Teachers' use of reform-oriented mathematics textbooks: A multiple-case study of Delhi government primary school teachers

Meghna Nag Chowdhuri
Fitzwilliam College

November 2019

This dissertation is submitted for the degree of Doctor of Philosophy (PhD)

DECLARATION

I hereby declare that my thesis entitled *Teachers' use of reform-oriented mathematics textbooks: A multiple-case study of Delhi government primary school teachers* is the result of my own work and includes nothing which is the outcome of work done in collaboration except where specifically indicated in the text. Also, my thesis is not substantially the same as any that I have submitted or will be submitted for a degree or diploma or other qualification at this or any other university.

STATEMENT OF LENGTH

This thesis does not exceed the prescribed word limit of 80,000 words, excluding footnotes, references and appendices.

Abstract

India in the last two decades has introduced several policy reforms to improve primary school mathematics teaching and learning, especially to make it more accessible for children. One such policy, National Curriculum Framework – 2005, outlines the need for making mathematics relevant to *all* children and connecting school mathematics to students' lives. Based on these reforms, the National Council of Educational Research and Training (NCERT) developed new primary school mathematics textbooks. These books are a radical departure from traditional mathematics textbooks, as they explicitly restructure its form, pedagogy and mathematical content. The crucial enabling link in actualising transformational ideals in textbooks are, the teachers. Yet, both in India and globally, very little is understood on how teachers use textbooks in their teaching.

To fill this gap, my study explores how teachers view and use textbooks in a reform context. The study adopts a participatory view of the relationship between the textbook and the teacher; which is both influenced by the textbook's features as well teachers' thinking. The study explores the cases of ten primary school teachers in Grades 4 and 5, in four government schools of Delhi. Data were collected from classroom observations, semi-structured teacher interviews, and textbooks. Thematic analysis was used to analyse the textbooks, classroom observations as well as interviews.

The textbook analysis reveals that several pedagogical changes are introduced within the textbook. The reformed textbook challenges the authority relations between school mathematics and the learner. Additionally, social justice messaging is implicitly embedded within the textbook. Teachers in turn make textbook related choices at two levels: first, at the level of task selection; second at an interpretive level. Challenging the predominant understanding of textbooks-centric teaching, my findings show that teachers use a range of strategies to engage with the textbook. These include *following* the textbook as a script, *customising* it to fit their own notions of mathematics teaching and institutional realities, as well as *avoidance* of the textbooks and the subject all together. There are two important implications of the study. First, in relation to producing reform oriented textbooks, the thesis argues for a simultaneous focus on teachers must be maintained, so that textbooks become educative materials for professional development. Second, the study also highlights the significance of institutional and cultural opportunities and barriers in enabling teachers' productive interpretations of textbooks.

Acknowledgements

First and foremost, I want to express my deepest gratitude to my supervisor Professor Nidhi Singal who enabled me to find 'my voice' as I wrote this thesis. She has patiently supported and guided me throughout this journey; especially when I found myself in a labyrinth of (paralysing) circuitous thinking. I also want to thank my co-supervisor Professor Kenneth Ruthven who introduced me to the academic world of Mathematics Education, as he supervised my MPhil thesis and early years of the PhD. His incisive comments on my work always made me reflect on unique perspectives. Many thanks to my advisor Professor Andreas Stylianides, who provided critical feedback that helped me immensely.

This study would not have been possible without the financial support that came from the Jawaharlal Nehru Memorial Fund and Cambridge Trust. I am very thankful to Cambridge Trust which supported me both during the MPhil as well as the PhD. I also want to thank Sue Free, Tereza Svecova, Sally Law and Rajashree Dhanaraj from Fitzwilliam College who provided prompt administrative support whenever I needed it. Fitzwilliam College's larger community, including its spaces – the library, café, MCR provided me with space to think, write, read, discuss and grow. The reading groups: Womanist reading group, Disability and Education reading group, Race Empire and Education reading group: have been intellectually formative and provided me with an avenue to share and express my larger critical and theoretical ideas.

Thank you to Sheeba Mathew, my manager at Oxford University Press, who taught me how to be a kind leader and educator, as I explored the educational space in India. Her engaging leadership inspired me to do this PhD.

In the last five years, I met some exceptional educators and scholars. I especially want to thank Firoz Ahmed, Snehlata Gupta, Ekta Goel, Murari Jha, Anil Teotia, Jyoti Sethi, Richa Dang who supported me in navigating Delhi's government schooling system, helped me with permissions and introduced me to a network of passionate teachers. Other scholars in India – Sonika Chauhan, Shikha Takker, Alprata Ahuja provided me the much-needed insight into the scholarship emerging within Indian academia.

I want to especially thank Dr Vidya K.S. who has acted as an academic peer-mentor through this PhD journey. She directed to me to diverse literature, encouraged me to keep a view of the larger political questions and comforted me as I struggled as an independent

researcher in Delhi. She was critical in familiarising me with the field and supported me to get in touch with several teachers and educators. A special thanks to Dr Manish Jain, Dr Rakhi Banerjee, Dr Arindam Bose and Dr Farida Khan who happily met a naïve first year PhD student and offered an opportunity to learn from their expertise. I finally want to thank the teachers who participated in the study and trusted me with their valuable time and allowed me to enter their classroom and school spaces. These teachers, who are navigating so many contradictions day in and out, are the motivation for this study.

While I collected data during my fieldwork, Swati Janu and Aditya Mazumdar provided me with ideal work spaces to come back to as I processed what I collected. My friends kept me sane through it all. Ekta Oza, Sukanya Purkayastha, Aanchal Kumar, Sanyam Sethi, S Vaishnavi (and her little one), Aparna Iyengar, Vinita Sivaramakrishnan, Siddharth Singh (always pointing to me how much I still needed to read!), Sachita Suryanarayan; thank you all for always being there.

