the question highlighting the need to select the statement that describes the entire graph. When asked why she did not choose other options, she explained:

“There is a particularity in this option (d)... it is not option (b) because it is more linguistic, and (d) is more mathematical... other [options] are just wrong.”

Despite the explicit instruction, her reasoning showed a focus on isolated values rather than trends or the overall graph. This suggests a form of *case-value* thinking, where individual data points are prioritised over aggregate patterns (Konold et al., 2004).

- 3. Overreading Descriptions:** Apart from Konold’s typology, another inductive theme emerged from the data. Only T6 initially selected the correct option, justifying it by referring to the overall shape and the decreasing rate of growth. She noted,

“I thought that compared to 2010-2011, the [growth] later, like in 2014-15, is less. I mean, compared to the first few years, the increase in number of books is only by 2-3 in the latter years”

However, during the discussion, she changed her answer to option (b). This shift suggests that T6 read graphs as aggregates, but she blurred the line between description and inference. The tendency to overread into data by bringing personal or contextual knowledge led T6 to overlook the focus of the question, which was to describe rather than infer.

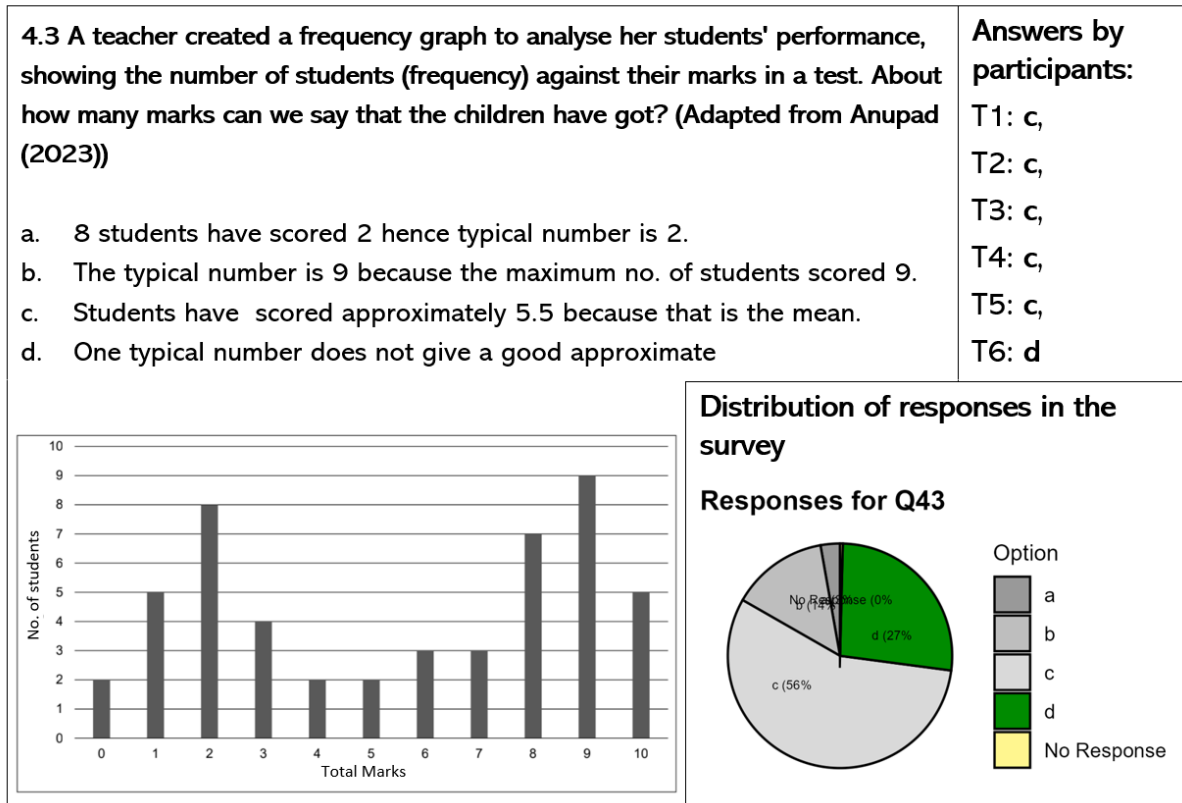
Further, the correct option (c) was often dismissed as obvious by all except T6. They misread it and equated decrease with negative trend direction, overlooking the fact that while the graph shows increasing values, the rate of increase was slowing. This subtlety, coupled with the distractor’s appealing language, likely contributed to this distribution of responses in the survey.

Question 5: Central Tendencies

This question aimed to assess whether teachers understood that the mean is an appropriate measure of central tendency, primarily when the data distribution is roughly normal. All

participants, except T6, selected option (c), indicating a general tendency to treat the mean as a default measure, irrespective of data distribution.

Figure 4.2.4
Question 43 details



1. ‘About’ as Mean: T1, T2, T3, and T4 focused on the word *about* in the question and immediately equated it with the mean. This interpretation led them to overlook the shape of the distribution completely. Even when I brought back their attention to the graph, they preferred calculating the mean. T1 persistently argued:

“I will add all the marks [by reverse] calculating from the graph and divide them by the number of [students]... because in the end, when ‘about’ how many marks are to be found, it is expected to calculate the average.”

This response reflects a procedural view of the mean. T1 did not see it as a typical or representative number.

2. Justifying the Mean as Inclusive: T2 and T3 expanded on the above reasoning by arguing that calculating the mean includes all data points and therefore must be considered typical. T2 explained:

“I thought about the entire graph. That is, how many students got 2 marks and how many got 3 marks [and so on] ... To calculate the average, we need to consider the entire class. If we say 9 marks [to be typical], we only focus

on one number. I am saying [the answer is] the mean because it considers all the students.”

Here, the mean was favoured not because of its representativeness, but because the entire dataset is used to calculate it. This shows a limited understanding of central tendency, where inclusion of data points is equated with typicality, without attending to the distribution of data or clustering.

3. Mean is Misleading in bimodal data: T6, who correctly chose option (d), demonstrated an intuitive grasp of the problem posed by using the mean in a bimodal distribution. She stated:

“The mean is 5.5. But there are not that many students who got 5.5 marks. There are many more who got, say, 10 marks. On the other hand, there are 5 students who got 1 mark too. So that [the mean] does not seem right.”

While T6 recognised that the mean did not reflect the data’s central features, she struggled to articulate alternative typical values. When probed about two possible representative values, she agreed in principle but hesitated to specify them. This might be due to the limited exposure to interpreting such distributions.

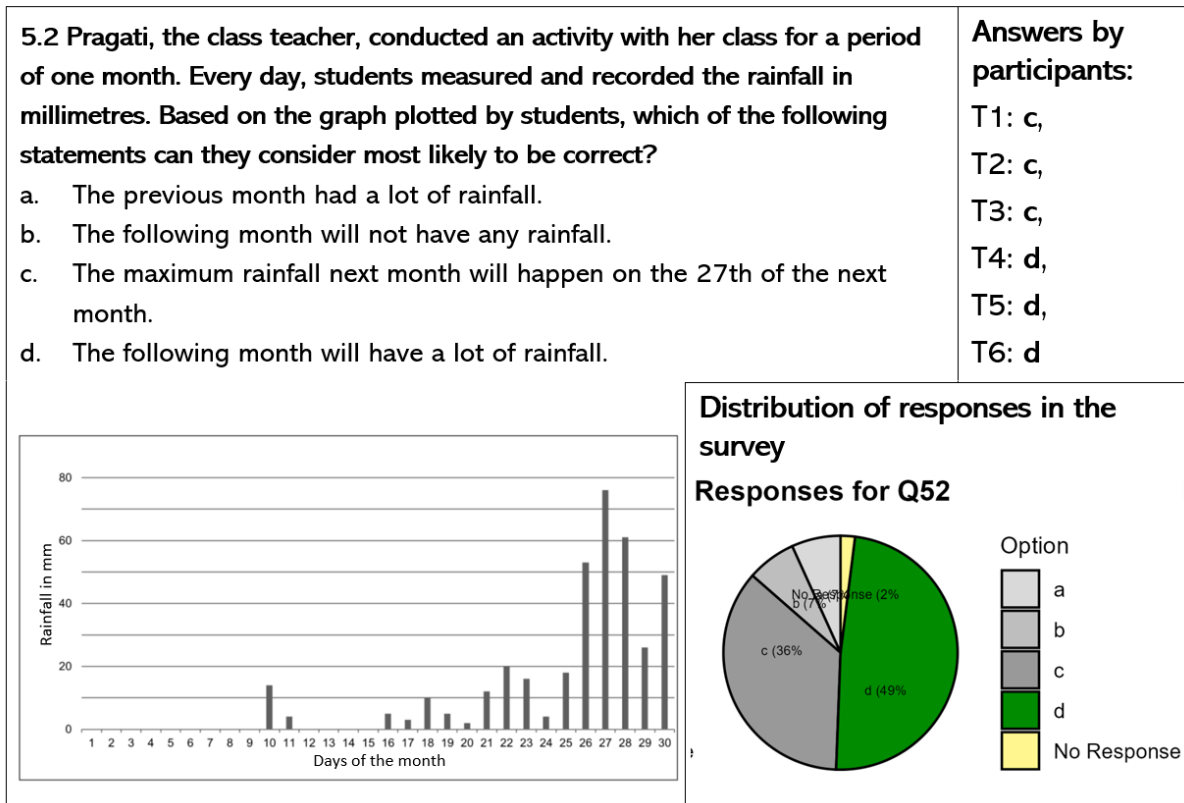
When the correct option (d) was discussed during probing, T2, T4, and T5 shifted away from statistical reasoning entirely. They argued philosophically that one number will never be a good approximation, may it be the average, to represent students’ abilities. They rejected the correct option as it did not look truly mathematical to them. However, none proposed either 2 or 9 marks as a typical value, noting that doing so would ignore a significant portion of the class. This reflects a deeper issue that teachers may lack the conceptual understanding that measures of central tendency are tools for representing typicality, which must be selected in relation to the distribution of the data. Given that teachers may be unaccustomed to interpreting non-normal data, the assumption that one typical number must exist often goes unchallenged in practice, concealing the limitations of the mean in skewed or bimodal datasets.

Question 6: Inferences and Prediction

In India, rainfall follows a typical monsoon pattern, starting in mid-June, it peaks in July and August and gradually decreases over September and October. The teachers in this study, like anyone from India, are well acquainted with this pattern. Considering this a prior knowledge, this question required teachers to engage in informal statistical inference (Makar, 2013; Makar & Rubin, 2009) by making a prediction based on data, going beyond

what was presented (Makar & Rubin, 2009). In this task, teachers were expected to interpret the predictions not as definitive claims but as ones embedded with probability. The following were some prominent themes.

Figure 4.2.5
Question 52 details



1. Struggling with Uncertainty: T1 selected an option that appeared the least plausible prediction given the graph. Initially, she did not differentiate between a definite statement and a predictive statement with uncertainty. Upon further probing by drawing attention to the question’s wording about selecting the *most likely* claim, T1 shifted her stance. However, rather than identifying the most likely outcome, she defaulted to a position where all predictions were treated as equally uncertain due to a lack of additional information. She noted:

“Any of these can happen... If we think about it from the students' perspective, they don’t know about the other conditions, such as the direction of the winds or the environment that is necessary for the rainfall to occur.... Even experts cannot predict, how can children tell?”

T1’s discomfort with making a probabilistic inference in the presence of uncertainty led her to disengage from evaluating likelihood altogether. This tendency is common

among students early in learning data-informed prediction, where they often either make definitive claims or reject predictions due to uncertainty (Ben-Zvi et al., 2012).

- 2. Reframing the Prediction as Probabilistic:** T2 and T3 initially misinterpreted the options and thought that option (c) referred to the current month rather than a future one. Upon re-reading, they found all statements problematic, as they treated them as definitive. T3 commented:

“It is not option (a), we can’t do this, we can't predict rains like this, after all, it’s nature [anything can happen] ... Given that the graph is of this month, we can only talk about this month... I don’t think any of these [statements] are possible.”

To explore this further, I again highlighted the part of the question emphasising the *most likely* prediction. This reframing helped both teachers recognise that the statements were not definitive claims but probabilistic ones. This shift eased their initial discomfort. They then returned to the data, began considering overall patterns, and made informed choices. T2, for instance, reflected:

“Option (d) would be correct then. If you look, there has been no rain for the first 10 days, it is slowly increasing.... So, I am making a prediction here that it will continue.”

After making this claim, T2 highlighted multiple times that it is only a prediction, emphasising the assumed uncertainty.

- 3. Confident Informal Inference:** T4, T5, and T6 answered the question correctly in the survey and continued to justify their reasoning using both the data trend and appropriate uncertain language. Their explanations showed an awareness of prediction as a probabilistic statement rather than a definitive one. T4 stated:

“If you see, it hasn't rained much in the first 10 days, and [in the latter half] the rainfall is increasing gradually. So, I can more or less say that this trend is likely to continue over the coming days.”

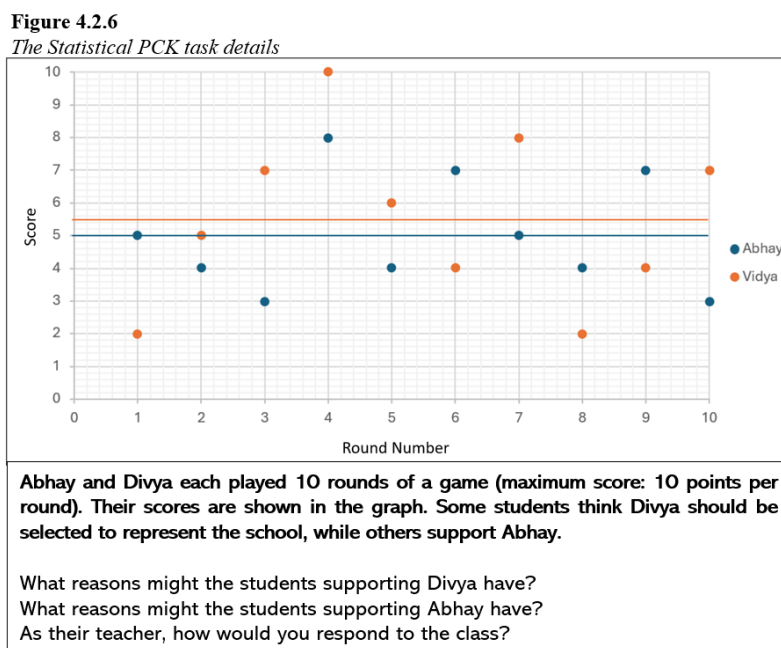
This response illustrates clear informal statistical inference, integrating the use of aggregated data as evidence and making a claim beyond given data with informal probabilistic terms such as “likely” and “more or less” (Makar, 2013; Ben-Zvi et al., 2012).

This range of responses suggests that not all teachers were comfortable with using uncertain language, and many noted that they had never encountered such a question before. If the power of statistics lies in its inferential dimension (Ben-Zvi et al., 2012),

and we aim to give students exposure to it, then it may be necessary to support teachers in developing this skill.

4.2.4 Section 3: Teachers' Pedagogical Content Knowledge

This task required a balance of CK and PCK, as teachers had to interpret data themselves while also reasoning through a student's perspective (See Figure 4.2.6). When asked why students might support Vidya, all teachers referred to her higher mean score. This was visually apparent through the horizontal lines indicating mean scores on the graph.



However, when asked to consider why a student might support Abhay, responses fell into two categories.

1. Recognising pointer-type thinking: T1, T2, and T6 believed that Vidya was clearly the better choice. They anticipated that students may have ignored the data, and students' bias might be playing a role while selecting Abhay despite his lower average. For example, T1 said:

“So, children can say that they want to send a boy or that Abhay is their friend. Some may think that they shouldn't send a girl, what will she do... So, I will have to explain who is better.”

This shows teachers' awareness that students may make decisions based on the events or their beliefs (pointer (Konold et al., 2004)), rather than statistical evidence. However, these teachers did not recognise the spread of the data (variation) at all.

2. Observing variance and consistency: T3, T4, and T5 recognised the role of variation.

They interpreted students' preference for Abhay as possibly stemming from a perception of consistency in his performance. As T4 explained:

“The children may be thinking that even though Abhay's [average] score is low, the variation is low. That is, his points are closer to average. His scores have fallen in a certain range, with a minimum of 3 and a maximum of 8. That means his performance may be steadier.”

These teachers also mentioned pointer-type reasoning, but their main focus was on statistical variation. They used words like “steady”, “consistent” and “reliable” to describe the low variation.

Together, these responses indicate that while all teachers acknowledged possible non-statistical reasoning by students, some were also able to attribute statistical justifications involving consistency and variation.

The Role of Content Knowledge in Interpreting Student Thinking

As Ma (1999) argues, well-structured CK contributes significantly to teacher understanding. This was clearly evident in how teachers interpreted student reasoning in the PCK task. For instance, T2 did not identify variance in the graph and instead focused on non-statistical explanations for why students might choose Abhay. She said:

“Some children may feel that [Abhay] can perform better because he is a boy... but they may not understand the graph properly. So, we understand their reasons and then take them towards the correct answer whose average is higher.”

T2's comment reflects an awareness that students might ignore the data entirely and rely on beliefs or events, what Konold et al. (2004) describe as *pointer* thinking. She recognises this as incorrect but also did not engage with the statistical reasoning that might underlie students' choices. Importantly, T2 herself demonstrates pointer reasoning in a separate CK question (See [Question 4](#)), where the concept of rate of change or slope was required. While she effectively recognised students' pointer thinking about the mean in the PCK task, a concept familiar to her, she reverted to pointer-type reasoning herself when addressing a less familiar statistical concept, such as slope. This suggests that her ability to understand students' reasoning is shaped by her own CK.

This example highlights how CK not only influences how teachers interpret data but also how they anticipate student thinking. Without a firm understanding of key concepts,

teachers may struggle to identify valid statistical reasoning, even in their students' thinking.

The Role of Situated Knowledge

McEwan and Bull (1991) argue that all knowledge is inherently pedagogical content knowledge, as it is situated and always presented with the intention of communication. This suggests that when a question is situated in a familiar context, teachers may respond differently. This was clearly observed in the case of T3. In the CK task related to prediction (See [Question 6](#)), T3 struggled with the use of uncertain language and was unable to extend her reasoning beyond the given data. However, in the PCK task, where the context involved student performance, something more familiar, she was much more confident in reasoning about prediction. She explained:

“While choosing a representative, it is important to check if they are consistent. If there is uncertainty that you get 10 or as low as 2, then it is risky. But if someone who is consistent is not taking pressure... then he is a good player. So, I would advise the children to choose the one who has more guarantee.”

Here, T3 addressed uncertainty with clarity and confidence. This shift is likely because making inferences from students' academic or performance data is a routine part of teachers' professional judgment. In contrast, predicting weather or rainfall (contexts used in CK tasks) is not something they engage with regularly. This contrast supports the idea of knowledge as situated. It also has implications for teacher education: if concepts like inference and prediction are introduced in familiar contexts, teachers may engage with them more deeply before applying them in less familiar domains.

4.2.5 Summary

The qualitative findings highlight both the resourcefulness and the limitations of primary teachers' engagement with statistics. Across interviews, teachers showed a tendency to adapt and contextualise textbook activities, recognising gaps between curricular objectives and prescribed tasks. However, much of their practice remained procedural, focusing on data collection and representation over engagement with statistical enquiry. Only a few teachers articulated the broader purpose of statistical investigations, reflecting a lack of alignment between teachers' reported objectives and curricular LOs. This reliance on procedural reasoning extended into CK tasks. Many teachers struggled to distinguish statistically investigable questions, often conflating familiarity, numerical answers, or textbook-derived procedures with statistical enquiry. Similarly, their reasoning about

central tendencies and data description revealed strong reliance on the mean as a default and difficulty interpreting aggregate patterns, especially in non-normal distributions. Positively, teachers demonstrated relatively sound understanding of sampling, particularly the role of representativeness and bias, which contrasts with earlier studies reporting weaker understanding.

The PCK task revealed how teachers' own CK shaped their interpretations of student reasoning. Situated knowledge emerged as particularly influential as when statistical ideas were embedded in familiar contexts, teachers reasoned with greater confidence. Overall, the findings suggest that while teachers are willing and creative in adapting their practice, they struggle with fostering enquiry-driven approaches in the classroom. The next chapter discusses insights that emerge from the integration of qualitative and quantitative findings.

Chapter 5: Discussion

This chapter discusses findings of the study by organising them around the three research questions. It draws on both quantitative and qualitative findings to offer a holistic account of primary teachers' statistical knowledge. It also reflects on implications, limitations and future recommendations. This research was driven by practical concerns within Indian primary mathematics education: unclear curricular guidance for statistics, disconnects between textbook activities and learning outcomes, and insufficient teacher preparation (See Chapter 1). To understand the impact of these gaps, this study investigates how teachers understand and teach statistical ideas in practice. Specifically, it explores their conceptual grasp of key statistical ideas, the pedagogical strategies and the challenges they face in classroom implementation as reported by them.

5.1 RQ1: Teachers' Content Knowledge of Statistics

The findings from this study point to a complex and uneven picture of primary teachers' statistical content knowledge in Maharashtra. Rather than being uniformly low or high, the results reveal gradations of understanding shaped by context and structure of the task, and familiarity with the statistical concepts. These findings challenge reductive narratives that assume teachers lack adequate knowledge and instead invite a more nuanced interpretation of what it means to *know* statistics on informal level.

Although overall scores on the survey were low ($M = 4.87/12$) with no correlation between teachers' confidence and actual performance (Spearman's $\rho = -0.01$), the integration of qualitative data suggests that this performance does not reflect a uniform absence of knowledge. Rather, it highlights two key characteristics of teachers' current knowledge. First, teachers' statistical CK appears fragmented. For example, while many teachers answered sampling questions correctly in the survey, interview responses revealed variation in the depth of their reasoning. Teachers who lacked conceptual understanding of sampling tended to justify their choices based only on practical considerations (e.g., ease of measuring 100 students), whereas others recognised issues of bias and representativeness. This pattern suggests that many teachers relied on partial reasoning, indicating a fragmented rather than fully integrated understanding of sampling. This also suggests that correct survey answers did not always reflect the same depth of understanding. This aligns with Ma's (1999) concept of *connectedness*, where knowledge

is relational rather than isolated. However, such coherence was evident only in selected big ideas, indicating that most teachers possess fragmented understandings rather than integrated knowledge packages.

Second, the context-bound nature of teachers' statistical CK. A key insight that became evident was that wherever teachers showed some understanding of statistical ideas, their ability to generalise them across contexts was limited. Teachers' ability to reason statistically seemed to depend not just on their conceptual grasp, but on the familiarity of the context used in the task (McEwan & Bull, 1991). For example, Teachers reasoned more effectively when questions mirrored school settings (e.g., student height) than when they involved less familiar scenarios (e.g., rainfall data). This raises concerns for classroom practice, as curricula and textbooks often include tasks with unfamiliar contexts, and teachers who lack confidence with such scenarios may struggle to teach them effectively.

A clear continuum of reasoning emerged within each big idea. Teachers' justifications ranged from non-statistical explanations to procedural mathematical reasoning, and, in stronger cases, to informal statistical arguments. Their reasoning closely mirrored Konold et al.'s (2004) typology, originally developed to describe students' thinking. Teachers with lower survey scores often exhibited pointer or case-value thinking (reasoning more typical of early-stage learners), whereas higher-performing teachers demonstrated a shift toward reasoning with aggregate data and the use of uncertain language. These patterns reinforce the developing nature of teachers' CK and underscore the need for professional development that explicitly supports this progression.

While the quantitative phase of this study relied on a non-randomised sample, the large size ($n = 251$) and geographic diversity of the dataset provide some confidence in the generalisability of the findings across the state of Maharashtra (Gorard, 2001, p.13). No significant differences were observed based on teaching experience, medium of instruction, or school type, indicating that statistical CK may be consistently underdeveloped across the system. This suggests an urgent need for targeted professional development in statistics education, cutting across teacher profiles.

5.2 RQ 2: Teachers' Pedagogical Content Knowledge

The qualitative findings reveal notable variation in teachers' PCK of statistics, much of which appeared to be shaped by the depth and organisation of their CK. Teachers who demonstrated stronger statistical reasoning in CK tasks were also more proficient at articulating pedagogical

strategies that aligned with what the given task demanded. This suggests a strong interdependence between CK and PCK, reinforcing Shulman's (1987) foundational claim that pedagogical reasoning is shaped by subject knowledge, and Ma's (1999) argument that well-structured and connected CK supports effective teaching.

For instance, teachers who noticed variation in student data in the PCK task were able to link these observations to student reasoning, using appropriate descriptors such as “steady” or “consistent” to describe low-variance datasets. These teachers demonstrated not only accurate interpretation of given data but also insight into how students might reason with such data. In contrast, teachers with weaker CK tended to focus on surface-level features (e.g., mean) and overlook variation. As a result, they often assumed students were making choices based on non-statistical preferences (e.g., gender, friendship). This reflected a limited ability of these teachers to anticipate data-informed reasoning that might come from students.

Teachers' performance on PCK tasks was, in several cases, stronger than on CK tasks. The PCK task was embedded in a familiar classroom scenario, and just like the CK task with familiar context, the familiarity of the context enabled teachers to respond more confidently and with greater clarity. This pattern aligns with McEwan and Bull's (1991) view that teacher knowledge is situated, constructed through experience, interaction, and context. While this contextual sensitivity can be an asset, it also raises concerns. If teachers' statistical reasoning is confined to familiar scenarios, they may struggle to support students. This challenge is particularly relevant in multilingual and diverse Indian classrooms, where students interpret data in different ways based on their language (Thatte et al., 2025; Thatte & Nimkar, 2022). To address this, teachers require not only a solid grasp of statistical concepts but also the ability to scaffold students' reasoning using uncertain or aggregate language, often in languages that lack formal statistical vocabulary (Thatte et al., 2025).

5.3 RQ 3: Classroom Practices

While teachers' CK and PCK shape their instructional capacity, understanding how they actually teach statistics, including what they prioritise, how they interpret curricular materials, and what challenges they face, is crucial to examine the current scope of statistics education in classrooms. Findings of this study suggest a recurring tension: although teachers demonstrated willingness to adapt and contextualise textbook tasks, their ability to do so was limited by curriculum design, lack of professional support, and gaps in their statistical understanding.

A consistent pattern across interviews was teachers' reliance on textbooks as primary instructional tools, a pattern well documented in Indian classrooms (Kumar, 1988; Nimkar & R., 2024). While some teachers critically noted that textbook activities were disconnected from students' experiences or insufficient to prompt inquiry, others expressed faith in textbook-curriculum alignment and accepted them uncritically. This duality reveals how curricular constraints interact with teacher beliefs (Estrada et al., 2011; Pierce & Chick, 2011) to limit classroom opportunities for statistical reasoning.

Despite these constraints, most teachers described efforts to contextualise tasks by using local data or inviting students to collect their own. These adaptations reflect pedagogical agency and awareness of students' contexts (McEwan & Bull, 1991). However, such adaptations were largely confined to surface-level modifications of given textbook tasks. Teachers frequently reported guiding students in data collection and visual representation, but few moved beyond this to interpretation or inference. This mirrors broader findings that statistical instruction in Indian classrooms tends to remain procedural (Thatte & Nimkar, 2022; Nimkar & R., 2024). This was also evident in how teachers posed questions while teaching statistics. The questions tended to be comparative, focusing on individual data points rather than investigable questions, suggesting that while disjoint elements of statistical inquiry are present in classroom practice, the more critical aspect of statistics, engaging with uncertainty to make inferences (Davidian & Louis, 2012), is often missing (Arnold, 2012). Only teachers with very high scores in CK reported supporting aggregate-level reasoning or clarifying the purpose of data collection. This suggests that such skills remain underdeveloped not just in curricular guidance and textbooks but also in teacher knowledge. This aligns with frameworks that highlight instructional practice is not solely shaped by curricular materials but by the structure and depth of teachers' own knowledge (Ma, 1999; Shulman, 1987).

Structural barriers further constrain practice. Teachers cited time limitations, a lack of targeted training, and challenges teaching in multilingual classrooms, where statistical vocabulary is often ambiguous or unfamiliar (Thatte et al., 2025). Without sustained professional development that supports both conceptual understanding and pedagogical flexibility, teachers may struggle to move beyond procedural instruction, even when they are pedagogically motivated to do so.

5.4 Implications

This section outlines the key implications of the study, which make a unique contribution to the existing research gap. From a pragmatic perspective, I see these implications as also justifying the methodological and design choices I have made (Creswell & Clark, 2018; Punch & Oancea, 2014). The findings highlight the structural and pedagogical shifts required for meaningful primary-level statistics education in India, while also identifying specific directions for teacher professional development to support effective statistics teaching.

First, the study found that teachers often focus on procedural aspects and visual representations of statistics while struggling with core ideas such as reasoning with uncertainty, understanding the purpose of inquiry, and drawing inferences from data. This implies that teacher professional development (PD) must move beyond procedural instruction and explicitly focus on the underlying characteristics of statistical inquiry. Incorporating these foundational ideas into PD will not only give meaning and context to statistical procedures and calculations but also support teachers in engaging with the five ‘big ideas’ of statistical inquiry (Wild & Pfannkuch, 1999). As teachers become more confident with these core ideas, they will be better equipped to guide students through the full cycle of statistical reasoning and help them develop deeper, more connected statistical thinking.

Second, the findings indicate that teachers were more confident and articulate when engaging with scenarios drawn from familiar classroom contexts, but they struggled to reason through tasks situated in unfamiliar contexts. This suggests that PD should begin by engaging teachers with contextualised scenarios that reflect classroom realities, before gradually introducing them to unfamiliar tasks using deliberately selected, often simplified or constructed, datasets. This staged approach will not only improve teachers’ ability to transfer statistical reasoning across contexts but also help them understand the pedagogical value of using both real-world and made-up data. Specifically, it will support teachers in recognising that while real data may be messy, carefully engineered datasets, especially those not drawn from everyday contexts, can still be effective tools for teaching specific statistical ideas such as the median or variation.

Third, the study revealed that many teachers struggled to express statistical concepts in Marathi informally and found it difficult to scaffold students' reasoning when teaching in multilingual classrooms. This implies that PD must explicitly address the language of statistics, especially in early grades where formal terminology is inaccessible and teachers must rely on informal, everyday language (e.g., *likely*, *about*, *typical*). By integrating language-sensitive strategies

(e.g., developing appropriate vocabulary and modelling classroom dialogue that includes uncertain statistical language), PD can help teachers more effectively support student reasoning. This will ensure that even in linguistically diverse and resource-constrained classrooms, students can begin to develop informal inferential thinking and engage meaningfully with statistical ideas.

Together, these implications call for PD that is sustained, context-sensitive, and grounded in the multilingual and diverse realities of Indian primary classrooms. Only through such targeted support can teachers move beyond procedural instruction and foster inquiry-based, conceptually rich statistics education.

5.5 Limitations

This study, while carefully designed and pragmatically aligned, has some limitations that are important to acknowledge. These relate to sampling choices, instrument design, and the scope of data collection.

First, the study used non-random sampling in the quantitative phase. While the sample achieved strong geographical coverage across Maharashtra and was complemented by qualitative interviews that added depth and context, the generalisation of findings must be done cautiously (Ercikan & Roth, 2009, p.215). Generalisability is constrained by both the non-random nature of the sample (VanVoorhis & Morgan, 2007; Field, 2018; Gorard, 2001) and the linguistic and cultural situatedness of statistical reasoning, which is shaped by local curricula and socio-educational conditions (Campos et al., 2011). However, due to common structural features in teacher education and curriculum across Indian states, it is reasonable to assume that parallel challenges may exist beyond the state of Maharashtra. Further, the survey was administered digitally via Microsoft Forms; an online platform not widely used in the Indian context. This may have skewed participation toward digitally literate, digitally connected, and urban teachers, while under-representing rural or less-connected groups (De Leeuw et al., 2012). This concern reflects wider critiques that digital methods in low-resource settings may privilege more advantaged participants (Selwyn, 2022; Greenhow et al., 2021).

Second, the instrument used to assess statistical CK was newly developed for this study. Although informed by theory and refined through expert review and pilot testing, it did not undergo formal psychometric validation such as reliability testing or factor analysis. This limits claims about its precision in consistently measuring CK. Additionally, the limited number of survey questions reduced data variability, potentially affecting the robustness of the

quantitative analyses (Clark et al., 2021). Such limitations are common in context-specific tools developed for exploratory research (Harrell-Williams et al., 2015).

Finally, the study did not include direct classroom observations. Due to time and resource constraints, insights into teaching practice relied solely on teacher self-reports, which may be subject to recall bias or social desirability (Dunning et al., 2004; Krumpal, 2013). Additionally, the rich qualitative data included underexplored but significant themes, such as teacher confidence and language use in multilingual settings. These areas fell outside the analytical scope of this study but are important, as teachers' beliefs, affect, and linguistic comfort have been shown to shape instructional decisions (Garfield & Ben-Zvi, 2008), demanding closer attention in future work.

5.6 Conclusion and Directions for Future Research

This study set out to investigate primary teachers' statistical knowledge and practices within the context of Maharashtra, India. Using a mixed-methods approach, it explored teachers' statistical content knowledge, pedagogical content knowledge, and classroom practices, structured around the five big ideas of the statistical inquiry cycle. The study addressed implications of three critical gaps in the Indian context: unclear curricular goals, textbook-curriculum misalignment, and limited teacher professional development in statistics. It revealed that teachers' knowledge is not uniformly lacking, but rather fragmented, context-bound, and unevenly developed across different statistical domains. It also showed that while some teachers demonstrated the ability to adapt tasks to students' contexts, classroom practices remain largely procedural, shaped by overreliance on textbooks.

These findings offer a grounded understanding of the current state of statistics education at the primary level and serve as a foundation for future work. One important direction for further research is to explore each of the five big ideas of statistics in greater detail. This study used the five big ideas (statistically investigable questions, data collection and sampling, describing data, central tendency, and inference) as a framework to assess overall teacher understanding of statistical inquiry. However, the findings suggest that each idea has its own distinct challenges and strengths. For example, while teachers generally had a better understanding of sampling, they struggled significantly with formulating investigable questions and reasoning with uncertainty. Future research could focus on each domain/big idea individually, examining how teachers conceptualise and teach these ideas, how misconceptions develop, and what forms of support might strengthen understanding in each area.

Second, this study developed a new instrument to assess statistical CK through the lens of informal inferential reasoning. While the tool was theoretically grounded and refined through expert review, it has not yet undergone formal psychometric validation. Further development through reliability testing, construct validation, and possible adaptation into multiple languages would allow for its application across diverse Indian contexts. A validated tool would enable researchers and policymakers to identify patterns in teacher knowledge across regions and help design more targeted and context-sensitive professional development.