In Cambridge I found multiple families, which nourished me in different ways. Aliya Khalid provided me with comfort I often needed whenever I doubted myself. I knew I could go to her home anytime, and spend time with her, Adnan and Amna, and it would immediately replenish me. Akshyeta Suryanarayan was just a call away, and would bring me warmth, her hugs and *chai* when I struggled with anything. Vibhu Tewary, François Guérit, and Manuel Piña Dreyer were part of endless nights of chatting, watching films and cooking together. Rashmi Singh and Asiya Islam provided me with gossip, loud laughter, and lots of food which made me feel like I was back in Delhi. Asma Zubairi's engaging discussions on politics, always taught me something new. Music lessons with Prachi Acharya satiated my musical appetite. My housemates – Nipun Sawhney, made sure there was always some chicken curry for me at home; Jade Han, taught me crocheting; and Daniele Rada, finally got me to cycle.

Thank you to Seema Nath, Hannah Ware and Carly Christensen for being the most amazing group of PhD-comrades, with whom I could have endless discussions on epistemology (!). Siddharth Pandey and Charleen N Chiong became more than colleagues working on a student-journal and were willing to be my study-buddies and indulge in long chats anytime. Liliana Chávez-Díaz, Juana Yunis Marulanda, Jana Ehret and Sebastian Selvén provided me with early friendships that taught me how to be a companion during the long-winded PhD journey.

I could not have done this PhD without the support of my parents, *Ma* and *Baba*. They placed importance on education ever since we were young, and made all efforts to provide the best for us. Nikhil, Indrani aunty and Anisha, gave me a home away from home in the UK, ready to host me, feed me and comfort me whenever I needed it.

Didi and Richa, my wonderful sisters – your support, your love, your strength has made me who I am. You both inspire me to be better every day. This PhD would never have existed if you had not made me believe that I could be whoever I wanted to be.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

Figure

List of Abbreviations

NCERT	National Council of Educational Research and Training
SCERT	State Council of Educational Research and Training
NCF	National Curriculum Framework
SCF	State Curriculum Framework
NCTE	National Council for Teacher Education
NCFTE	National Curriculum Framework for Teacher Education
GOI	Government of India
RTE	Right to Education Act
NEP	National Education Policy
DOE	Directorate of Education
MCD	Municipal Corporation of Delhi
DIET	District Institutes of Education and Training
BElEd	Bachelor of Elementary Education
CTET	Central Teacher Eligibility Test
MHRD	Ministry of Human Resources Development
BEd	Bachelors in Education
DEd	Diploma in Education
JBT	Junior Basic Training
ETE	Elementary Teacher Education
ASER	Annual Status of Education Report
U-DISE	Unified District Information System for Education

CHAPTER 1: INTRODUCTION

1.1 The Research Problem

Textbooks have been central to schools in India ever since an education system was formally introduced during the colonial era in the early nineteenth century (Kumar, 1988). Their relevance has continued as postcolonial India still prescribes textbooks to state-run schools. They not only define teacher instruction, they also dictate student assessment patterns. One of the central contentions against such a prescriptive system is that it curbs teacher autonomy, whose curricular decisions are bound by the text (Apple & Christian-Smith, 2017; Kumar, 1986). Thus, there has been a call for broadening resource systems for teachers in India, which has been evident for over two decades (GOI, 1993, 2019; NCERT, 2006c). However, within a financially-constrained educational system, textbooks continue to be the only available material resources in most schools. Hence, they have become the basic minimum equalising force, ensuring that all children have access to equal educational opportunities (Morris & Hiebert, 2011). This is the reason why, along with efforts of broadening resource systems, attempts at improving the quality of these important curricular documents have continued.

As a school subject, *primary mathematics* has particularly been troubling for a large number of school-going children, and improvement in its learning has become imperative. Both performance in basic arithmetic as well as mathematical ability to apply this knowledge are consistently low among Indian primary school children (see ASER, 2019; Kumar, 2017). An early difficulty in mathematics also causes it to become a potential obstacle to entering higher education, especially high status professions, which require school mathematics qualifications (Khan, 2015b; Subramanian, 2015). Many Indian scholars have ascribed the difficulty of coping with school mathematics to the curriculum itself, calling for reform in both the content as well as the pedagogies related to it (see Batra, 2015). In this context, curricular reforms brought into the Indian education system in 2005 were particularly significant (see Chapter 2, Subsection 2.1.2).

Reform-oriented mathematics textbooks, both in India and globally, have tried to 'change' the way mathematical teaching and learning takes place. Whilst all textbooks bring with them a particular version of 'authoritative' content and pedagogy (Love & Pimm, 1996), the

reformed ones do so in varying ways. In particular, 'reform-oriented' textbooks attempt to reform teaching and learning, marking themselves out as different from traditional textbooks. The kinds of reforms introduced within the textbooks are based on contextual policies, ideologies and significant research findings in mathematics education. For instance, in the 1990s, with the introduction of the National Council of Teachers of Mathematics (NCTM) *Standards* in the US (NCTM, 1989), a number of textbooks and other curricular materials were designed to promote reforms focused on problem-solving and challenging mathematical tasks. These influenced several other reforms across the world (see Fan & Zhu, 2007). Similarly, in the Netherlands, the Realistic Mathematics Education (RME) movement led to Dutch textbooks that were designed based on RME principals (Gravemeijer, 2014).

For this thesis, the curricular reforms in India under the National Curriculum Framework (hereafter NCF-2005) are investigated, with the main focus being on the mathematics textbooks (NCERT, 2005). Based on these reforms, *Math-Magic* textbooks (Book 1-5) were developed and introduced by the National Council of Educational Research and Training (hereafter NCERT) (NCERT, 2006a, 2006b, 2007a, 2007b, 2008). Despite it now being more than 10 years since the introduction of these textbooks, there is a lack of studies aimed at understanding how they are being used by teachers. Whilst researchers, both in India and other parts of the world, explore the 'quality' of textbooks using textbook analysis (Nawani, 2010; Fan, 2013), there is generally a lack of studies focusing on teachers' use of textbooks. That is, within the context of primary school reform-oriented mathematics textbooks in India, there is a gap in the understanding of how teachers use these textbooks. Further, India also has a variety of schools with different types of resourcing: from elite schools accessed by children from higher socio-economic backgrounds, to the government schools accessed by the poorest (see Subsection 4.3.2). These schools not only have a variety of resourcing (with private elite school accessing privately published textbooks and digital resources), they also have a very different type of teacher cadre (see Section 2.2). In this thesis, understanding how teachers in Delhi's government primary schools use reform-oriented mathematics textbooks is probed.

1.2 Genesis and Significance of the Study

1.2.1 Genesis of the study

The motivation to pursue this project came from my own experience of developing and editing primary school mathematics textbooks. After initially training as a mathematician, I joined an Indian private publishing house, where I was involved in developing primary school mathematics textbooks for five years. The experience of interacting with the textbook authors as well as the teachers using the textbooks, piqued my interest in the relationship between the author/publisher's ideas of teaching and the teachers' perception of these books. I was also particularly interested in understanding how ideas of innovation and reform, which may be based on research or ideology incorporated into the textbooks, are viewed by teachers. For my MPhil thesis (Nag Chowdhuri, 2015), I explored teachers' perspectives on reform-oriented mathematics textbooks. After gauging teachers' views about the textbook series, I aimed to understand the relationship of the teacher and textbook more holistically by further investigating their practices relating to these books in my PhD.

1.2.2 Significance of the study

The study, focused on teachers' use of reform-oriented textbooks in the context of ordinary government schools in Delhi, contributes both to theory as well as practice. Firstly, by focusing on textbook use with a unique reform initiative within the global South[1], it contributes to the growing field of textbook use research across the world. As highlighted in the recent book *Research on Mathematics Textbooks and Teachers' Resources: Advances and Issues* by Fan, Trouche, Qi, Rezat, and Visnovska (2018), it is important to question the significance of concepts and methodologies in textbook studies for different contexts.

> Are the concepts and methodologies appropriate for the context in which they are applied or do they need to be transformed as we adapt them to new contexts? This 'comparative attitude' is then a means for making theoretical concepts and frameworks better fitted to a broader scope of context-specific realities (Fan et al., 2018, p. 355).

[1] Terms such as global South, Southern contexts or postcolonial contexts are contested terms and have signified much more than geographical locations of different countries. In particular, there is rich scholarship on postcolonial and Southern theory to understand education (see Connell, 2014). While this thesis does not use postcolonial theory in specific, it uses the terms 'global South' and 'postcolonial' to refer to contexts which are both understudied and undertheorized and often become 'recipients' of theory from Northern Eurocentric contexts. Further, curriculum itself within these contexts are often influenced and structured due to the colonial experience which has implications on both curriculum development and reforms (Kumar, 1988; Pinar, 2015).

These authors not only highlighted the need for more context-specific studies, but also, emphasised investigation of how theories and frameworks developed in certain contexts get used and 'fitted' into other contexts. This thesis will involve extending concepts and methodologies from the larger field of mathematics education through their application in an Indian school context. By so doing, there will be critical examination of their 'universality' (Valero & Zevenbergen, 2004) across different contexts. The approach used in this thesis involves the importation of theories and practices from the discipline of mathematics education mostly developed in Northern contexts, whilst also problematising them (Valero & Vithal, 1999).

This brings up the matter of the study's significance at the practical level. By exploring teachers' classroom practices and their voices in ordinary settings, this thesis can provide professional insights. By understanding the nuances of teachers' work, the dichotomies often engrained in policies simplistically labelling teachers as 'teacher-as-manager' versus 'teacher-as-professional' (Sarangapani, Mukhopadhyay, & Jain, 2018) can be investigated. Additionally, as argued by Banerjee (2012) and Behar (2016), given India has extremely diverse and varied regional cultures and languages, there is a complete lack of classroom-based studies that have shed light on how this diversity plays out in schools. Only by collecting classroom-based evidence can policies and recommendations for improving teaching and learning become more nuanced. This study contributes to broadening this evidence base by bringing empirical findings from classrooms. The research is geared towards addressing the following overarching question:

How do primary school teachers view and use reform-oriented mathematics textbooks in government run schools in Delhi?

This main research question is tackled through dealing with the following sub-questions:

RQ 1: How are the key *reforms represented* in the mathematics textbooks?
RQ 2: How do teachers *use* the reform-oriented mathematics textbooks in their lessons?
RQ 3: How do teachers *view* the reform-oriented mathematics textbooks?

A multiple-case study of ten teachers in four government-run schools in Delhi was carried out to address the above research questions. Each sub-research question is addressed using a different naturalistic research method. Regarding the first, data from the textbook itself is analysed using framework and concepts from the field of mathematics education, which are

most relevant for the reforms that influenced the textbooks. The second research question is addressed by analysing classroom observations and finally, the third research question is tackled through analysis of data collected from semi-structured teacher interviews.

1.3 Structure of the Thesis

This thesis is composed of nine chapters. The following one provides the context of the study, detailing the Indian educational landscape, in particular, from the perspective of reforms in mathematics education, textbook development and the status of primary teachers. Chapter 3 provides a review of the literature on the main concepts covered by the study. It conceptualises and positions the work, whilst also defining the key constructs used. Chapter 4 details the methodology and research methods utilised in the study, justifying the decisions made during the course of the endeavour. Chapters 5, 6, 7 address each of the three research questions, by presenting the key findings. Chapter 8 provides discussion that combines each of the research findings. Finally, Chapter 9 draws a conclusion to the thesis and provides recommendations for the future.

CHAPTER 2: THE CURRICULUM REFORM CONTEXT AND STATUS OF PRIMARY SCHOOL TEACHERS

2.0 Introduction

This chapter provides an overview of the mathematics reform policy in India that is the basis of this study. The initial subsection provides a historical background to the reforms (Subsection 2.1.1). Then, details of the NCF-2005 reforms are provided, with examination of the aims for school mathematics and the consequent development of textbooks based on them (Subsection 2.1.2). In this section, the notion of textbook culture, which is central to the Indian education system, is also considered. In Subsection 2.1.3, recent debates and critiques raised by different scholars around the NCF-2005 reforms are then discussed. The section ends with discussing parallel discourses on mathematics learning outcomes that are increasingly influencing school mathematics curricula. The second section of this chapter provides an overview of the status of primary teachers in India (Section 2.2). The first subsection focuses on the teacher education system and other professional development programmes in India (Subsection 2.2.1). The second, discusses the status and multiple roles of primary school teachers, especially those working in government schools (Subsection 2.2.2).