Finally, this study provides a snapshot of the current scenario regarding statistics education, but if lasting changes in teaching-learning practices are to be achieved, the next step is to design and evaluate an intervention informed by these findings. Such an intervention could involve the development of PD programmes specifically focused on statistics education. Future research could include classroom observations, tracking how teachers implement statistical instruction after training, and assessing both teacher growth and student learning outcomes. This would move beyond merely identifying the present state and begin to examine how intentional change can be brought about.

Appendix

Appendix A: Instrument: Structure, Online Survey with Translation

A.1 Structure

Table A1.1

Questions mapped to Big Ideas along with the source

Big Idea	# Q	Question Title & Objective
Defining Statistically investigable Question	2	Q11[#]. Investigable Question & Q12[#]. Favourite Snack: Teachers demonstrate understanding that a statistically investigable question will involve uncertainty in its answer. They are able to identify such a question from other questions which may involve collecting some data, but their answers do not have any uncertainty Q21[#]. Bag Weight: Teachers are able to identify the most critical data to answer a statistical question requires recognising that some data, while useful for practical solutions, may not be necessary for addressing the specific question.
Collecting data & Sampling	2	Q22[#]. Students' Height: Teachers understand that a representative sample is needed for answering a statistical question and recognise that a random sample is most likely to be the best representative sample. Q31[#]. Temperature & Q6[#]. Tanmay's Reading: Teachers demonstrate the ability to describe patterns or trends in visual representations of data using appropriate statistical language. 32[#]. Plant Height: Teachers are able to determine the most appropriate measure of central tendency (mean vs. median) based on the characteristics of a given dataset and its relevance in the given context.
Describing Data	2	Q41*[*]. Skipping Rope: Teachers are able to determine the most appropriate measure of central tendency (mean vs. mode) based on the characteristics of a given dataset and its usefulness in the given context. Q42*[*]. Marks: Teachers understand that a single number may not always be an appropriate measure of central tendency for a dataset. Q51*[*]. Vehicles: Teachers can analyse data as an aggregate, use it as evidence, and make conjectures using uncertain language.
Understanding Central Tendencies	3	Q52*[*]. Rainfall: Teachers can make predictions using uncertain language based on the data provided. Q53⁺. Students' TV Habits: Teachers demonstrate the ability to evaluate whether the conclusion or prediction drawn from the data is reasonable and determine if the given data is sufficient to support the claim.
Interpreting & Predicting from Data	3	
Total	12	

Note: *Question from Saksham, +Question from LOCUS question bank, #Question created

A.2 Changes made in the instrument pre- to post-pilot study

Table A.2

Changes in the survey instruments based on pilot

Before Pilot		Corrections based on pilot			Post pilot
Q.	Initial Question	Removing questions	Strengthening Distractors	Improving clarity	Final Question
Q11	Investigable Question			✓	Investigable Question
Q12	Favourite Snack			✓	Favourite Snack
Q21	Bag Weight				Bag Weight
Q22	Students' Height				Students' Height
Q31	Temperature		✓		Temperature
Q32	Tanmay's Reading		✓		Tanmay's Reading
Q41	Plant Height			✓	Plant Height
Q42	Skipping Rope				Skipping Rope
Q43	Social Media	✓			Marks
Q51	Vehicles				Vehicles
Q52	Rainfall		✓	✓	Rainfall
Q53	Students' TV Habits			✓	Students' TV Habits

A.3 Online Survey English

** Indicates the compulsory questions in the survey*

Demographic Information

1. Name *

2. School District:

3. Vocational Education (select all options that apply to you)

- a. SSC D.Ed.
- b. HSC D.Ed.
- c. B.Ed.
- d. Other

4. Education (select all options that apply to you)

- a. B.A.
- b. B.Sc.
- c. B.Com.
- d. M.A.
- e. M.Sc.
- f. M.com
- g. Other

5. Teaching Experience (in Years)

- a. 0-3 years
- b. 3-5 years
- c. 5-10 years
- d. 10-15 years
- e. 15 + years

6. Type of school currently teaching

- a. Unaided schools
- b. Aided Schools
- c. Zilla Parishad School
- d. Municipal / Municipal School
- e. Government Ashram School
- f. Aided Ashram School

7. Medium of your school

- a. Marathi
- b. Semi-English
- c. English

8. Do you teach Mathematics to children from class 1-5 or have you taught it before? *

Section 0

0. How confident are you in your understanding of statistical concepts required to teach statistics at the primary level?

- a. Not at all confident
 - b. Slightly confident
 - c. Very confident
 - d. Extremely confident
-

Section 1

1.1 Which of the following questions is statistically investigable?

- a. What is the total number of books read by all the grade 6 students this week?
- b. How many girls and boys were enrolled in your school in 2018?
- c. Which is the most favorite color of the grade 6 students?
- d. All of the above

1.2 The 4th-grade class is trying to create statistically investigable questions about chips packets. Below are some examples they have created. Which of the following is a good question that can be answered through statistical investigation?

- a. What is the procedure for making chips?
- b. In how many sizes do you get chips packets?
- c. Which statistical information does the manufacturer print on the chip packet?
- d. How many chips are there in the smallest packet of chips?

1.3 How confident are you that you have answered the questions in this section correctly?

- e. Not at all confident
 - f. Slightly confident
 - g. Very confident
 - h. Extremely confident
-

Section 2

2.1 Nandkishor Sir is an Education Officer. A local journalist has complained to him that students in a particular school have to carry an excessively heavy school bag. Nandkishor Sir wants to investigate the validity of this complaint.

Which of the following pieces of information would be the most important to collect for this investigation? (Adapted from LOCUS, 2024)

- a. How many books and notebooks do students have to carry daily?
- b. How many students are required to bring a school bag?
- c. What is the weight of a fully packed school bag?
- d. How many days do students need to carry a school bag to school?

2.2 Across all the schools in your small town there are 560 students in grade 4, with 360 girls and 200 boys. You want to estimate the typical height of grade 4 students in the town. How many and which students should they measure the height of to get a reliable approximation of the typical height? Choose the most appropriate option.

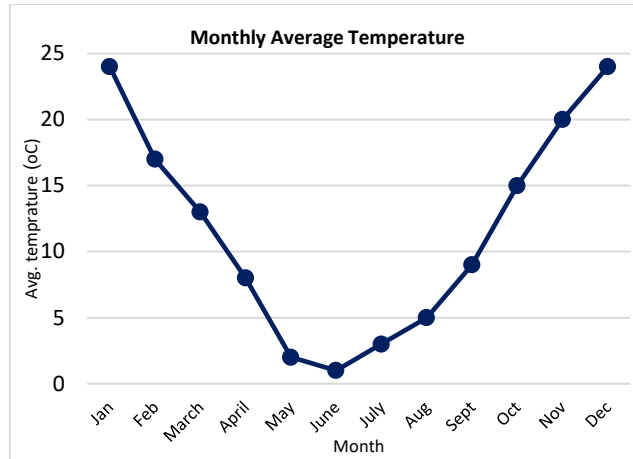
- a. Select 20 boys and 36 girls from a 4th-grade classroom of any one school and measure their heights.
- b. Randomly select a hundred 4th graders from the district and measure their heights.
- c. Measure the heights of all 360 girl 4th graders in the town, as they make up the majority.
- d. Any of the above measurements will give an equally good approximation of height.

2.3 How confident are you that you have answered the questions in this section correctly?

- a. Not at all confident
- b. Slightly confident
- c. Very confident
- d. Extremely confident

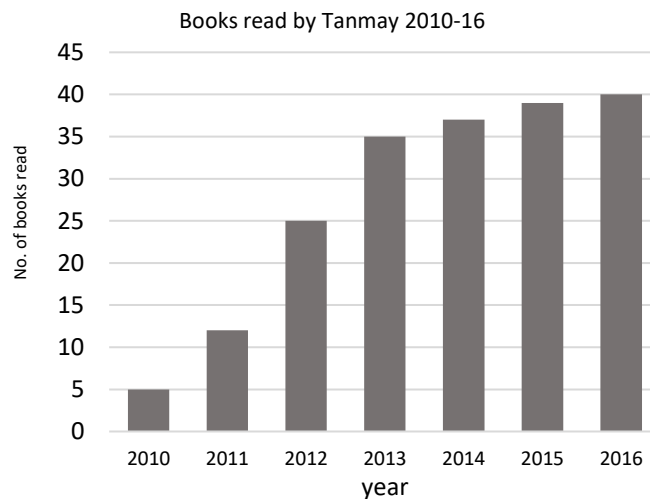
Section 3

3.1 The graph above shows the average monthly temperatures (in °C) for a city in Europe over the course of a year. Which of the following best describes the overall trend in the graph?



- This city has summer at the beginning and end of the year and winter in the middle of the year.
- The lowest temperature in this city is in the month of June.
- The lowest temperature in this city is at the beginning of the monsoon season and the temperature in winter is much higher.
- The temperature in December is higher than in March in this city.

3.2 The graph below shows the number of books Tanmay read from the school library each year from 2010 to 2016. Which of the following statements best describes this graph?



- The number of books Tanmay read increased constantly every year from 2010 to 2016.
- Tanmay developed an interest in reading, leading to an increase in the number of books he read.

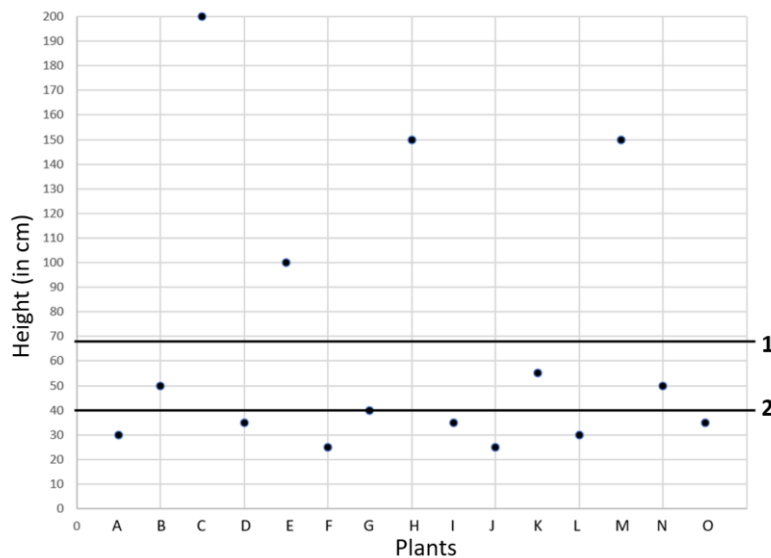
- c. The growth in the number of books Tanmay reads each year has decreased.
- d. Tanmay read least number of books in year 2010.

3.3 How confident are you that you have answered the questions in this section correctly?

- a. Not at all confident
- b. Slightly confident
- c. Very confident
- d. Extremely confident

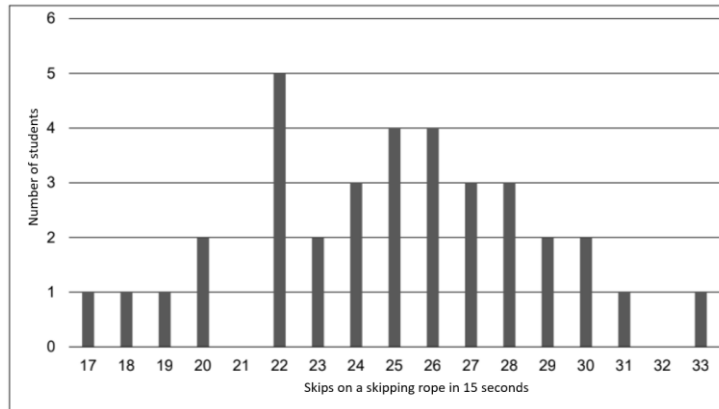
Section 4

4.1 Consider the graph showing plant height distribution. Which horizontal line best represents the typical height of the plants in this garden?



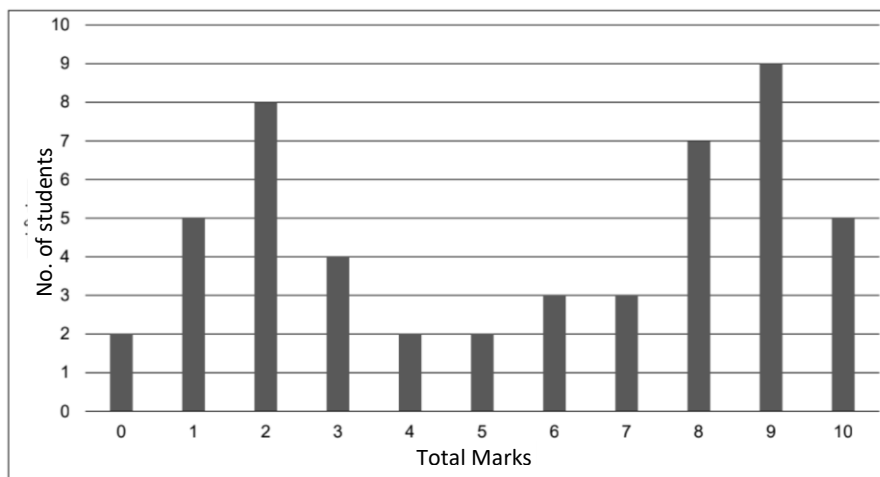
- a. Neither Line 1 nor Line 2 represents the typical height of the plants.
- b. Line 1 better represents the typical height of the plants because it is the mean.
- c. Line 2 better represents the typical height of the plants because it is positioned where most plant heights are concentrated.
- d. Both Line 1 and Line 2 are equally good representations of the typical height of the plants.

4.2 The graph below shows how many jump ropes children in a class of 3rd graders jump in 15 seconds. From the graph, can we say that on average, how many jumps do the children in the class jump in 15 seconds?



- Since the number of children who jump 22 is the largest, it can be said that the children jump an average of 22.
- Since most of the children in the class are around 25, it can be said that the children jump an average of 25.
- Since there is one child each who jumps 17, 18, 19, 31 and 33, any of these numbers can be said to be the average number of jumps.
- It will not be useful to determine the average number of jumps without collecting information about how long each child in the class practices.

4.3 A teacher created a frequency graph to analyse her students' performance, showing the number of students (frequency) against their marks in a test. About how many marks can we say that the children have got? (Adapted from Anupad (2023))



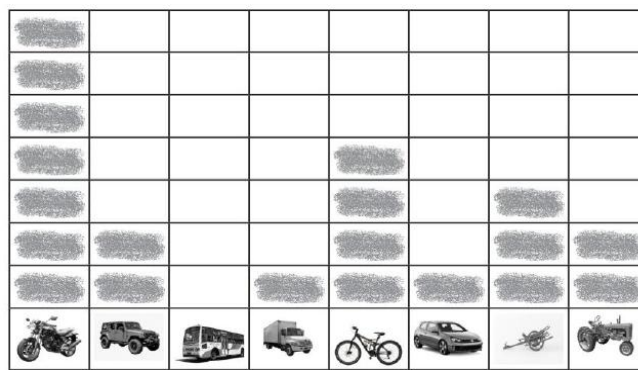
- 8 students have scored 2 hence typical number is 2.
- The typical number is 9 because the maximum no. of students has scored 9
- Students have scored approximately 5.5 because that is the mean.
- One typical number does not give a good estimate of the central tendency.

4.4 How confident are you that you have answered the questions in this section correctly?

- a. Not at all confident
- b. Slightly confident
- c. Very confident
- d. Extremely confident

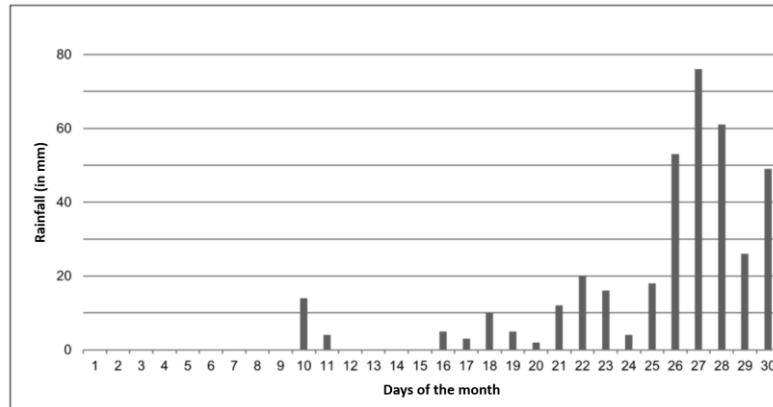
Section 5

5.1 Following is the pictograph showing the vehicles that passed in front of your school in 5 minutes. Based on this graph, what conclusions can we draw? (Anupad, 2023)



- a. This school is likely to be located in the middle of a big city.
- b. Students at this school like to ride motorcycles.
- c. Buses never pass in front of the school.
- d. It is likely that the school is located in a village.

5.2 Pragati, the class teacher, conducted an activity with her class for a period of one month. Every day, students measured and recorded the rainfall in millimetres. Based on the graph plotted by students, which of the following statements can they consider most likely to be correct?



- The previous month had a lot of rainfall.
- The following month will not have any rainfall.
- The maximum rainfall next month will happen on the 27th of next month.
- The following month will have a lot of rainfall.

5.3 A recent study on reading habits of elementary and middle school students reported that elementary school boys typically read 2 fewer books per month than girls, and middle school boys typically read 4 fewer books per month than girls. Based on these data, can we conclude that in high school boys typically read 6 fewer books per month than girls?

- No, because data were not collected from high school students.
- No, because high school students have more responsibilities and may not read as much.
- Yes, because 6 fewer books are the next number in the pattern.
- Yes, it is reasonable to predict reading habits of high school students from middle school students.

5.4 How confident are you that you have answered the questions in this section correctly?

- Not at all confident
- Slightly confident
- Very confident
- Extremely confident

A.4 Online Survey: Marathi

* Indicates the compulsory Questions in the survey

Demographic Information

1. नाव *
2. शाळेचा जिल्हा:
3. व्यावसायिक शिक्षण (तुम्हाला लागू होणारे सर्व पर्याय निवडा)
 - a. SSC D.Ed.
 - b. HSC D.Ed.
 - c. B.Ed.
 - d. Other
4. शिक्षण (तुम्हाला लागू होणारे सर्व पर्याय निवडा)
 - a. B.A.
 - b. B.Sc.
 - c. B. Com
 - d. M.A.
 - e. M.Sc.
 - f. M.com
 - g. Other
5. शिकवण्याचा अनुभव (वर्षात)
 - a. 0-3 वर्षे
 - b. 3-5 वर्षे
 - c. 5-10 वर्षे
 - d. 10-15 वर्षे
 - e. 15 + वर्षे
6. सध्या शिकवत असलेल्या शाळेचा प्रकार
 - a. विना अनुदानित शाळा
 - b. अनुदानित शाळा
 - c. जिल्हा परिषद शाळा
 - d. नगर पालिका / महानगर पालिका शाळा
 - e. शासकीय आश्रमशाळा
 - f. अनुदानित आश्रमशाळा
7. तुमच्या शाळेचे माध्यम
 - a. मराठी
 - b. सेमी-इंग्रजी
 - c. इंग्रजी
8. तुम्ही इयत्ता 1ली ते 5वीच्या मुलांना गणित शिकवता का किंवा या आधी शिकवले आहे का?*

Section 0

पुढील विधानाशी तुम्ही किती प्रमाणात सहमत आहात.

प्राथमिक स्तरावरील गणिताच्या अभ्यासक्रमातील माहितीचे व्यवस्थापन (data handling) हा भाग शिकवण्या इतके सांख्यिकी (statistics) या विषयाचे ज्ञान मला आहे.

- असहमत
 - थोड्या प्रमाणात समहत
 - बऱ्यापैकी समहत
 - सहमत
-

Section 1

1.1 पुढील पैकी कोणत्या प्रश्नाचे उत्तर माहिती (data) गोळा करून सांख्यिकीय पद्धतीने देणे अर्थपूर्ण ठरेल.

- इयत्ता सहावीच्या मुलांनी या आठवड्यात एकूण किती पुस्तके वाचली?
- 2018 साली तुमच्या शाळेच्या पटावर किती मुलगे आणि किती मुली होत्या?
- इयत्ता सहावीच्या वर्गातील मुलांचा सर्वात आवडता रंग कोणता आहे ?
- वरीलपैकी सर्व

1.2 मोरे गुरूजींच्या चौथीच्या वर्गातील मुलांचा सगळ्यात आवडता खाऊ कुरकुरे हा आहे. गुरूजींनी मुलांना या खाऊ बद्दल सांख्यिकीय पद्धतीने उत्तर द्यावे लागेल असे प्रश्न तयार करायला सांगितले. त्यांच्या मुलांनी तयार केलेल्या पुढीलपैकी कोणत्या प्रश्नांची उत्तरे सांख्यिकीय पद्धतीने देणे अर्थपूर्ण होईल.

- कुरकुरे कसे तयार केले जातात?
- कुरकुरे तयार करण्यासाठी कोणकोणते पदार्थ लागतात?
- कुरकुर्यांच्या पाकिटावर कोणती सांख्यिकीय माहिती छापलेली असते?
- कुरकुर्यांच्या सर्वात लहान पाकिटात साधारण किती कुरकुरे असतात?

1.3 पुढील विधानाशी तुम्ही किती प्रमाणात सहमत आहात

विभाग 1 मधील प्रश्नांची मी दिलेली उत्तरे बरोबर आहेत.

- असहमत
 - थोड्या प्रमाणात समहत
 - बऱ्यापैकी समहत
 - सहमत
-

Section 2

2.1 नंदकिशोर साहेब गट शिक्षणाधिकारी म्हणून काम करतात. त्यांच्या तालुक्यातील एका शाळेतील मुलांना दफ्तराचे अवाजवी ओझे वागवावे लागत असल्याची तक्रार एका स्थानिक पत्रकाराने त्यांच्याकडे केली आहे. पत्रकाराच्या या तक्रारीत कितपत तथ्य आहे हे नंदकिशोर साहेबांना शोधायचे आहे. या साठी पुढील पैकी कोणती माहिती गोळा करणे सर्वात महत्वाचे आहे.

- मुलांना रोज किती पुस्तके आणि वहया न्याव्या लागतात?
- किती मुलांना शाळेत दफ्तर आणावे लागते?
- मुलांच्या दफ्तराचे सामान व वहया-पुस्तकांसोबतचे वजन किती आहे?
- मुलांना शाळेत किती दिवस दफ्तर घेऊन जावे लागते?

2.2 तुमच्या शहरातील सर्व शाळांत मिळून इयत्ता चौथीचे ५६० विद्यार्थी आहेत. त्यांत ३६० मुली आणि २०० मुलगे आहेत. तुम्हाला तुमच्या शहरातील इयत्ता चौथीच्या विद्यार्थ्यांची साधारण उंची किती आहे हे अभ्यासायचे आहे. तुम्हाला त्यांच्या उंचीचा बऱ्यापैकी अंदाज मिळण्यासाठी तुम्ही किती आणि कोणत्या विद्यार्थ्यांची उंची मोजायला हवी? पुढील पर्यायांमधून सर्वात योग्य पर्याय निवडा.

- शहरातील कोणत्याही एका चौथीच्या वर्गातील २० मुलगे आणि ३६ मुली यांची उंची मोजावी.
- तुमच्या शहरातील चौथीच्या वर्गात मुली बहुसंख्येने आहेत त्यामुळे सर्व ३६० मुलींची उंची मोजावी.
- शहरातील सर्व चौथीच्या वर्गामधून १०० विद्यार्थी यादृच्छिक रीतीने निवडून त्यांची उंची मोजावी.
- वरील पैकी कोणत्याही प्राकरे उंचीचे मोजमाप केले तरी मिळणारा अंदाज सारखाच असेल.

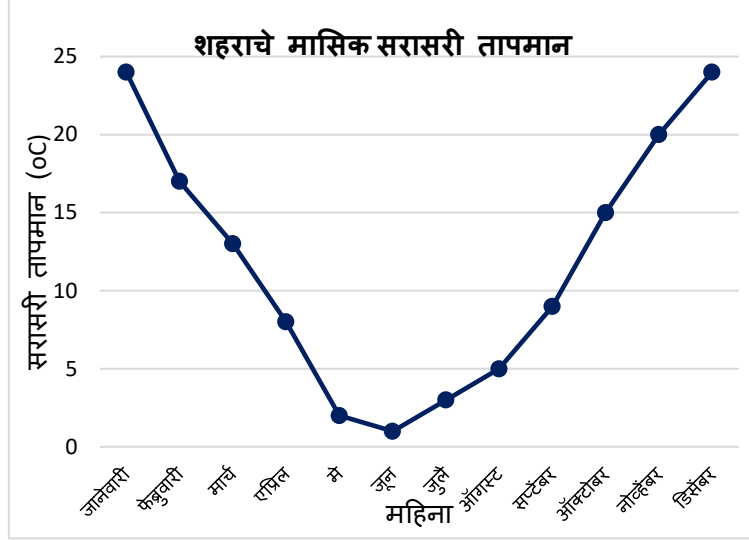
2.3 पुढील विधानाशी तुम्ही किती प्रमाणात सहमत आहात

विभाग 2 मधील प्रश्नांची मी दिलेली उत्तरे बरोबर आहेत.

- असहमत
- थोड्या प्रमाणात समहत्त
- बऱ्यापैकी समहत्त
- सहमत

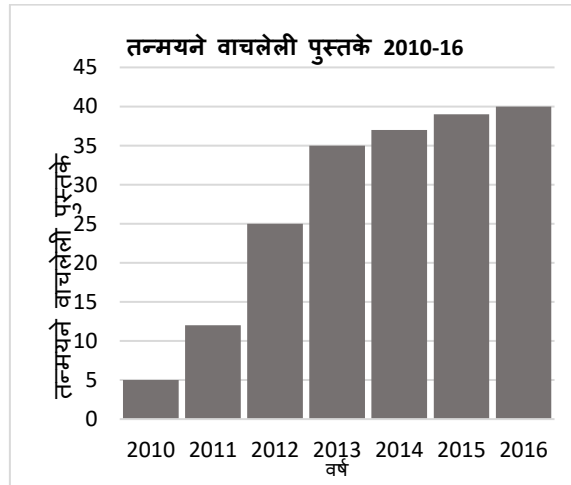
Section 3

3.1 खालील आलेखामध्ये एका शहराचे सरासरी मासिक तापमान अंश सेल्सिअस मध्ये ($^{\circ}\text{C}$) दाखवले आहे. खालीलपैकी कोणता पर्याय संपूर्ण आलेखाचे योग्य वर्णन करतो?



- या शहरात वर्षाच्या सुरुवातीला आणि शेवटी उन्हाळा असतो तर वर्षाच्या मध्यात हिवाळा असतो.
- या शहरात सर्वात कमी तापमान जून महिन्यात असते.
- या शहरात पावसाळ्याच्या सुरुवातीला सर्वात कमी तापमान असते तर हिवाळ्यातील तापमान बरेच जास्त असते.
- या शहरात डिसेंबर महिन्यातील तापमान मार्च महिन्यापेक्षा जास्त असते.

3.2 2010 ते 2016 या काळात तन्मयने शाळेच्या ग्रंथालयातून वर्षभरात किती पुस्तके आणून वाचली याचा आलेख खाली दिला आहे. पुढील पैकी कोणते विधान या संपूर्ण आलेखाचे सर्वात चांगले वर्णन करते?



- २०१० ते २०१६ या काळात तन्मयने दरवर्षी वाचलेल्या पुस्तकांच्या संख्येत एकसमान वाढ झाली आहे.
- तन्मयला वाचनाची गोडी लागल्याने त्याचे वाचन वाढले आहे.
- तन्मयने दरवर्षी वाचलेल्या पुस्तकांच्या संख्येत झालेली वाढ एकसमान नाही.
- २०१० मध्ये तन्मयने सर्वात कमी पुस्तके वाचली.

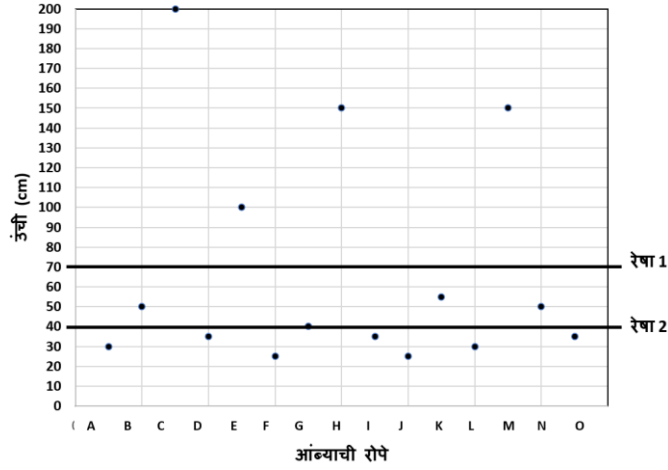
3.3 पुढील विधानाशी तुम्ही किती प्रमाणात सहमत आहात

विभाग 3 मधील प्रश्नांची मी दिलेली उत्तरे बरोबर आहेत.

- असहमत
- थोड्या प्रमाणात समहत
- बऱ्यापैकी समहत
- सहमत

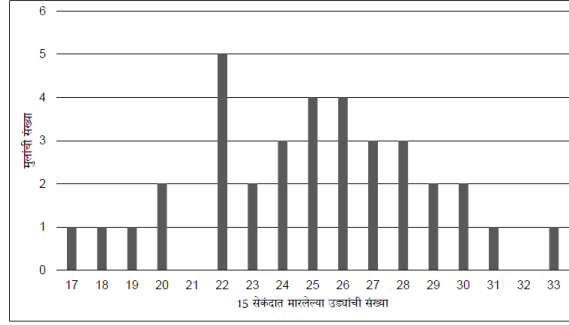
Section 4

4.1 एका नर्सरीमधील आंब्याच्या १५ रोपांची उंची दाखवणारा आलेख पुढे दिला आहे. आलेखावरील कोणती रेषा या नर्सरीतील रोपांची साधारण उंची दाखावते आहे असे आपण म्हणू शकतो?



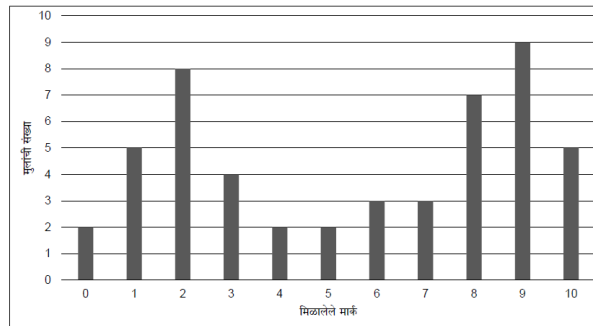
- रेषा 1 किंवा रेषा 2 या पैकी कोणतीच रेषा झाडांचा साधारण उंची दाखवत नाही.
- झाडांच्या उंचीची सरासरी ७० सेमी आहे. त्यामुळे रेषा 1 ही नर्सरीतील रोपांची साधारण उंची दाखवते आहे.
- बऱ्याचशा झाडांची उंची रेषा 2 च्या आसपास असलेली दिसते आहे. त्यामुळे रेषा 2 झाडांची साधारण उंची दाखवते आहे.
- झाडांची साधारण उंची किती आहे हे ठरवण्यासाठी या आलेखात दिलेली माहिती पुरेशी नाही.

4.2 इयत्ता तिसरीच्या वर्गातील मुले 15 सेकंदात किती दोरीच्या उड्या मारतात याचा आलेख पुढे दिला आहे. आलेखावरून वर्गातील मुले 15 सेकंदात साधारण किती उड्या मारतात असे आपण म्हणू शकू?



- २२ उड्या मारणाऱ्या मुलांची संख्या सर्वाधिक आहे म्हणून मुले साधारण २२ उड्या मारतात असे म्हणता येईल.
- वर्गातील बरीचशी मुले २५ च्या आसपास आहेत म्हणून मुले साधारण २५ उड्या मारतात असे म्हणता येईल.
- १७, १८, १९, ३१ व ३३ उड्या मारणारे प्रत्येकी एक मूल आहे त्या मुळे यांच्यापैकी कोणतीही संख्या साधारण उड्यांची संख्या आहे असे म्हणता येईल.
- वर्गातील कोणती मुले किती वेळ सराव करतात याची माहिती गोळा केल्याशिवाय साधारण उड्यांची संख्या ठरवणे उपयोगाचे होणार नाही.

4.3 प्रल्हाद गुरूजींनी वर्गात दहा गुणांची चाचणी घेतली. या चाचणीत किती मुलांना किती गुण मिळाले आहेत याचा आलेख पुढे दिला आहे. आलेखावरून त्यांच्या वर्गातील मुलांना साधारण किती गुण मिळाले आहेत असे आपण म्हणू शकतो?



- चाचणीत ८ मुलांना २ गुण मिळाले आहेत. त्यामुळे वर्गातील मुलांना साधारण २ गुण मिळाले आहेत असे आपण म्हणू शकतो.
- वर्गातील सर्वाधिक मुलांना ९ गुण मिळाले आहेत त्यामुळे साधारण ९ गुण मिळाले आहेत असे म्हणणे योग्य होईल.

- c. वर्गातील मुलांच्या गुणांची सरासरी ५.५ आहे त्यामुळे साधारण साडेपाच गुण मिळाले आहेत असे म्हणणे योग्य आहे.
- d. प्रल्हाद गुरूजींच्या वर्गातील मुलांना साधारण किती गुण मिळाले आहेत याचे वर्णन एकच संख्या वापरून करणे उपयोगाचे होणार नाही.























4.4 पुढील विधानाशी तुम्ही किती प्रमाणात सहमत आहात

विभाग 4 मधील प्रश्नांची मी दिलेली उत्तरे बरोबर आहेत.

- a. असहमत
- b. थोड्या प्रमाणात समहत
- c. बऱ्यापैकी समहत
- d. सहमत

Section 5

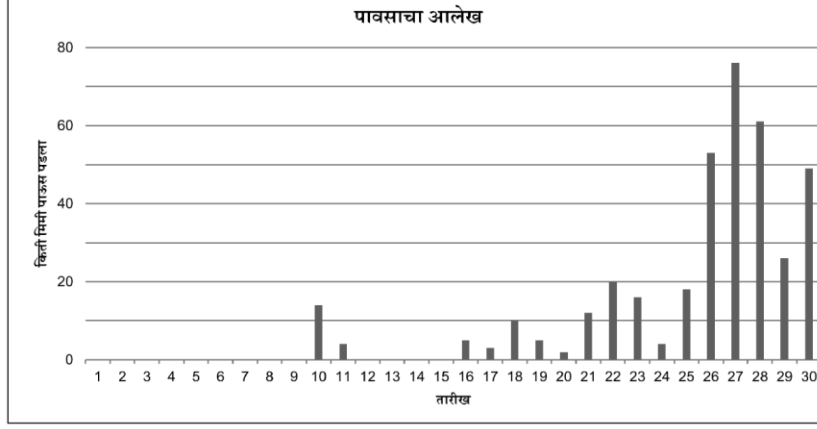
5.1 एका शाळेसमोरील रस्त्यावरून पाच मिनिटांत गेलेल्या वाहनांचा चित्रालेख खाली दाखवला आहे. या आलेखाकडे बघून पुढीलपैकी कोणता निष्कर्ष काढता येईल?