2.1 Indian School Mathematics Curriculum Landscape

2.1.1 History of primary mathematics education in India

During the colonial era in India, formal schooling of British colonial knowledge systems replaced indigenous mathematics education systems (Babu, 2012; Dauben, Yee, Raina, & Xu, 2014; Schubring, 2017). Dauben, Yee, Raina and Xu (2014) explain that before 1835, there were still some efforts to use methods of "engraftment": finding common ground between indigenous mathematical practices and British practices to "allure natives" (p. 377) to study European science. However, by 1835, such efforts had been mostly abandoned and British textbooks were introduced focusing on transferring Eurocentric mathematical knowledge. Post-independence, instead of taking up the opportunity to re-invent the knowledge sources for the mathematics curriculum, there was continual use of the British system. Some tokenistic changes were made by showcasing India as a global contributor to mathematics, including excerpts on the history of Indian mathematics within textbooks.

Rather than developing an alternative mathematics curriculum, such efforts intended primarily to create a national identity (Dauben et al., 2014). Further, due to the emphasis on industrial nation-building immediately after independence, science and technology subjects were prioritised. This focus meant that renewing the mathematics curriculum was by and large neglected. Khan (2015a), in her discussion on the evolution of mathematics education in the Indian context, argues that mathematics served as a foundational subject for science and technology. Thus, while it retained its compulsory status (up until Grade 10), it was more of a supporting subject to the sciences.

Innovation in mathematics education was led by activists who were primarily working on science education, perhaps unsurprisingly, since there was such great emphasis on the sciences. In the 1960s, experimentation in science education began. In 1967, a science textbook, developed in collaboration with UNICEF '*Science is doing'*, was introduced in India (NCERT, 2006e). Additionally, in the 1970s, influenced by the Nuffield science project in the UK and disillusioned by the failure of science teaching and learning in rural parts of India, a group of academic activists started the famous Hoshangabad Science Teaching Programme (hereafter HSTP) in Madhya Pradesh. This programme collaborated with science teachers and students to develop a meaningful curriculum of "activities, experiments, and discussions", instead of using one textbook as the source of all knowledge (Subramaniam, 2016, p.140). It was one of the first voluntary projects with state collaboration, which had a long-term and large-scale impact (Kumar, 2008). It brought with it some of the most foundational ideas of inquiry-based learning as well as questions of contextualising the curriculum, thus calling for a fundamental change in the curriculum-pedagogy relationship prevalent in India. Yet, these curricular innovations initially remained mostly within the sciences.

Efforts in reforming the mathematics curriculum as well as textbooks only began in the 1990s, when both *Eklavya* (the NGO associated with HSTP) and the Homi Babha Centre for Science Education (hereafter HBCSE) started focusing on the mathematics curriculum. Projects, such as the *School Mathematics Project* (SMP) in Delhi, led by Prof Amitabha Mukherjee (Mukherjee & Varma, 2015), and the adult literacy project – *Numeracy counts!* by Prof Anita Rampal (Rampal, Ramanujan, & Saraswathi, 1997), were some initiatives in mathematics Education. One of the central ideas of these efforts was 'contextualising' the curriculum (Paliwal & Subramaniam, 2006). For example, the SMP project conducted surveys of 'street mathematics' in an effort to understand everyday mathematics as opposed

to formal school mathematics. Similarly, the premise of *Numeracy counts!*, a book on adult literacy, was to investigate ways in which adults include mathematical knowledge in their own work and life. What was crucial in these efforts is that both pedagogy (how to learn) and curriculum (what to learn) were being investigated in tandem. Within a postcolonial context, these efforts of 'contextualising' can be viewed as efforts of 'decolonising' the inherited Euro-centric mathematics curriculum. As Dauben et al. (2014) argue, by the end of twentieth century, questions around cultural translation that were lost in the 1830s were brought back in a very different historical era.

Another effort to 'Indianise' school mathematics is important to mention as it has often been seen as controversial. This is the introduction of 'Vedic mathematics' into the curriculum, as suggested by National Curriculum Framework-2000 (NCF-2000). This effort of turning to the 'Vedas'[2] suggested by Hindu nationalist groups, is also often justified as an effort to "indigenise" (NCERT, 2000, p. 37) the curriculum. Raju (2014) argues that contemporary Vedic mathematics (fast arithmetic computations) do not really have Vedic origins, but rather, comprises opportunistic rhetoric to promote a certain narrative of Hindu nationalism. After analysing the NCF-2000, Kamat (2004) contends that Hindu nationalists' appropriation of the rhetoric of 'decolonisation' of education is a contradiction or "aporia" (p. 267) within the Indian postcolonial state. This indicates how the rhetoric of 'localising' the mathematics curriculum is used both by Hindu nationalist as well as progressive educationalists in India. In the next subsection, I will detail the way in which NCF-2005 articulates the aims of school mathematics and how the textbooks were reformed in line with aims of progressive educators.

2.1.2 NCF 2005: Transforming primary mathematics education

Innovations in science and later mathematics pedagogy were being discussed in activist circles from the 1970s through to the early 2000s. However, these were limited to small initiatives with some success in working with state governments. For example, the HSTP programme worked with the Madhya Pradesh state government for several years (see Subramaniam, 2016). At a national level, the impact of these discourses was felt only in 2005, when the new reformed curriculum framework was introduced. In the following

[2] As Hindutva ideologies have often been discussed as influencing the history curriculum of India, inclusion of Vedic texts within science and mathematics has also been suggested. For instance, NCF-2000 suggested bringing Vedic astrology into the curriculum. See Mahajan (2018) Visweswaran, Witzel, Manjrekar, Bhog, and Chakravarti (2009) and Kumar (2012) for details.

subsections, the framework and the way it views primary mathematics education is presented and compared with its predecessors.

Table 2.1: Comparison of the aims regarding mathematics and role of curricular materials in the different NCFs (1975, 1988, 2000, 2005)

National Curriculum Framework (NCF)	Aims of mathematics teaching and learning
NCF 1975	In a society which is rapidly transforming itself into an industrial and technological society, mathematical literacy is essential to every citizen (NCERT, 1975, p. 16).
NCF 1988	Since quantitative treatment, measurement, analysis and reasoning are being increasingly involved in many other subjects, the relevance should be seen not only as a specific subject area, but also, in the context of, and as concomitant to other concerned subject areas (NCERT, 1988, p. 23).
NCF 2000	One of the basic aims of teaching mathematics in schools is to inculcate the skill of quantification of experiences around the learners (NCERT, 2000, p. 55).
NCF 2005	The main goal of mathematics education in schools is the mathematisation of the child's thinking (NCERT, 2006d, p. v). Shifting the focus of mathematics education from achieving 'narrow' goals [*computation skills*] to 'higher' goals [*mathematisation*]" (italics added) (p. vi). The shift in focus we propose is from mathematical content to mathematical learning environments" (p. vi).

NCF-2005 reform aims for primary mathematics

The National Council for Educational Research and Training (NCERT), an autonomous organisation of the Government of India (GOI), develops both national curricular frameworks along with curricular materials. India has released four curricular frameworks (NCF1975, 1988, 2000, 2005) (Table 2.1). These national frameworks have become the basis for State Curriculum Frameworks (SCFs), the National Curriculum Framework for Teacher Education (NCFTE) as well as curricular materials, such as textbooks and teacher guides. The most recent National Curriculum Framework (NCF-2005) is particularly important for my study, since the reform-oriented mathematics textbooks *Math-Magic* were developed based on this framework. NCF-2005 has the following five overarching guiding principles:

(i) connecting knowledge to life outside the school;

(ii) ensuring that learning shifts away from rote methods;

(iii) enriching the curriculum so that it goes beyond textbooks;
(iv) making examinations more flexible and integrating them within classroom life; and
(v) nurturing an overriding identity informed by caring concerns within the democratic polity of the country. (NCERT, 2005, p. viii)

Apart from these general principals, unlike earlier curricular frameworks, which dedicated only a page or two on mathematics curricular aims and topics, NCF-2005 also came out with mathematics specific position paper called the: *National focus group on teaching of mathematics* (NCERT, 2006d) (one among 21 such focus groups). Within this position paper, the aims of mathematics are stated as follows:

(1) Children learn to enjoy mathematics;
(2) Children learn important mathematics
(3) Mathematics is a part of children's life experience which they talk about;
(4) Children pose and solve meaningful problems;
(5) Children use abstractions to perceive relationships and structure;
(6) Children understand the basic structure of mathematics; and
(7) Teachers expect to engage every child in the class. (NCERT, 2006a, p. i)

One of the key aims both of the guiding principles and for mathematics education was to *connect school mathematics to the lives and discourses* of the children (see (i) and (3) above). While the earlier NCF-2000 mentioned the use of mathematics in students' lives, this was limited to notion of transfer and application of school mathematics in them. For example, NCF-2000 stated "mathematics helps in the process of decision-making through its application to real-life situations in familiar as well as non-familiar situations" (p. 55). On the other hand, NCF-2005 viewed the links between school mathematics and students' lives through the lens of both critical pedagogy and ethnomathematics. For instance, using a critical approach[3], the position paper explicitly mentioned issues of systemic discrimination and its influence on school mathematics. For example, it talks about the relationship between gender and mathematics.

Mathematics tends to be regarded as a 'masculine domain'. This perception is aided by the complete lack of references in textbooks to women mathematicians, the absence of social

[3] In the NCF-2005, an entire subsection (Subsection 2.4.5) is dedicated to explaining 'Critical pedagogy' (p. 17-24)

> concerns in the designing of curricula, which would enable children questioning received gender ideologies and the absence of reference to women's lives in problems. (p. 7)

Further, through a lens of ethnomathematics (d'Ambrósio, 2006), the linking of mathematics and students' lives also meant bringing to the fore "mathematics that people use" (p. 11). The position goes on to state:

> What may be called *folk algorithms* exist for not only mentally performing number operations, but also for measurement, estimation, understanding of shapes and aesthetics. Appreciating the richness of these methods can enrich the child's perception of mathematics. (p. 11)

Clearly, legitimising and validating alternative forms of mathematics that students experience in their out-of-school lives was also given space within the curriculum, along with critically viewing the relationship of school mathematics and larger social structures. Apart from recommendations explicitly with the purpose of addressing school mathematics and social justice issues, other aims stressed on ambitious mathematics ideals[4]. That is, the authors proposed moving away from 'narrower' aims of computational skills to 'higher' aims of '*mathematisation'*. This higher aim was viewed as a shift in focus to processes rather than product, i.e. with mathematisation being defined as the learning process itself rather than the product. Citing Wheeler (1982), the position paper remarked: "it is more useful to know how to mathematise than to know a lot of mathematics" (NCERT, 2006, p. 1). Accordingly, the policy recommended a focus on processes, such as "formal problem solving, heuristics, estimation, optimisation, use of patterns, visualisation, representation, reasoning and proof, making connections, and mathematical communication" (page 8); rather than listing mathematical domain areas that needed to be focused on (as was the case in previous NCFs). Further, it proposed that such a shift required concentration on "mathematical learning environments" rather than "mathematical content". (p. 8). It recommended "activity-oriented" (p. 1) lessons, where children could actively participate in, discuss and engage with these processes. Thus, NCF-2005 aimed at higher or ambitious process-oriented mathematics and spearheaded issues of social justice and equity by proposing linking school mathematics to the lives of children.

[4] The position paper refers to scholars, such as Polya (2002) (on the aims of mathematics), Wheeler (1982) (on mathematisation) as well as other curricular reforms, such as NCTM in the Unites States. This kind of reference to Mathematics education literature and other curricular reforms in other parts of the world was new for policy documents in the Indian context.

Table 2.1 highlights the difference in the aims of mathematics of NCF-2005 compared to its predecessors. As discussed in Subsection 2.1.1, post-independence mathematics education at the school level had remained mostly static, void of much reform and played a secondary role to science and technology. This was reflected in earlier curricular frameworks as well. For example, NCF-1975 and NCF-1988 clearly stated the importance of mathematics, because of science and technology (see Table 2.1). NCF-2000 moved to articulating the importance of the application of mathematics in students' everyday lives. Finally, NCF-2005 articulated an active 'shift' in focus of school mathematics towards mathematisation away from the narrower aims of computation.