							
							
							
							
							
							
							
मोटरसायकल	जीप	बस	ट्रक	सायकल	कार	बैलगाडी	ट्रॅक्टर

- a. ही शाळा शहराच्या मध्यवर्ती भागात असण्याची शक्यता खूप जास्त आहे.
- b. ही शाळा एका लहानशा गावात असण्याची शक्यता खूप जास्त आहे.
- c. या शाळेतील मुलांना मोटरसायकल बसायला आवडते
- d. या शाळेसमोरून कधीही बस जात नाही.

5.2 प्रगती बाईंच्या विद्यार्थ्यांनी महिन्यात रोज किती. मिमी पाऊस पडला, हे मोजले आणि त्याच्या नोंदी ठेवल्या. त्यांच्या नोंदींचा आलेख पुढे दिला आहे. त्यावरून पुढीलपैकी कोणते विधान बरोबर असण्याची शक्यता सगळ्यात जास्त आहे?

- a. या महिन्याच्या पुढच्या महिन्यात फारसा पाऊस पडणार नाही.
- b. या महिन्याच्या आधीच्या महिन्यात खूप जास्त पाऊस पडला असावा.
- c. या महिन्याच्या पुढच्या महिन्यात २७ तारखेला सगळ्यात जास्त पाऊस पडेल.
- d. या महिन्याच्या पुढच्या महिन्यात बराच पाऊस पडेल.



5.3 एका अभ्यासात प्राथमिक आणि माध्यमिक शाळेतील मुलांच्या सवयीबाबत माहिती गोळा केली गेली. गोळा केलेल्या माहिती नुसार प्राथमिक शाळेतील मुलगे, मुलीपेक्षा दर आठवड्याला साधारण 2 तास अधिक टीव्ही पाहतात. तसेच माध्यमिक शाळेतील मुलगे, मुलीपेक्षा दर आठवड्याला साधारण 4 तास अधिक टीव्ही पाहतात. या माहितीवरून संशोधक पुढील निष्कर्ष काढू शकतील का?

निष्कर्ष : “उच्च माध्यमिक शाळेतील मुलगे, मुलीपेक्षा दर आठवड्याला साधारण 6 तास अधिक टीव्ही पाहतात.”

- नाही, कारण उच्च माध्यमिक शाळेमधील विद्यार्थ्यांबाबत माहिती गोळा करण्यात आलेली नाही.
- नाही, कारण उच्च माध्यमिक शाळेमधील बरेच विद्यार्थी कामाला जातात म्हणून ते एवढा वेळ टीव्ही पाहतील हे पटण्यासारखे नाही.
- होय, कारण ६ ही संख्या २, ४ या आकृतीबंधातील पुढची संख्या आहे आणि मुलगांचे टीव्ही बघण्याचे प्रमाण वाढत गेले आहे.
- होय, कारण माध्यमिक शाळेतील विद्यार्थ्यांच्या सवयींवरून उच्च माध्यमिक शाळेमधील विद्यार्थ्यांच्या टीव्ही पाहण्याच्या सवयींचा अंदाज करणे योग्य आहे.

5.4 पुढील विधानाशी तुम्ही किती प्रमाणात सहमत आहात

विभाग 5 मधील प्रश्नांची मी दिलेली उत्तरे बरोबर आहेत.

- असहमत
- थोड्या प्रमाणात समहत्
- बऱ्यापैकी समहत्
- सहमत

Appendix B: Interview Questionnaire

B.1 English + Marathi Version

1. Classroom practices

Aim:

- Understand the current classroom instruction practices used by teachers to teach statistics in the primary mathematics curriculum
- Understand the input teachers receive regarding statistics instruction through the in-service professional development programs.

Interview Questions:

1. What do you think are the objectives behind teaching data handling in primary grades?

इयत्ता पहिली ते पाचवी मध्ये "माहिती व्यवस्थापन" हा भाग शिकवण्याची उद्दिष्टे काय आहेत असे तुम्हाला वाटते?

2. Balbharati says "(relevant LOs)" What do you think this means for actual teaching practices?

Balbharati मध्ये केलेल्या या अपेक्षा आणि वर्गात माहिती व्यवस्थापन शिकवण्याची पद्धत यांत कशा प्रकारचा ताळमेळ आहे असे तुम्हाला वाटते?

3. How much time will you need to teach the XYZ (*relevant chapter*) chapter from your (*their grade*) textbook?

तुमच्या पाठ्यपुस्तकातील XYZ (संबंधित धडा) धडा शिकवण्यासाठी तुम्हाला किती वेळ लागतो?

4. Do you think that the activities given in the textbooks are enough to fulfil the objectives you mentioned earlier?

माहिती व्यवस्थापन शिकवण्याची उद्दिष्टे पूर्ण करण्यासाठी पाठ्यपुस्तकांमध्ये दिलेल्या कृती पुरेशा आहेत असे तुम्हाला वाटते का?

5. Do you get an opportunity to conduct activities related to data handling apart from those given in the textbook chapters? If yes, what kind of activities, please explain? If not, what are the challenges?

पाठ्यपुस्तकातील धड्यामध्ये दिलेल्या कृतीव्यतिरिक्त तुम्हाला माहिती व्यवस्थापन संबंधित उपक्रम करण्याची संधी मिळते का? जर हो, तर कोणत्या प्रकारचे उपक्रम? जर नसेल, तर काय प्रकारच्या अडचणी येतात?

6. How would you teach the XYZ (*screenshot displayed*) activity? Please explain in detail.

तुमच्या पाठ्यपुस्तकातील XYZ कृती तुम्ही कशी शिकवाल? तपशीलवार सांगा.

7. Have you received any input for teaching data handling in your teacher professional development courses/trainings/workshops? If yes, please explain.

माहिती व्यवस्थापन किंवा सांख्यिकी हा भाग कसा शिकवावा या बद्दल तुम्हाला प्रशिक्षणे कार्यशाळा किंवा इतर अभ्यासक्रमातून कोणत्या प्रकारचे मार्गदर्शन मिळाले आहे?

8. Do you face any challenges while teaching the data handling part of the mathematics curriculum?

गणित अभ्यासक्रमातील माहिती व्यवस्थापनाचा भाग शिकवताना तुम्हाला कोण कोणत्या अडचणी येतात?

2. Teachers' Understanding of Statistical Concepts

Aim: Explore how teachers justify some of their answers from the survey questionnaire

Display the relevant question on the shared screen.

In this section, I would like to understand more about how you approached and thought about some of the questions in the survey. Your responses help shed light on how teachers interpret and reason through different statistical ideas. I will now ask you a few questions based on specific items from the survey that you completed to understand your thought process in more depth.

या विभागात मी तुम्हाला सर्वेक्षणाबद्दल काही प्रश्न विचारणार आहे. याचे उद्दिष्ट तुम्ही कसा विचार केला, एखादे उत्तर का निवडले हे जाणून घेणे आहे. तुमच्या उत्तरांमुळे शिक्षक वेगवेगळ्या सांख्यिकीय कल्पनांचा अर्थ कसा लावतात आणि तर्क कसा करतात याबद्दल मला अधिक माहिती मिळेल. आता मी तुम्हाला सर्वे मधील काही प्रश्नाबद्दल विचारणार आहे.

Interview Questions:

1. You answered survey question 1.1 as *(their answer)*. Can you walk me through your thought process behind giving this particular answer?

तुम्ही सर्वेक्षण प्रश्न 1.1 चे उत्तर X दिले आहे. हे उत्तर देण्यामागील तुमचा काय विचार होता? तुम्ही प्रश्न वाचण्यासाठी आणि विचार करण्यासाठी वेळ घेऊ शकता

2. You have answered a similar question. In Question 1.2, you have answered *(their answer)*. Can you justify your choice of answer?

हा प्रश्न तुम्ही आधी दिलेल्या प्रश्न 1.1 सारखाच आहे. तुम्ही प्रश्न 1.2 चे उत्तर X दिले आहे. हे उत्तर देण्यामागील तुमचा काय विचार होता?

3. You have answered a similar question. In Question 2.2, you have answered *(their answer)*. Can you justify your choice of answer?

तुम्ही प्रश्न 2.2 चे उत्तर X दिले आहे. हे उत्तर देण्यामागील तुमचा काय विचार होता?

4. You answered survey question 3.2 as *(their answer)*. Can you walk me through your thought process behind giving this particular answer?

तुम्ही प्रश्न 3.2 चे उत्तर X दिले आहे. हे उत्तर देण्यामागील तुमचा काय विचार होता?

5. You answered survey question 4.3 as *(their answer)*. Can you walk me through your thought process behind giving this particular answer?

तुम्ही प्रश्न 4.3 चे उत्तर X दिले आहे. हे उत्तर देण्यामागील तुमचा काय विचार होता?

6. You answered survey question 5.2 as *(their answer)*. Can you walk me through your thought process behind giving this particular answer?

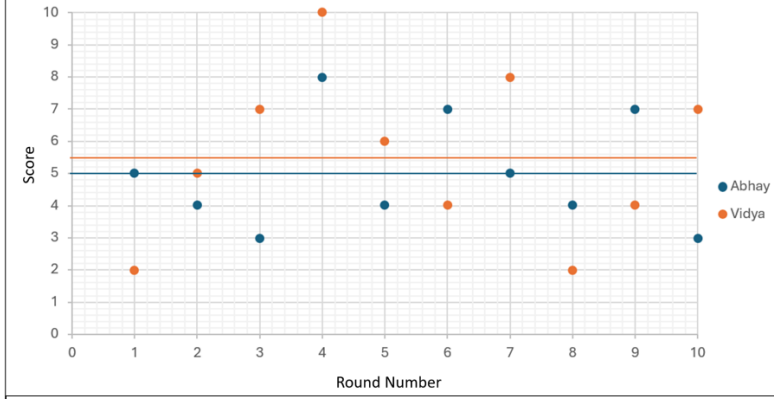
तुम्ही प्रश्न 5.2 चे उत्तर X दिले आहे. हे उत्तर देण्यामागील तुमचा काय विचार होता?

3. PCK Task

Aim: Understand how teachers make sense of students' understanding, errors, and reasoning in statistics.

Interview Questions:

The Statistical PCK task details



Abhay and Divya each played 10 rounds of a game (maximum score: 10 points per round). Their scores are shown in the graph. Some students think Divya should be selected to represent the school, while others support Abhay.

What reasons might the students supporting Divya have?
What reasons might the students supporting Abhay have?
As their teacher, how would you respond to the class?

अभय आणि दिव्या यांनी प्रत्येकी १० फेऱ्या खेळल्या (जास्तीत जास्त गुण: प्रत्येक फेरीत १० गुण). त्यांचे गुण आलेखात दाखवले आहेत. काही विद्यार्थ्यांना वाटते की दिव्याला शाळेचे प्रतिनिधित्व करण्यासाठी निवडले पाहिजे, तर काही अभयला पाठिंबा देतात.

गट १ ने विद्याची निवड करण्यामागे काय कारण असू शकते असे तुम्हाला वाटते?

गट २ ने अभयची निवड करण्यामागे काय कारण असू शकते असे तुम्हाला वाटते?

या दोन्ही गटांना तुम्ही काय प्रतिसाद द्याल.

Appendix C: Ethics Related Documents and Permissions

C.1 Ethical Approval



Education (Educ) DREC

15 Norham Gardens, Oxford, OX2 6PY

Applicant: Jioo Nimkar

Principal Investigator: Jenni Ingram

Department: Education

Study title: Knowing and Teaching Informal Statistics: Primary Teachers' pedagogical content knowledge of big ideas in statistics

(Version: 1.0)

Ethics reference: Education (Educ) DREC - 953865

Dear Jenni Ingram,

On behalf of the Committee, I confirm that the above research study described in the application and other supporting documentation submitted to the committee has been carefully considered by the Education (Educ) DREC in accordance with the University's regulations and policy for ethics approval of research involving human participants, human tissue and/or personal data. The opinion is as follows:

Opinion of Research Ethics Committee: Favourable Opinion

Subject to the following conditions:

Decision Date: 13 Feb 2025, 11:02

Opinion End Date: 13 Aug 2026

If favourable, insurance-provided indemnity arrangements will be in place between the decision date and opinion end date and you may now commence your study activities. Should you plan to continue the research beyond the end date above, it is your responsibility to ensure that you request, and receive, an extension (via amendment) from the committee for indemnity to remain in place. You may be required to provide a justification.

Please note the following:

Amendments: Should there be any subsequent changes to the reviewed study, applications for amendments can be made via the Oxford Ethics Application System (Worktribe Ethics).

Reports: Studies considered by OXTREC are expected to submit an *annual progress report* on each anniversary of study approval, until the study is completed. An end of study report is also required.

Audit: This study may be selected for audit at the discretion of the Research Governance, Ethics and Assurance Team.

Data safety: It is the responsibility of the PI to ensure that all data collected during the course of the study is stored and transferred safely and securely in accordance with university requirements. Further guidance and advice are available from the [Research Data Team](#). Additional information is available at <https://researchsupport.web.ox.ac.uk/governance/ethics>

Yours Sincerely

Education Ethics Officer

C.2 Participant Information Sheet

English Version

UNIVERSITY OF OXFORD DEPARTMENT OF EDUCATION

15 Norham Gardens, Oxford OX2 6PY

Tel: +44(0)1865 274024 Fax: +44(0)1865 274027

general.enquiries@education.ox.ac.uk, www.education.ox.ac.uk



Principle Investigator: Prof. Jenni Ingram: Department of Education

Primary Researcher: Jioo Nimkar: MSc Education (Research Design & Methodology)

Exploring Primary Teachers' notions of big ideas in statistics: Insights from Maharashtra, India

PARTICIPANT INFORMATION SHEET

Central University Research Ethics Committee Approval Reference: 953865

1. Introduction

You are being invited to take part in a research study. Before you decide to participate, it is important to understand why the research is being conducted and what your participation entails. Please take time to read the following information carefully. Please ask if there are any aspects of the project that are unclear or if you would like more information. Take time to decide whether or not you would like to take part in this research.

2. Why is this research being conducted?

I am conducting this research as part of my graduate dissertation project (M.Sc. Education). Data handling as a topic, has been emphasised in Indian curricula, with its introduction as early as grade 1 in mathematics textbooks. The study aims to understand teachers' notions of ideas in statistics in Maharashtra, India and their approaches towards teaching these ideas.

3. Why have I been invited to take part?

You are invited to participate in this study and to complete the survey because:

- a. You are a mathematics teacher teaching primary grades (Grade 1 to 5), and
- b. You are teaching at a school in Maharashtra, India.

OR

You may have already completed the survey and are now being invited to participate in an interview because you have signed up.

4. Do I have to take part?

Your participation in this study is entirely voluntary, and it is your choice whether to take part. You are free to withdraw at any time without facing any negative consequences. If you decide to withdraw, please inform me (Jioo), and any data collected from you will be destroyed (provided the data collection window is still open). However, if your data has already been anonymised, it cannot be removed. In such cases, your anonymised data will remain part of the study but will not be identifiable as yours. Please feel free to contact me, if you have any further questions. Once the project is completed, the anonymised data will be deposited in the Oxford Research Archive (ORA) to support future research.

5. What will happen to me if I take part in the research?

By agreeing to participate in this study,

- a. You will complete an online survey that focuses on understanding of key concepts in statistics.
- b. The survey will include a section where you can provide consent for the data collected to be anonymized and used for analysis.
- c. The survey will have MCQs related to statistical concepts as well as some personal information such as your name, contact information, educational qualifications etc.
- d. If you express interest in participating in an interview through the survey, I may contact you.
- e. Upon your confirmation, you will be invited to an interview where we will discuss these concepts in more detail.
- f. Your consent will also be sought to audio record the interview, and transcripts will be created for analysis.
- g. The interview will last less than one hour and will be conducted online via Microsoft Teams, scheduled at a mutually convenient time and date.

6. What are the benefits and disadvantages of taking part?

While there are no direct benefits to participating in this study, taking part in the pilot, survey, or interview will provide an opportunity to engage with or revisit various ideas in statistics and statistics education, which may develop your understanding of these topics further.

We do not anticipate any risks or disadvantages to taking part in this study.

7. What information will be collected and why is the collection of this information relevant for achieving the research objectives?

The aim of this study is to explore primary mathematics teachers' understanding of statistical concepts. Data collection will take place in two stages. The survey will include questions based on key statistical concepts. Your name will be collected solely as an identifier in case you wish to withdraw from the research at a later stage. Apart from this, personal data such as educational background and years of teaching experience will also be gathered. Participants who volunteer for an interview will be contacted, and audio recordings of the interviews will be collected. This information will contribute to a deeper understanding of teachers' statistical knowledge. Only the principal investigator and I (Jioo) will have access to the non-anonymised research data.

Identifiable data, including consent forms, will be securely stored in Oxford University's OneDrive account. Survey data will be retained for four years following the publication or public release of the research findings. We intend to use the anonymised survey data for future studies and to share it with other researchers (through ORA, as mentioned earlier). Interview data, however, will be permanently deleted upon completion of the dissertation project and will not be shared further.