Reforming mathematics textbooks: challenging textbook culture

A key focus of NCF-2005 was also to challenge the predominance and overuse of textbooks. One of its guiding principles was: "(iii) enriching the curriculum so that it goes beyond textbooks" (p. viii). A position paper specifically discussing curriculum, syllabus and textbooks was also published along with NCF-2005 (NCERT, 2006c) that also recommended using a "multiplicity of teaching and learning materials" (p. 38). This appeal for textbook reforms needs to be understood within the larger context of 'textbook culture' in India. In his two seminal articles, '*Textbook and educational culture*' (1986) and '*Origins of textbook culture*' (1988) Krishna Kumar discussed the central role of textbooks in the Indian educational system. Textbook culture, a term coined by him, refers to the culture of transferring the official 'knowledge' (represented in the curriculum) from the textbook, through the teacher, to the child, who in turn reproduces that same knowledge in centralised examinations. He describes four key features of this culture as follows:

> (a) Teaching is based on the state prescribed textbooks, (b) teachers must complete these prescribed textbooks, and do not have much freedom to change that, (c) resources other than these textbooks are not available, (d) end-of-year assessments are also based on textbooks (language modified) (Kumar, 1988, p. 453).

Other studies in the past two decades have further suggested an overreliance on textbooks in the Indian educational system (see Clarke, 2001; Sarangapani, 2003). Vijaysimha (2013) and Maithreyi (2012) describe how knowledge is regulated within the textbook culture in science and mathematics lessons. Maithreyi (2012) argues:

> Here [in India], textbooks do not function merely as a measure of practice or habituation, but have a central, overarching effect on the learning situation, displacing the agency of the learner and the teacher, through the production of 'ought-to-know' knowledge that must be digested in the form of a set of 'right answers'. (p. 37)

Thus, textbook culture symbolises a wider culture of focusing on one type of 'official knowledge' that is strictly regulated both by the teacher and the textbook. NCF-2005 directly attempted to address issues that accompany textbook culture, by both calling for diversification in terms of resources (and moving away from one textbook) as well as attempting to conceptualise a 'good textbook'. It claimed that a good curriculum resource "leads the child to interact with their environment, peers, and other people rather than be a self-contained transferrer of knowledge as a finished product" (p.38).

Consequently, an active effort was made to develop and introduce textbooks that were aligned with the aims of NCF-2005. It is particularly important to note that Professor Krishna Kumar (who conceptualised the notion of textbook culture in India) himself was tasked with this, as the director of NCERT. Under his directorship, NCERT came out with a series of primary school textbooks (Book 1 to Book 5) based on the principles espoused in NCF 2005, named *Math-Magic* (NCERT, 2006a, 2006b, 2007a, 2007b, 2008). In this thesis, I call them 'reform-oriented' textbooks (see Subsection 3.3.1 for a discussion on the term reform, as used in the mathematics education literature). These reform-oriented *Math-Magic* textbooks, which are the focus of my study, were introduced in Delhi government schools in 2010. One crucial feature of the textbook development process was the inclusion of civil society members (NGO leaders and university professors) along with the NCERT faculty. Thus, many of the voices that had previously been working on the periphery, demanding change in the curriculum, were actively involved in the process (see Subsection 2.1.1). These included activists involved in HSTP efforts, such as Professor Anita Rampal (Chairperson of the Advisory Committee), who had previously worked in the adult literacy programme, and Professor Amitabha Mukherjee (Chief Advisor), who had engaged in the SMP project (see Section 2.1). Syeed (2018), in her study aimed at shedding light on the ideologies that feature in these NCERT textbooks, (including *Math-Magic*) tried to capture how this unique process took place. Her analysis brought to the fore the contested ideologies among the NCERT

faculty and the civil society activists. She called this the micro-level "war of position" [5] (p. 554), pointing especially to the difficulty academic-activists faced in integrating critical pedagogies within the textbook:

> [] government authorities were more accepting of changes that allowed for the introduction of student-centred pedagogy in the textbooks rather than content that raised critical questions regarding the nation's diversity or inequality. (p. 541)

Additionally, civil society activists were also seemingly aware of the rare position of power that they had been afforded and used this opportunity to make the textbook, such that "it [was] embarrassing for anyone to go back to old styles of textbooks." (p. 555). Indeed, these textbooks were commended for having attempted a unique approach by several newspaper articles and reviewers (see Mukherji & Mukul, 2009; Sengupta, 2007; Subrahmaniam, 2005; Tripathi, 2006). In several articles, the textbook authors themselves described the ways in which reform ideas were embedded within the books (Rampal, 2015; Rampal & Makar, 2012; Rampal & Subramanian, 2012). In Rampal and Makar (2012), the authors discussed the role of 'authenticity' within the textbooks. In Rampal (2015) the author focused on the critical socio-political aspect of the books, and in Rampal and Subramaniam's (2012) chapter, the notion of 'cultural responsiveness' was highlighted. Together, the authors contended that the textbooks use both socio-constructivist and critical pedagogies to restructure primary school mathematics textbooks.

2.1.3 Recent debates and critiques around mathematics education reforms

There have not been any further revisions to the reforms or changes to the textbooks since they were introduced in 2005 and mandated use in government schools in 2010, respectively. However, several critiques and concerns around the reforms have emerged within academic circles, along with several parallel discourses around primary mathematics education.

Concerns around mathematics reforms of NCF-2005

Khan (2015a, 2015b), Subramanian (2015) and Banerjee and Seshaiyer (2019) provide an overview of reform movements within mathematics education in India, as well as critiques of the reforms, raising critical issues that contemporary mathematics education in India needs to address. Khan (2015a) raises three concerns. The first relates to the stark difference between the ideal teaching imagined within the textbook and the current educational system. She

[5] Note that I have not included data from the interviews with the textbook authors. During my fieldwork and interactions with authors and government officials, a similar dissonance was observed.

discusses how the meaningful use of textbooks assumes a kind of teaching, learning and knowledge that is neither currently prevalent in schools, nor encouraged in the current educational system. She stresses that without addressing these assumptions, the implementation of curricular change will fail to be meaningful. This operational concern is particularly important for my study. The second concern is more theoretical, with her critiquing the textbook itself for conflating 'social constructivism' with 'individual constructivism'. In other words, while students have their own spontaneous knowledge, she argues that these cannot be deemed automatically as "mathematical". Thus, in her opinion, the textbooks fail to address how intuitive thinking can be socialised into formal mathematical thinking. Her third contention with the textbook is its undermining of 'powerful mathematical ideas'. She warns that whilst it is worthwhile to critique hegemonic knowledge systems, in a highly unequal system, such as India, important mathematical ideas are central for gaining access to high-status professions.