8. Will the research be published? Could I be identified from any publications or other research outputs?

The results of this research will form the basis of an Oxford graduate dissertation. Some results may be published in academic journals concerned with exploring mathematics education. A copy of my thesis/dissertation will be deposited online in the [Oxford University Research Archive](#) where (it will be publicly available to facilitate its use in future research). The study will take place over the upcoming 4-6 months after which the published results will be publicly available. If you wish to obtain a copy of the published results, please contact me.

The identities of the participants will be fully anonymised, ensuring they cannot be identified in any publications or reported results. I would like your permission to use anonymised quotations from the interviews in any research outputs.

9. Data Protection

The University of Oxford is the data controller with respect to your personal data, and as such will determine how your personal data is used in the research. The University will process your personal data for the purpose of the research outlined above. Research is a task that is performed in the public interest. Further information about your rights with respect to your personal data is available from the University's Information Compliance website at

<https://compliance.admin.ox.ac.uk/individual-rights>.

10. Who has reviewed this research?

This research has received ethics approval from a subcommittee of the University of Oxford Central University Research Ethics Committee. (Ethics reference: 953865).

11. Who do I contact if I have a concern about the research or I wish to complain?

If you have a concern about any aspect of this research, please Jioo Nimkar or Prof. Jenni Ingram, and we will do our best to answer your query. We will acknowledge your concern within 10 working days and give you an indication of how it will be dealt with. If you remain unhappy or wish to make a formal complaint, please contact:

University of Oxford Research Governance, Ethics & Assurance (RGEA) team at rgea.complaints@admin.ox.ac.uk or on +44 (0)1865 616480.

12. Contact for Further Information or Follow-up

If you would like to know more about the research in advance or have any questions during your participation, please use the following contact information.

Jioo Nimkar
Department of Education, 15 Norham Gardens,
Oxford, United Kingdom, OX2 6PY
WhatsApp No.: +44 78847 74286

Your inquiries are most welcome.

Marathi Version

UNIVERSITY OF OXFORD
DEPARTMENT OF EDUCATION

15 Norham Gardens, Oxford OX2 6PY

Tel: +44(0)1865 274024 Fax: +44(0)1865 274027

general.enquiries@education.ox.ac.uk, www.education.ox.ac.uk



Principle Investigator: Prof. Jenni Ingram: Department of Education

Primary Researcher: Jioo Nimkar: MSc Education (Research Design & Methodology)

प्राथमिक शिक्षकांच्या सांख्यिकीविषयक संकल्पनांचा धांडोळा:
महाराष्ट्रातील अभ्यास

सहभागी माहिती पत्रक

Central University Research Ethics Committee Approval Reference: **Education (Educ) DREC - 953865**

1. पार्श्वभूमी

तुम्हाला एका संशोधन अभ्यासात सहभागी होण्यासाठी मी निमंत्रण देत आहे. सहभागी होण्याचा निर्णय घेण्यापूर्वी, हे संशोधन का केले जात आहे आणि तुमच्या सहभागाचे स्वरूप काय आहे हे तुम्ही समजून घेणे महत्वाचे आहे. कृपया खालील माहिती काळजीपूर्वक वाचा. प्रकल्पाच्या कोणत्याही बाबी संदिग्ध वाटल्यास किंवा तुम्हाला अधिक माहिती हवी असल्यास, तुम्ही आम्हाला संपर्क साधू शकता. या संशोधनात सहभागी होण्याचा निर्णय घेण्यासाठी पुरेसा वेळ घ्या.

2. हे संशोधन का केले जात आहे?

मी सध्या ऑक्सफर्ड विद्यापीठात M.Sc. चा अभ्यास करत असून, हे संशोधन माझ्या पदव्युत्तर शिक्षणाचा भाग आहे. भारतातील अभ्यासक्रमांत सांख्यिकी हा विषय 'माहिती व्यवस्थापन' या नावाने गणिताच्या अभ्यासक्रमात आला असून, त्याची ओळख अगदी इयत्ता पहिलीपासून करून दिली जाते. प्राथमिक स्तरावर गणित शिकवणाऱ्या शिक्षकांच्या या विषयाबाबत काय धारणा आहेत आणि हा विषय ते कसे शिकवतात याचा अभ्यास करणे हे या अभ्यासाचे प्रमुख उद्दिष्ट आहे.

3. मला या संशोधनात सहभागी होण्यासाठीचे निमंत्रण का पाठवले आहे?

तुम्हाला या संशोधन प्रकल्पात सहभागी होण्यासाठी निमंत्रण पाठवले आहे कारण

अ. तुम्ही इयत्ता १ ते ५ या वर्गाना गणित शिकवता किंवा या पूर्वी शिकवले आहे आणि

आ. तुम्ही महाराष्ट्रातील कोणत्याही भागातल्या शाळेत शिकवता.

किंवा

तुम्ही सर्वेक्षण पूर्ण केलेले आहे आणि तुम्ही मुलाखतीत सहभागी होऊ इच्छिता.

4. मला या संशोधन प्रकल्पात भाग घ्यावाच लागेल का?

या प्रकल्पात भाग घेणे पूर्णपणे ऐच्छिक आहे. त्यामुळे प्रकल्पात सहभागी व्हायचे की नाही याचा निर्णय सर्वस्वी तुमचा असेल. प्रकल्पात सहभागी झाल्यानंतरही तुम्हाला प्रकल्पातून बाहेर पडावेसे वाटले, तरी तुम्हाला बाहेर पडता येईल. तुम्हाला बाहेर पडावेसे वाटले तर तुम्ही माझ्याशी (जिऊ निमकरशी) संपर्क साधू शकता. माहिती गोळा करण्याचे काम चालू असताना तुम्ही बाहेर पडायचा निर्णय घेतलात तर तुमच्याकडून घेतलेली सर्व माहिती डिलीट करण्यात येईल. माहिती गोळा करण्याची प्रक्रिया पूर्ण झाल्यानंतर, ज्या माहितीमधून तुमची ओळख काढण्यात आली आहे अशी माहिती अभ्यासाचा भाग असेल. मात्र ही माहिती तुम्ही दिलेली आहे हे कोणालाही ओळखता येणार नाही. याबद्दल तुम्हाला अधिक माहिती हवी असेल तर माझ्याशी संपर्क साधा. प्रकल्प पूर्ण झाल्यावर गोळा केलेली सर्व माहिती Oxford Research Archive (ORA) मध्ये भविष्यातील संशोधनासाठी साठवून ठेवली जाईल.

5. या संशोधन प्रकल्पात सहभागी झाल्यास मला काय काय करावे लागेल?

- अ. सांख्यिकी या विषयातील काही महत्त्वाच्या संकल्पनांवर आधारलेले एक ऑनलाईन सर्वेक्षण (form) तुम्हाला पूर्ण करावे लागेल.
- आ. याच सर्वेक्षणा दरम्यान तुमच्या कडून गोळा केलेली माहिती तुमची ओळख उघड न करता संशोधनासाठी वापरण्यासाठीची मान्यता तुम्हाला द्यावी लागेल.
- इ. सर्वेक्षणात सांख्यिकी विषयक संकल्पनांवर आधारलेले बहुपर्यायी प्रश्न असतील तसेच तुमचे नाव, इमेल, फोन नंबर या सारखी काही वैयक्तिक माहिती असेल.
- ई. जर सर्वेक्षणानंतरच्या ऑनलाईन मुलाखतीत सहभागी होण्याची तुमची इच्छा असेल तर मी तुमच्याशी संपर्क साधेन
- उ. मुलाखती दरम्यान सांख्यिकी विषयक संकल्पनांबद्दल मी तुमच्याशी सविस्तर चर्चा करेन
- ऊ. तुमच्या परवानगीने मी तुमच्या मुलाखातीचे ऑडिओ रेकॉर्डिंग करेन या रेकॉर्डिंगचे लेखनात रूपांतर करून त्यांचा वापर संशोधनाती विश्लेषणासाठी केला जाईल.
- ऋ. आपल्या दोघांच्या सोयीच्या वेळी मायक्रोसॉफ्ट टीम्स वापरून ही मुलाखत सुमारे एक तासात पूर्ण केली जाईल.

6. या अभ्यासात सहभागी होण्याचे फायदे तोटे काय आहेत?

या अभ्यासात सहभागी होण्याचा कोणताही थेट फायदा तुम्हाला होईल असे नाही. मात्र सर्वेक्षण आणि मुलाखतीच्या प्रक्रियेतून जाताना तुम्हाला सांख्यिकी या तुलनेने अपरिचित विषयाच्या स्वरूपाबद्दल बरीच सखोल माहिती मिळेल व कदाचित त्याचा फायदा तुम्हाला पुढे हा विषय शिकवताना होईल. माझ्या दृष्टीने या अभ्यासात सहभागी होण्याने तुम्हाला कोणताही तोटा होण्याचा धोका नाही.

7. या संशोधनासाठी कोणती माहिती गोळा केली जाईल आणि संशोधन उद्दिष्टे साध्य करण्यासाठी ही माहिती गोळा करणे का महत्त्वाचे आहे?

या अभ्यासाचा उद्देश प्राथमिक शाळेतील गणिताच्या शिक्षकांच्या सांख्यिकी संकल्पनांच्या धारणांचा शोध घेणे हे आहे. या संशोधनासाठी माहितीचे संकलन २ टप्प्यांत होईल. पहिल्या टप्प्यातील सर्वेक्षणात मुख्यतः सांख्यिकी संकल्पनांवर आधारित प्रश्नांचा समावेश असेल. या शिवाय शैक्षणिक पार्श्वभूमी आणि शिकवण्याचा अनुभव वर्षे या सारखी वैयक्तिक माहिती ही घेतली जाईल. ज्या सहभागींनी

मुलाखतीसाठी सहमती दर्शवली आहे, त्यांच्याशी संपर्क साधला जाईल आणि मुलाखतीदरम्यान ऑडिओ रेकॉर्डिंग गोळा केल्या जातील. या माहिती आधारे शिक्षकांच्या सांख्यिकी विषयक धारणाचे सखोल आकलन होण्यासाठी मदत मिळेल. संशोधनातून बाहेर पडण्याची इच्छा असल्यास तुमचे नाव केवळ ओळख पटविण्यासाठी घेतले जाईल. या प्रकल्पाच्या मुख्य मार्गदर्शक (जेनी इनग्राम) आणि मी (जिऊ निमकर) यांनाच गोळा केलेली माहिती सहभागींच्या ओळखी सकट पाहता येईल.

ज्या वरून सहभागीची ओळख पटेल अशी सर्व माहिती सहमतीच्या फॉर्मसोबत, ऑक्सफर्ड विद्यापीठाच्या वनड्राइव खात्यामध्ये सुरक्षितपणे साठवली जाईल. या सर्वेक्षणाचा अहवाल, संशोधन पत्रिका प्रसिद्ध झाल्या नंतर चार वर्षांपर्यंत ही माहिती सुरक्षित ठेवण्यात येईल. ORA मध्ये साठवलेली तुमची ओळख पटणार नाही अशी माहिती पुढील संशोधनाकरता वापरण्यात येईल. मुलाखती दरम्यान ऑडिओ स्वरूपात गोळा केलेली माहिती इतर कोणालाही देण्यात येणार नाही व अहवाल व संशोधन पत्रिका प्रसिद्ध झाल्या नंतर कायमची नष्ट करण्यात येईल.

8. हे संशोधन प्रकाशित होईल का? कोणत्याही प्रकाशनांवरून किंवा इतर संशोधन निष्कर्षांवरून माझी ओळख उघड होऊ शकेल का?

या संशोधनाचे निष्कर्ष माझ्या ऑक्सफर्डमधील प्रबंधासाठी वापरण्यात येतील. काही निष्कर्षांच्या आधारे गणित शिक्षणातील संशोधन नियतकालिकांत संशोधन पत्रिका प्रसिद्ध करण्यात येतील. माझा प्रबंध या [Oxford University Research Archive](https://www.oxfordjournals.org/) ऑनलाईन आर्काइव्हमध्ये ठेवण्यात येईल व तो पुढील संशोधनासाठी सर्वांना उपलब्ध असेल. हे संशोधन पुढील ४ ते ६ महिन्यांत पूर्ण करण्यात येईल आणि प्रकाशित झालेले सर्व निष्कर्ष सर्वांना उपलब्ध असतील. जर तुम्हाला या प्रबंधाची प्रत हवी असेल, तर तुम्ही माझ्याशी संपर्क साधू शकता.

संशोधनात सहभागी होणाऱ्यांची ओळख पूर्णपणे गुप्त ठेवण्यात येईल. कोणत्याही प्रकाशित केलेल्या साहित्यामधून ही ओळख उघड होणार नाही याची काळजी घेतली जाईल. तुम्ही दिलेल्या माहितीतील काही विधाने उदाहरणे म्हणून तुमची ओळख उघड न करता वापरण्याची परवानगी तुम्ही मला द्यावी.

9. डेटा संरक्षण

ऑक्सफर्ड विद्यापीठ हे तुमच्याकडून गोळा केलेल्या माहितीचे नियंत्रक आहे आणि म्हणूनच संशोधनासाठी तुमच्याकडून गोळा केलेल्या माहितीचा वापर कसा केला जाईल हे विद्यापीठ ठरवेल. तुमच्याकडून गोळा केलेली माहितीवरील संशोधनाच्या उद्देशाने विद्यापीठ वापरेल. संशोधन हे सार्वजनिक हितासाठी केले जाणारे कार्य आहे. तुमच्या वैयक्तिक डेटाशी संबंधित तुमच्या हक्कांविषयी अधिक माहिती विद्यापीठाच्या माहिती वेबसाइटवर उपलब्ध आहे.

<https://compliance.admin.ox.ac.uk/individual-rights>.

10. या संशोधनाचे पुनरावलोकन कोणी केले आहे?

या संशोधन प्रकल्पाची नैतिक दृष्टीकोनातून समीक्षा ऑक्सफर्ड विद्यापीठाच्या मध्यवर्ती नैतिक मान्यता समितीच्या उपसमीतीने केली असून प्रकल्पाला मान्यता दिली आहे. (नैतिक मान्यता क्रमांक : **Education (Educ) DREC - 953865**)

11. जर मला या संशोधन प्रकल्पाबाबत काही शंका व्यक्त करायची असेल किंवा तक्रार करायची असेल तर मी कोणाशी संपर्क साधावा?

या संशोधनाच्या एखाद्या बाबीबद्दल तुम्हाला काही चिंता वाटत असेल तर तुम्ही जिऊ निमकर किंवा प्रोफेसर जेनी इनग्राम यांच्याशी संपर्क साधू शकता. आम्ही तुमच्या शंकांचे निरसन करण्याचा पूर्ण प्रयत्न करू. तुमच्या शंकेचे निरसन न झाल्यास तुम्ही पुढील विभागाशी संपर्क साधू शकाल.

University of Oxford Research Governance, Ethics & Assurance (RGEA) team at rgea.complaints@admin.ox.ac.uk or on +44 (0)1865 616480.

12. अधिक माहितीसाठी किंवा पाठपुरावासाठी संपर्क

तुम्हाला संशोधनाविषयी आधीच अधिक माहिती हवी असल्यास किंवा सहभागासंदर्भात काही प्रश्न असल्यास, कृपया खालील पत्त्यावर संपर्क करा.

Jioo Nimkar

Department of Education, 15 Norham Gardens,

Oxford, United Kingdom, OX2 6PY

WhatsApp No.: +44 78847 74286

C.3 Consent Form: Survey

English Version

UNIVERSITY OF OXFORD DEPARTMENT OF EDUCATION

15 Norham Gardens, Oxford OX2 6PY

Tel: +44(0)1865 274024 Fax: +44(0)1865 274027

general.enquiries@education.ox.ac.uk, www.education.ox.ac.uk



Research Consent Form: Online Survey

Central University Research Ethics Committee (CUREC) approval reference: **953865**

Project Title: Exploring Primary Teachers' notions of big ideas in statistics: Insights from Maharashtra, India

Principal Investigator: Prof. Jenni Ingram: Department of Education

Primary Researcher: Jioo Nimkar: MSc Education (Research Design & Methodology)

Purpose of Study: The aim of this study is to explore primary mathematics teachers' understanding of statistical concepts.

**Please initial
each box if you
agree with the
statement**

I confirm that I have read and understand the information sheet version V0.2, dated 10th January 2025 for the above research. I have had the opportunity to consider the information, ask questions and have had these answered satisfactorily.

I understand that my participation is voluntary and that I am free to withdraw at any point 01/05/2025, without giving any reason.

I understand who access to personal data will have provided, how the data will be stored and what will happen to the data at the end of the project.

I understand that I will not be identifiable from any publications or conference presentations, reports.

I understand how to raise a concern or make a complaint.

I agree to take part.

I agree that I can provide my personal contact details, and they can be retained in a secure database so that the researchers can contact me for the interview

YES /
NO

This consent form was be presented at the beginning of the Online survey

Marathi Version

UNIVERSITY OF OXFORD
DEPARTMENT OF EDUCATION

15 Norham Gardens, Oxford OX2 6PY
Tel: +44(0)1865 274024 Fax: +44(0)1865 274027

general.enquiries@education.ox.ac.uk, www.education.ox.ac.uk



Research Consent Form: Online Survey

Central University Research Ethics Committee (CUREC) approval reference: **953865**

Project Title: प्राथमिक शिक्षकांच्या सांख्यिकीविषयक संकल्पनांचा धांडोळा: महाराष्ट्रातील अभ्यास

Principal Investigator: Prof. Jenni Ingram: Department of Education

Primary Researcher: Jioo Nimkar: MSc Education (Research Design & Methodology)

Purpose of Study: The aim of this study is to explore primary mathematics teachers' understanding of statistical concepts.