Alternatively, Subramanian (2015) critiques the NCF-2005 for not challenging hegemonic disciplinary mathematics far enough. She argues that for a curriculum to be truly for 'all' children, it needs to look beyond the purpose of induction into disciplinary mathematics (which Khan (2015a) calls 'powerful mathematics'). She criticises the NCF-2005 for failing to accommodate this and continuing to have a "narrow vision of higher aims" (p. 268), as the structure and arrangement of school mathematics as a discipline continues to be maintained. Importantly, the same reforms and textbooks are criticised from two distinct perspectives. Clearly, the notion of powerful mathematical knowledge and its role in equity, as proposed within textbooks and the curriculum, are important considerations for scholars.

Apart from these theoretical and operational issues, Banerjee and Seshaiyer (2019) raise an important issue around lack of research and evidence that might support (or oppose) these reforms. They say:

> One of the difficulties with mathematics curriculum reform within the country has to do with insufficient theorisation of issues which influence curriculum development and teaching and learning of a subject. Research done within the country in the area of mathematics education is inadequate for the purposes of building these reform initiatives. (p. 228)

They highlight how research in mathematics education is carried out by a handful of scholars in India, and continues to be a neglected field. This is a major reason for the lack of

advancements and development in the reforms in mathematics education in India. The present study becomes crucial in this context, as it directly contributes in both theorising teachers' use of textbooks and interrogating the in-depth consequences of reform-oriented textbooks in classrooms.

Parallel discourses on mathematics learning outcomes

Critiques of the NCF-2005 reforms have involved investigating both the pedagogies it proposed as well as the contested notions of 'powerful knowledge' within the reforms. Along with these, global discourse on the "learning crisis" (UNESCO, 2014, p. 18) has significantly influenced innovations and policy in improving mathematics learning. The "learning crisis" suggests that children are not learning in schools, as evidenced by low levels of basic numeracy learning outcomes[6]. In India, the latest Annual Status of Education Report 2018 report shows that only 28% of students in Grade 3 across the country can perform basic subtraction[7] (ASER, 2019). Influential non-governmental organisations, such as *Pratham* are at the forefront in addressing this. Such organisations are bringing curricular and pedagogical interventions in partnership with state governments, which they believe can impact on the learning outcomes regarding basic numeracy[8] skills on a large scale (Banerji & Chavan, 2016). One of the issues that they raise is the fast pace of the school curriculum. They argue that teachers aiming to cover the syllabus do not pay attention to the 'level' of pupils who start to get left behind. Some researchers even call the current curricular pace "overambitious" (Pritchett & Beatty, 2012, p. 1). *Pratham'*s flagship programme promotes the idea of 'Teacher at the right level' (TaRL), whereby students' ability levels are identified and then, teaching is constructed based on their 'level', instead of the age/grade-wise curriculum requirement. These learning goals are both measurable and "simple and clear" (Banerjee et al., 2016, p. 3). These ideas are not new in the mathematics education field or in the Indian context[9], yet these are not in line with the NCF-2005's pedagogical ideals. The authors of NCF-2005 clearly view these as reductionist approaches to learning, strongly

[6] See Winthrop, Anderson and Cruzalegui (2015) for a review of policies focusing on learning within the development and education agenda.

[7] ASER (2019) uses the notion of 'grade level', which signifies the skills students have acquired compared to the level that they 'should' be at. This notion of 'grade level' is similar to earlier constructs of Minimum Level of Learning (MLL) that were prominent in frameworks up until NCF-2000.

[8] Note that the notion of numeracy in the mathematics education context is complex, and while it is often used in the field of international development (and growingly in the Indian policy context) to mean 'basic arithmetic', numeracy as a concept, is much wider than this. See Ruthven (2016) for a detailed discussion on this contested notion.

[9] Sarangapani (2014) talks about the influence of Bloom's taxonomy and other behaviourist notions in the Indian curricular context.

condemning the idea of minimum learning levels:

> Designing learning and test items for these competencies, and teaching to these learning outcomes, is impractical and pedagogically unsound. (NCERT, 2005, p. 75)

Yet, approaches that focus on scale are starting to appeal to governments, which are increasingly taking them into consideration for policy change. The Delhi government recently adopted the idea of level-grouping in the upper primary classes, when it launched the *Chunauti-2018* programme to increase levels of basic reading and arithmetic skills (see Sahni, 2018; Wadhwa, 2018). These discourses are also reflected in the current draft of the new National Education Policy (2019), which specifically talks about focusing on basic literacy and numeracy in primary education (GOI, 2019). The draft document refers to the learning crisis seven times, and also highlights one of the causes for this being due to "too little curricular emphasis on foundational literacy and numeracy" (p. 56). This critical difference in perspective between this parallel discourse (which is now gaining approval at a policy level) and the NCF-2005 curricular reform discourse is crucial. This thesis is a part of evidence building regarding the implementation of the NCF-2005 reforms, at a time when it is both contested and contradicted by the emerging parallel discourse.

2.2 Status of Government Primary Teachers in India

In this section, I explain the status of government primary school teachers[10] in India and discuss the ways in which research positions teachers and their work. Much like the varied understanding and aims of mathematics education (outcome-oriented or process-oriented or critical), the role of teachers in the Indian education system is also a contested field. Scholars have conceptualised two views of teachers' work, which are highly controversial (Majumdar, 2011; Sarangapani, Mukhopadhyay, Parul & Jain, 2018; Sriprakash & Mukhopadhyay, 2015). Sarangapani et al. (2018) view these narratives as the: "managerial-approach-to-teaching" versus "teaching-as-a-profession" (p. 127). The former views teachers as an input in the public education system and thus, determines their worth by assessing the outcomes they produce. These studies often report high level of teacher absenteeism, high costs in salaries and training along with low teacher efficiency (Anand, 2016; Kingdon & Muzammil,

[10] Note that in this thesis, I have focused on government primary school teachers, who are interchangeably referred to as government teachers or primary teachers. These are teachers who are hired, recruited and placed by state agencies to teach in state run schools. These schools in India are known as government schools, which compulsorily use the state produced textbooks. All Delhi government schools use the NCERT *Math-Magic* textbooks (see Chapter 4, Subsection 4.3.2).