**Please initial
each box if you
agree with the
statement**

मला संशोधनाविषयक माहितीपत्रक वाचण्याची संधी मिळाली आहे. मला प्रश्न विचारण्याची संधी मिळाली असून, त्यांची समाधानकारक उत्तरेही मिळाली आहेत.

मी स्वेच्छेने या अभ्यासात सहभागी होत आहे.

या संशोधनात गोळा केलेली माहिती सुरक्षितरित्या कॉम्प्युटरवर साठवली जाईल व मी दिनांक 01/05/2025 पर्यंत कधीही या संशोधनातून माघार घेऊ शकतो/शकते, हे मला माहित आहे.

माझे नाव व ओळख कुठेही वारपरले जाणार नाही, हे मला माहित आहे.

कोणताही प्रश्न, काळजी किंवा तक्रार असल्यास, ती कशी नोंदवावी हे मला माहित आहे.

मी सहभागी होण्यासाठी सहमत आहे.

संशोधक माझ्याशी मुलाखतीसाठी संपर्क साधू शकतील यासाठी माझे वैयक्तिक संपर्क तपशील संशोधकांना देऊ शकतो.

YES /
NO

This consent form was be presented at the beginning of the Online survey

C.4 Consent Form: Interview

English Version



UNIVERSITY OF OXFORD DEPARTMENT OF EDUCATION

15 Norham Gardens, Oxford OX2 6PY
Tel: +44(0)1865 274024 Fax: +44(0)1865 274027
general.enquiries@education.ox.ac.uk,
www.education.ox.ac.uk

Principle Investigator: Prof. Jenni Ingram:

Department of Education

Primary Researcher: Jioo Nimkar: MSc Education (Research Design & Methodology)

ORAL CONSENT FORM: Interviews

Exploring Primary Teachers' notions of big ideas in statistics: Insights from Maharashtra, India

The researcher will read aloud the following information before asking the consent related questions.

“My name is Jioo Nimkar, and I am a master’s student pursuing MSc Education at the University of Oxford. I am conducting this study as part of my dissertation for this degree. The aim of this study is to explore primary teachers' understanding of statistics in India. This study has been approved by the ethics committee 953865. The findings of this study will be reported in my dissertation, and they may also be submitted to academic journals.

You have been invited to participate in this interview because you meet the criteria for the participants in this study. Participation is entirely voluntary, and we do not see any risks associated with your involvement. However, you can stop the interview at any time, without providing a reason, and the interview will be immediately discontinued. You can withdraw your participation at any time until your data has been anonymised. Once the data has been anonymised, it will not be possible to remove your information from the study. Please contact me or my dissertation supervisor in such a case. The contact details and further information can be found in the information sheet already shared with you. This interview will be audio-recorded, and the recordings will only be accessed by my dissertation supervisor and me. Thank you for your time and willingness to participate.”

The researcher will then read aloud the following questions and check the boxes to record that the question has been asked, and that the participant has responded in the affirmative:

1. Do you confirm that you have read the information sheet for this study? Have you had the opportunity to consider the information, ask questions and have these answered satisfactorily?	
2. Do you agree to participate in this study?	
3. Do you agree to this interview being audio recorded?	
4. Do you understand how the audio recording of this interview will be used in research outputs?	
5. Do you understand that your participation is voluntary and that you are free to stop this interview at any time without giving any reason?	
6. Do you give permission to use anonymised quotes from this interview in the study?	
7. Do you give permission for the researcher to contact you again to clarify information?	
8. Do you understand how to raise a concern or make a complaint?	
9. Would you like to proceed with the interview?	

The researcher will begin with the interview questions once the participant has responded affirmatively to each of the questions.

Marathi Version

नमस्कार माझं नाव जिऊ निमकर आणि मी ऑक्सफर्ड विद्यापीठामध्ये एमएससी एज्युकेशन रिसोर्स डिझाईन अँड मेथोडोलॉजी नावाची डिग्री करते आहे. या पदवीचा भाग म्हणून मी महाराष्ट्रातील प्राथमिक शिक्षकांच्या सांख्यिकी विषयक संकल्पनांचा अभ्यास करते आहे. या अभ्यासातून तयार झालेल्या रिझल्टच्या आधारे मी माझा थिसिस पूर्ण करेल. तुम्हाला या मुलाखतीत सहभागी होण्यासाठी आमंत्रित करण्यात आले आहे कारण तुम्ही महाराष्ट्रातील प्राथमिक शाळेत गणित शिकवता व तुम्ही मुलाखतीसाठी इच्छुक असल्याचे दर्शवले होते. मुलाखती दरम्यान आपण सांख्यिकी विषयक संकल्पना बदल सविस्तर चर्चा करणार आहोत. तुमच्या परवानगीने मी मुलाखतीचे ऑडिओ रेकॉर्डिंग करणार आहे या रेकॉर्डिंगचे लेखनात रूपांतर करून त्याचा वापर संशोधनातील विश्लेषणासाठी केला जाईल. संशोधनात सहभागी होणाऱ्यांची ओळख पूर्णपणे गुप्त ठेवण्यात येईल कोणत्याही प्रकाशित केलेल्या साहित्यामधून ही ओळख उघड होणार नाही याची काळजी घेतली जाईल.

1. तुम्हाला संशोधनाविषयक माहितीपत्रक वाचण्याची संधी मिळाली आहे का व प्रश्न विचारण्याची संधी मिळाली असून, त्यांची समाधानकारक उत्तरेही मिळाली आहेत का?	
2. तुम्ही या अभ्यासात सहभागी होण्यासाठी सहमत आहात का?	
3. मी मुलाखतीचे ऑडिओ रेकॉर्डिंग करू शकते का?	
4. या मुलाखतीचे ऑडिओ रेकॉर्डिंग संशोधनाच्या निकालांमध्ये कसे वापरले जाईल हे तुम्हाला माहिती आहे का?	
5. तुमचा सहभाग ऐच्छिक आहे आणि तुम्ही कोणतेही कारण न देता कधीही मुलाखत थांबू शकता हे तुम्हाला समजले आहे का?	
6. तुम्ही दिलेल्या माहितीतील काही विधाने, उदाहरण म्हणून तुमची ओळख उघड न करता वापरण्याची परवानगी मला आहे का?	
7. माहिती स्पष्ट करण्यासाठी तुम्ही संशोधकाला पुन्हा तुमच्याशी संपर्क साधण्याची परवानगी देता का?	
8. कोणताही प्रश्न, काळजी किंवा तक्रार असल्यास, ती कशी नोंदवावी हे तुम्हाला माहित आहे का?	
9. तुम्हाला मुलाखती बदल काही प्रश्न आहेत का?	

Appendix D: Details of Quantitative Findings

D.1 Assumptions for parametric tests

Parametric tests like independent t-tests and ANOVA were used for analysis, it meets all the assumptions for both.

1. Scale of Measurement

The dependent variable, Total Score, was measured on a ratio scale. This implies that the variable is continuous, possesses a true zero point, and supports meaningful ratio comparisons (Field, 2018, p. 59). Teachers were assessed out of a maximum of 12 marks, resulting in a score range of [0, 12].

2. Normality of Distribution

Visual inspection of the histograms for each level of the independent variables (School Type, Teaching Experience, Medium of Instruction, Highest Academic Qualification, and Professional Qualification) suggested an approximately normal distribution of the Total Score. Skewness values also fell within the acceptable range of ± 1 , and kurtosis values were within ± 3 (See Table D.1, Figure D.1). Although the Kolmogorov-Smirnov test returned a statistically significant result (Field, 2018) yielded significant result, these outcomes were expected given the large sample size and the known sensitivity of these tests under such conditions (Agresti, 2018; Field, 2018, p. 420).

3. Homogeneity of Variance

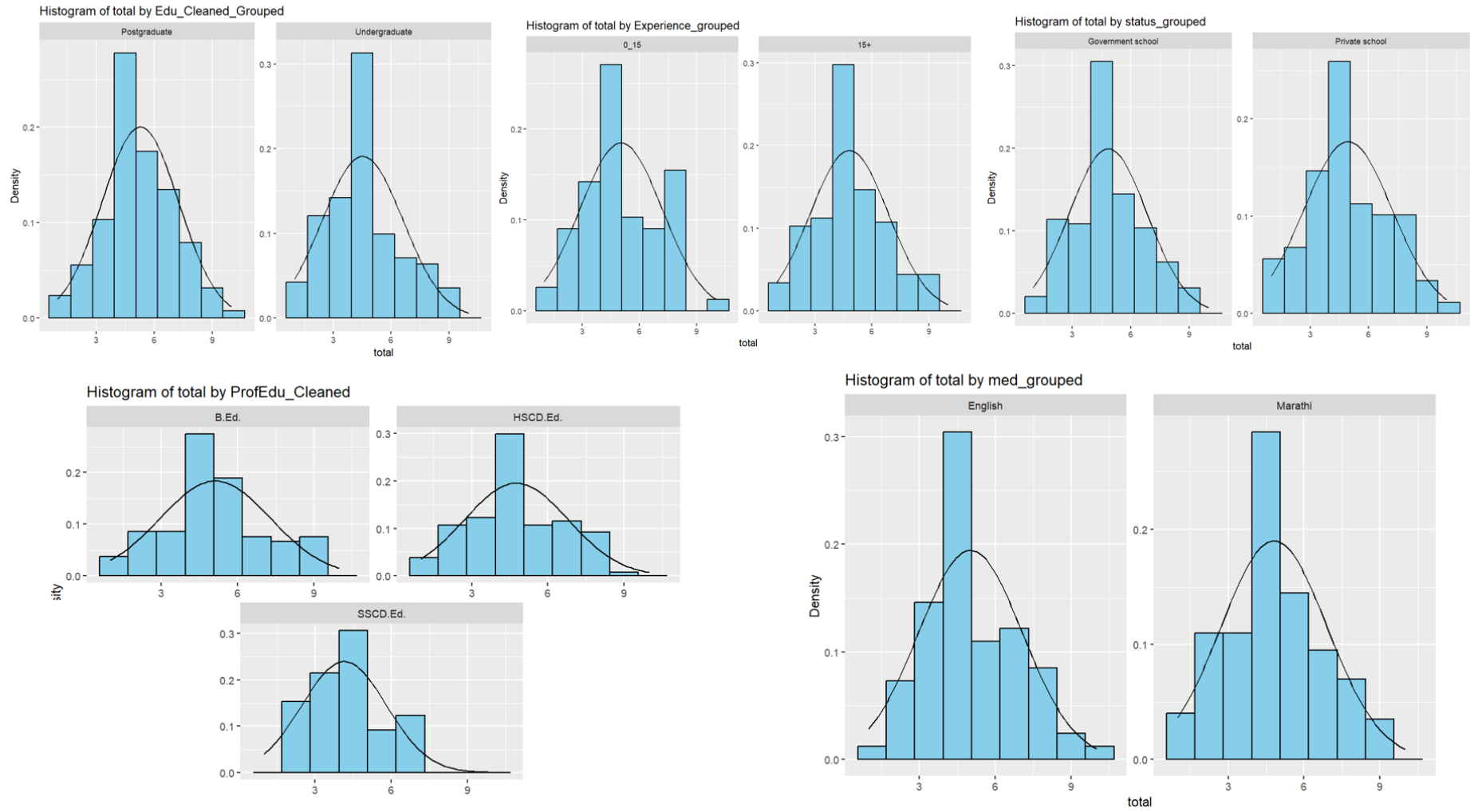
Assumption of homogeneity of variances, necessary to ensure comparability of variability across levels of the independent variables, was tested using Levene's test. The results confirmed equality of variances for Total Score across all factor levels, indicating that this assumption was met (See Table D.1; Field, 2018, p. 1037).

Table D.1
Statistics for Assumption

Variables & Categories	n	Mean	Skew	Kurt	Homogeneity of Variance*
School Type					
Government schools	172	4.84	0.13	-0.81	$F_{[78,171]} = 0.78,$ $p=0.20$
Private schools	79	4.94	0.13	-0.91	
Teaching Experience					
15+ years	182	4.81	0.15	-0.74	$F_{[68,181]} = 1.11,$ $p=0.59$
0-15 years	69	5.03	0.1	-1.03	
Medium of Instruction					
Marathi	178	4.81	0.09	-0.85	$F_{[72,177]} = 0.96,$ $p=0.84$
English	73	5.01	0.29	-0.82	
Highest Academic Qualification					
Postgraduate degree	112	5.28	-0.07	-0.63	$F_{[111,124]} = 0.91,$ $p=0.61$
Undergraduate degree	125	4.52	0.37	-0.69	
Professional Qualification					
Bachelor's in education (B.Ed.)	94	5.12	0.04	-0.8	$F_{[2,236]} = 1.77,$ $p=0.17$
HSC Diploma in Education	116	4.75	0.04	-1	
SSC Diploma in Education	29	4.14	0.42	-1.1	

Note: *checked using Levene's test

Figure D.1: Histogram of total scores by factor levels of each independent variable



D.2 Other Descriptives

Figure D.2: Distribution of responses for confidence level questions

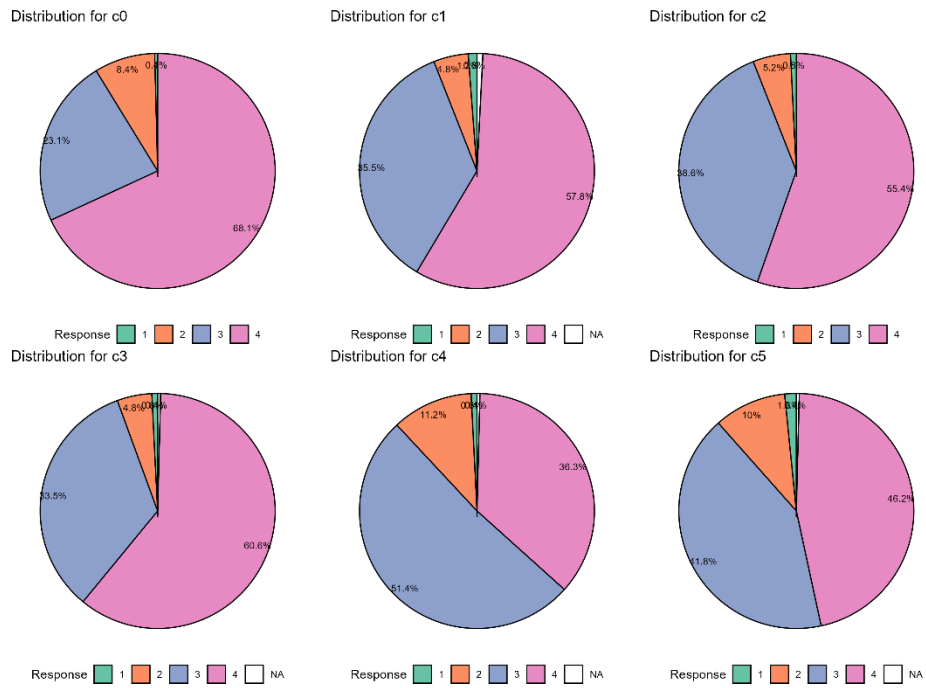


Figure D.3

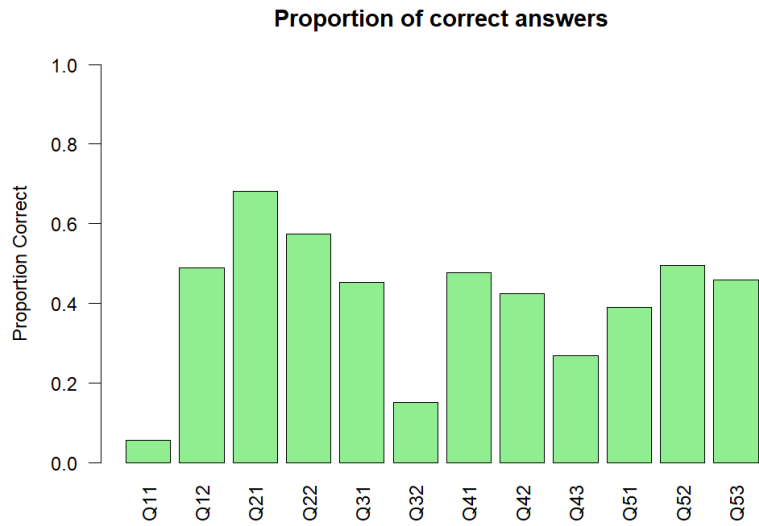
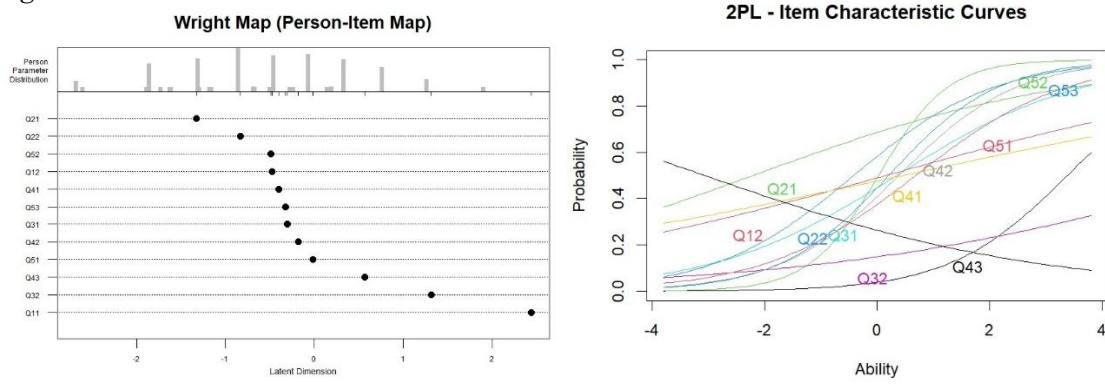


Figure D.4



Both maps in Figure D.4 support the selection of questions that were pursued further in the qualitative phase.

Appendix E: Details of Qualitative Findings

E.1 Original Marathi Quotes (Verbatim)

(p.45) हो, नक्कीच, ह्या कृती पुरेश्या आहेत. मुळात, अभ्यासक्रम तयार करताना या सर्व गोष्टी विचारात घेतल्या जातात. अभ्यासक्रम आणि पाठ्यपुस्तकातील कृती उद्दिष्टांनुसार निश्चित केली जाते. म्हणून, पाठ्यपुस्तकांमधील chapter आणि कृती उद्दिष्ट पूर्ण करण्यासाठी पुरेश्या आहेत

(p.45) पाठ्यपुस्तकांमध्ये एक ढोबळ माहिती आहे आणि त्या माहितीच्या आधारे प्रश्नाची उत्तर देणे इतकंच आहे. जर उद्दिष्ट नाही वाचली तर नीट शिकवता नाही येणार. दिलेल्या माहितीच्या पलीकडे जाऊन काहीतरी निष्कर्ष काढायला हवा ते काही नाही दिलेले.

(p.49) तिन्हीचे आलेख काढता येणार आहे. त्याचा तौलनिक अभ्यास करण्यासाठी वगैरे त्याचा आलेखच्या माध्यमातून त्याचं चांगलं उत्तर मिळू शकणार आहे

(pp.49-50) T: पहिल्या ऑपशन मध्ये सांख्यिकी काय करणार असा मला प्रश्न आला, कि त्यात varity काय येईल.... आणि पुन्हा हे हि कि दुसऱ्या पर्याय त्यात जर एकूण मुलांचा काढायचा असेल तर त्यात पुढे काय करणार मग? असा वाटलं

R: म्हणजे

T: एका आकड्यात उत्तर येईल direct

R: तुम्ही varity नाही, असा म्हणालात आधी, म्हणजे काय हे सांगू शकाल?

T: बरोबर पर्यायामध्ये, जे मुलांचे आवडते रंग आहे तो समजा आपण लिहिला आणि आलेख केला, तर त्यातून आपण काहितिरी एक निष्कर्ष काढू शकतो कि मुलांचा आवडता रंग कोणता आहे.

(p.51) कारण एवढ्यासगळ्या विद्यार्थ्यांना नाही आपल्याला मोजता येणार, तर सोपं काय आहे, तर सोपं हेच असणार आहे कि शहरामधील सर्व वर्गामधील एक शंभर विद्यार्थी घेऊन कारण एवढी मोठी संख्या, ५६० संख्या आहे, मग ५६० संख्या एवढे मोजण्यापेक्षा जर १०० विद्यार्थी जर आपण randomly घेतले तर आपण त्या पद्धतीने सोडवू शकतो

(p.51) या age मध्ये साधारण उंची किती वाढते ह्याचा एक प्रमाण असतं. असं फार क्वचित असता कि अफाट उंची वाढली आहे एका मुलाची किंवा एखादा मुलगा ठेंगू च राहिला, असतात उदाहरण पण कमी असतात. पण आपल्याला सर्वसाधारण काढायचा असेल तर १०० घेऊन सुद्धा काम होऊ शकत.

(p.51) random का घ्यायचा तर, समजा मुलं निवडताना समजा माझ्याच डोक्यात काहीतरी bias आहे, कि समजा मला असा वाटतंय कि मुलगांची उंची जास्त असावी असा मला आतून खूप वाटतंय तर मुलं निवडताना जर मी उंचच मुलगे घेतले तर तो साधारण येणार नाही, तो bias असणार.

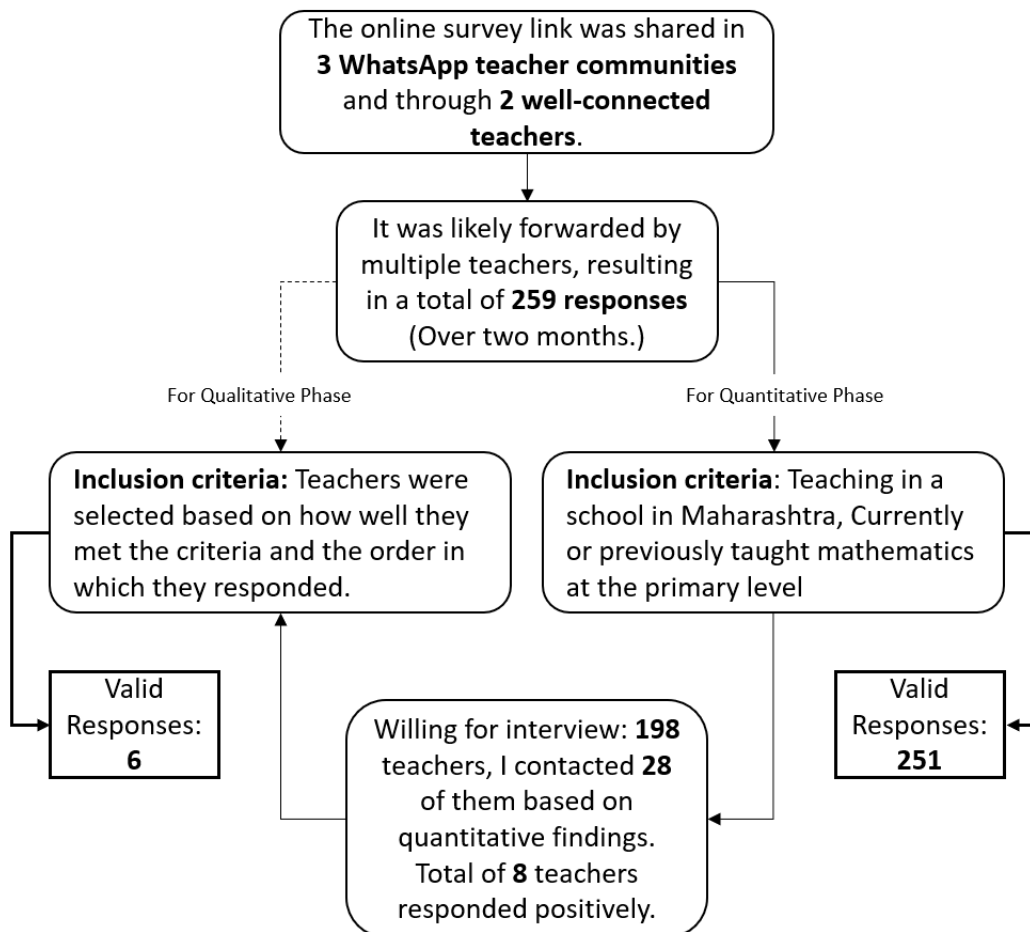
- (p.53) ह्यावरून असं दिसत आहे कि तत्याचं वाचन वाढत गेलं आहे. पुस्तकांची संख्या वाढली आहे म्हणजे त्याचं वाचन वाढला आहे. एखादी गोष्ट का वाढते तर ती आपल्याला आवडते म्हणून. जर आपल्याला एखादी गोष्ट आवडली नाही तर ती आपण constantly करत नाही. म्हणजे विद्यार्थ्यांसाठी तर नक्कीच हे आहे कारण शिक्षणात तुमची रुची, interest हे सगळ्यात महत्वाच आहे. ते जर नसेल तर तुम्ही काहीही शिकू शकत नाही जरी तुमच्याकडे capability असेल.
- (p.53) या option (d) मध्ये particularity आहे... हा (b) option नाहीये कारण तो जास्त linguistic आहे, आणि (d) जास्त गणितीय आहे... इतर चुकीचे आहेत.
- (p.53) मी असा विचार केला होता कि २०१० ते २०११ च्या तुलनेत, पुढे जी, जसं कि २०१४-१५ ह्या दरम्यान जी आहे ती कमी आहे. म्हणजे सुरुवातीच्या काही वर्षांच्या तुलनेत नंतर फक्त २-३ पुस्तकांच वाढली आहेत.
- (p. 54) ग्राफवरून इथे सगळे मार्क घेतले असते, करून त्याचा भागाकार केला असता... कारण शेवटी जेव्हा साधारण विचारलेले असते तेव्हा सरासरी च काढणे अपेक्षित असते.
- (p. 55) मी पूर्ण आलेखाचा विचार केला. म्हणजे २ मार्क मिळाले मुलं किती आहेत ३ मार्क मिळालेले किती?... पूर्ण वर्गाचा विचार केला तर मगच ती सरासरी काढता येणार आहे. कारण ९ गुण म्हटलं तर एकच नंबर येतो. सगळ्या विद्यार्थ्यांचा विचार करून मी सरासरी म्हणते आहे.
- (p. 55) सरासरी ५.५ आहे. पण ५.५ गुण मिळालेले तेवढे विद्यार्थी नाहीयेत ना. पुढे पण बरेच जसं १० गुण मिळाले ५ जण आहेत.. तसाच दुसऱ्या बाजूला १ गुण मिळालेले ५ जण आहेत. त्यामुळे ते प्रमाण योग्य नाही वाटत आहे.
- (p. 57) यातील काहीही होऊ शकते... जर विद्यार्थ्यांच्या दृष्टिकोनातून विचार केला तर, म्हणजे पाऊस पडण्याच्या संदर्भामध्ये इतर परिस्थिती जी आहे ती तेवढी त्यांना माहित नसेल. म्हणजे एकतर वाऱ्यांची दिशा किंवा पाऊस पाडण्यासाठी जे environment गरजेचे आहे, तेव्हाच त्यांना ती माहिती नसणार आहे.... चांगली चांगली माणसं predict करू शकत नाहीत मुलं कशी सांगणार.
- (p.57) option a नाहीये, आपण असं करू शकत नाही, आपण असा पावसाचा अंदाज लावू शकत नाही, शेवटी, तो निसर्ग आहे ... आलेख या महिन्याचा आहे तर, आपण फक्त या महिन्याबद्दल बोलू शकतो ... मला वाटत नाही की यापैकी कोणतेही शक्य आहे.
- (p.57) Option (d) योग्य होईल. जर तुम्ही बघितलं तर पहिल्यांदी १० दिवसात पाऊस नाहीये, तो हळू हळू वाढत चालला आहे.... तर तो पुढे पडत राहणार असा त्याचा अंदाज बांधते आहे मी.
- (p.57) महिन्याच्या शेवटच्या १५ दिवसात म्हणजे पडलाय पाऊस, त्या वरून अंदाज लावून असा मी म्हटलंय कि पुढच्या महिन्यात साधारण तसाच राहिला तर तो पडण्याची जास्त शक्यता आहे.

- (p.59) म्हणजे मुलं म्हणू शकतात कि मुलगाच पाठवायचा आहे किंवा आमचा मित्र आहे. काहीना असं वाटत असेल कि मुलीला का पाठवायचं, ती काय करणार... त्यामुळे खरंच बेटर कोण आहे हे त्यांना समजावून सांगावं लागेल.
- (p.59) मुलं असा विचार करत असतील कि जरी अभयचा स्कोर कमी असला, तरी त्याच variation कमी आहे. म्हणजे सरासरीच्या रेषेपासून लांब कमी आहेत. म्हणजे गुण जे आहेत ते ठराविक range मध्ये आलेत. जस कमीत-कमी ३ आणि जास्तीत-जास्त ८. म्हणजे त्याचा performance steady असू शकतो.
- (p.59) एखाद-दुसऱ्या मुलाला असं हि वाटत असेल कि मुलगा आहे तर better performance देऊ शकेल... पण कदाचित त्यांना ग्राफ नीट कळलेला नसेल... त्यामुळे त्यांचा जे म्हणणं आहे तिथून correct जे आहे तिथं पर्यंत न्यावं लागेल कि कोणाचं average जास्त आहे.
- (p.60) जेव्हा तुम्ही एक प्रतिनिधी निवडता तेव्हा त्याच्यात एक सातत्य असणं गरजेचं आहे. सातत्य नंतर असेल आणि अशी शक्यता असेल कि मिळाले तर १० नाहीतर एकदम २ असं असेल तर ते risky आहे. पण ज्याचं सातत्य आहे तो pressure घेत नाहीये, म्हणजे त्याची कामगिरी एकसारखी राहतेय तर, तो एक चांगला खेळाडू आहे. त्यामुळे ज्याच्यात जास्त guaranty आहे त्याला निवडावं असा सल्ला मी मुलांना देईन

Appendix F: Accessing Participants

F.1 Flow chart of access to the participants

Figure F.1



F.2 The WhatsApp message shared through the teachers' group (Online Survey)

Marathi Version

सस्नेह नमस्कार,

मी जिऊ नीलेश निमकर. सध्या मी इंग्लंडमधील ऑक्सफर्ड विद्यापीठात शैक्षणिक संशोधन या विषयात M.Sc. करत आहे. माझ्या पदव्युत्तर अभ्यासाचा भाग म्हणून मी प्राथमिक शिक्षकांच्या सांख्यिकी (Statistics) विषयक संकल्पनांचा धांडोळा या विषयावर संशोधन करत आहे.

भारतातील गणिताच्या अभ्यासक्रमात सांख्यिकी हा विषय माहितीचे व्यवस्थापन या नावाने आला असून तो अगदी पहिलीपासून शिकवला जावा अशी अपेक्षा आहे. महाराष्ट्रातील शाळांत इयत्ता पहिली ते पाचवी या वर्गात हा विषय कसा शिकवला जातो, शिक्षकांना त्यात कोणत्या अडचणी जाणवतात हे समजून घेणे हा या संशोधनाचा प्रमुख हेतू आहे. एक ऑनलाईन सर्वेक्षण आणि त्यानंतर काही निवडक शिक्षकांच्या मुलाखती घेऊन हे संशोधन पूर्ण करण्याचा माझा विचार आहे.

आपण जर इयत्ता १ ते ५ मध्ये गणित शिकवत असाल किंवा या पूर्वी शिकवले असेल तर या सर्वेक्षणात भाग घेऊन मला माझे संशोधन पूर्ण करण्यासाठी मदत करावी ही विनंती. सोबत पाठवलेल्या लिंकवर क्लिक करून तुम्ही सर्वेक्षणात भाग घेऊ शकता. अधिक माहितीसाठी माहिती पत्रक पहा.

आपल्या सहकार्याबद्दल मनापासून धन्यवाद.

[LINK]

English Version

Hello,

I am Jioo Nimkar. I am currently pursuing an M.Sc. in Educational Research at the University of Oxford, UK. As part of my postgraduate studies, I am conducting research on the conceptualisation of statistics by primary school teachers.

Statistics has been introduced in the mathematics curriculum in India under the name of information management, and it is expected to be taught from the very first grade. The main objective of this research is to understand how this subject is taught in schools in Maharashtra from classes 1 to 5 and what difficulties teachers face in it. I plan to complete this research by conducting an online survey and then interviewing some selected teachers.

If you are teaching mathematics from classes 1 to 5 or have taught it before, please help me complete my research by participating in this survey. You can participate in the survey by clicking on the link sent to you. For more information, see the Participant Information Sheet.

Thank you very much for your cooperation.

F.3 The WhatsApp message shared to contact teachers (Online Interview)

Marathi Version

नमस्कार!

माझे नाव जिऊ निमकर, मी सध्या ऑक्सफर्ड विद्यापीठात मास्टर्स पदवीचे शिक्षण घेत आहे.

काही काळापूर्वी आपण "प्राथमिक शिक्षणातील सांख्यिकी संकल्पनांचा धांडोळा: महाराष्ट्रातील एक अभ्यास" या माझ्या संशोधनासाठी तयार केलेला सर्वे पूर्ण केला होता. त्या सर्वेमध्ये आपण मुलाखतीसाठी इच्छुक असल्याची नोंद केली होती. हा मेसेज त्याच संदर्भात पाठवला आहे. एकूण २५९ शिक्षकांच्या प्रतिसादांमधून मी सहा शिक्षकांची निवड मुलाखतीसाठी केली आहे. या मुलाखतीत मला आपल्या शिकवण्याच्या अनुभवांबद्दल आणि सांख्यिकीविषयक दृष्टिकोनाबद्दल अधिक जाणून घ्यायचं आहे.

ही मुलाखत सुमारे ३० ते ४० मिनिटांची असेल आणि Microsoft Teams या ऑनलाईन माध्यमातून घेतली जाईल. आपले विचार ऐकण्यासाठी मी उत्सुक आहे.

आपण या मुलाखतीत सहभागी होण्यास इच्छुक असाल, तर कृपया मला कळवा. त्यानुसार आपण वेळ व तारीख निश्चित करू.

धन्यवाद!

English Version

Hello!

My name is Jioo Nimkar, and I am currently pursuing my Master's degree at the University of Oxford.

Some time ago, you completed a survey prepared for my research titled "Exploring Primary Teachers' Notions of Big Ideas in Statistics: Insights from Maharashtra, India". In that survey, you indicated that you were willing to be interviewed. This message is sent regarding the interview. Out of a total of 259 responses, I have selected six teachers for interviews. In this interview, I would like to know more about your teaching experiences in statistics. This interview will last about 30 to 40 minutes and will be conducted online through Microsoft Teams. I look forward to hearing your thoughts.

If you are interested in participating in this interview, please let me know. We will arrange the time and date accordingly. PFA the Participant Information Sheet.

Thank you!

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