2013). Through a managerial and economistic lens, they promote different ways of cost-efficiency, incentivising teachers for better efficiency, and advocating greater teacher accountability (see Aslam et al., 2016). These studies have been used to justify several policies. For example, teachers are increasingly hired on a contractual basis instead of permanent positions, as a measure of cost-efficiency, thus creating fragmentation within the teacher cadre and making their identity even more complex (Béteille & Ramachandran, 2016; Govinda & Josephine, 2005; Goyal & Pandey, 2013; Muralidharan & Sundararaman, 2013).

Conversely, the 'teaching-as-profession' studies view teachers as professionals and situates their work within a social, political and cultural context (Batra, 2012; Kundu, 2019). For instance, in a recent study, Kundu (2019) analyses the conditions of government school teachers in six states. She argues that the criticism levied on government schoolteachers' individual dereliction of non-performance or absenteeism needs to be understood within the larger systemic context of: "their training, working conditions, and, above all, resource-allocation by the government" (p. 34). Such scholarship emphasises the development of teachers professionally (Batra, 2011; Raina, 2018; Srinivasan, 2016). In the present study, the view subscribed to is that teachers are professionals, with the aim of understanding their use of textbooks from a situated perspective. To understand primary teachers' professional lives, the following subsections explore both their educational opportunities (teacher education and professional development) as well as the multiple roles of a government school teacher and their implications.

2.2.1 Teacher education for government primary schoolteachers

At the pre-service level, the recommended minimum qualification of primary teachers is twelve years of schooling (Rajput & Walia, 2001). However, according to the recent teacher qualification reports across India, about 11% of primary teachers at the national level have 10 years of schooling, about 25% of the teachers have 12 years and the remaining 62% have some form of post-school degree (U-DISE, 2016). The certified course to qualify as a primary school teacher is a two-year diploma programme (DEd), which is provided both in government-run institutions as well as private teacher-training institutes. Whilst constructivist as well as critical pedagogical ideas of teaching and learning have been introduced into the curriculum (NCF-2005) and consequently, teacher education frameworks (NCFTE- 2009), it is yet to be seen how these have been integrated into the teacher education institutions (see Batra, 2014; Pathmarajah, 2014; Sarangapani, 2011). In Delhi, there has been some effort to

rethink teacher training programmes, for instance, the introduction of a four-year innovative programme *Bachelor of Elementary Education* (BElEd) at the University of Delhi (Batra, 2009; Raina, 2018). Yet, these remain exceptions and more than 80% of primary school teacher training institutes belong to the private sector, where implementation of the NCFTE norms are a big challenge[11] (see Batra, 2014; Goel & Goel, 2016). Despite there being some evidence that institutions run by District Institutes of Education and Training (DIET) attract qualified and competent students and have qualified teacher trainers (Akai & Sarangapani, 2017), there are equally a large number of private and fraudulent institutions that often go under the radar. These institutes remain influenced by ideas of behavioural psychology[12], rather than constructivist notions of teaching and learning. There is also insufficient attention given to subject matter knowledge for training primary school teachers on their teacher training programmes, with subject-specific knowledge presumed to be acquired through general education (Kumar, Dewan, & Subramaniam, 2012; Batra, 2014). Effort to ensure that teachers have basic content knowledge has meant that mathematics-related understanding is tested in the teacher entrance tests (TET). Regarding which, for primary teacher tests, out of 150 questions, 30 are on mathematics subject matter (Kumar, Dewan, & Subramaniam, 2012). However, the pass per cent of these tests has been extremely low, with about 6% of the student-teachers qualifying ("Teacher test results show abysmal pass percentage," 2012). In the most recent exams, the qualifying per cent rose to about 15% ("CTET result 2019 out," 2019).

At the in-service level, the notion of teachers continued professional development (CPD) is mostly associated with in-service one-off training (Bolitho & Padwad, 2013 as cited in Subitha, 2018). These one-off training events invite an external 'expert' to deliver lectures or workshops for teachers. Teachers' views, voices, agency, experiences and expertise are often not taken into consideration during in-service courses. Moreover, most of these 'expert' teacher educators are secondary school teachers, who have no experience of teaching in primary years (NCTE, 2009; Raina, 2018), provided by District Institutes of Education and Training (DIETs). Hence, the courses are considered inadequate, with many teachers viewing

[11] The National Council for Teacher Education (NCTE) came out with a reformed Teacher Education framework (NCFTE-2009), in line with NCF-2005. All teacher education institutions (government and private) are recommended to follow these guidelines, but are not obliged to do so. Furthermore, private teacher training institutions are often unregulated and offer long-distance courses; rarely complying with NCFTE-2009.

[12] In the 1970s, India saw a strong impact of Bloom's (1956) approach to curriculum development since USAID (United States Agency for International development) funded Indian scholars to study under it (Sarangapani, 2014).

them as rituals that need to be engaged with and lacking in any consequential value-addition to their practice (Ramachandran et al., 2005). In essence, teachers remain "intellectually isolated" (Batra, 2005, p. 4352): they do not receive the needed academic stimulation at the pre-service level and the 'expert' knowledge coming from in-service training institutes is not linked with their local knowledge or understanding (Dyer et al., 2004). Given this situation, there has been a call for developing more participatory-based continuous professional development, which takes into account teachers' own work lives and experience, thus not just viewing them as implementers of policies (Saigal, 2012; Subitha, 2018). In sum, teachers are neither provided sufficient pre-service nor in-service support to prepare them for reform-oriented teaching or subject-specific knowledge to tackle mathematics teaching in classrooms.

2.2.2 Multiple roles of government primary schoolteachers

Along with teacher preparation and their professional development opportunities, it is also important to understand the role of teachers within the Indian public schooling system. Government primary schoolteachers are not subject specialists, but responsible for the holistic development of the child for five years of primary schooling, including curricular and co-curricular growth in mathematics, environmental studies (EVS), Hindi, English, arts (drawing, music) and physical activity. The same group of children typically spend all their years of primary schooling (Grades 1 to 5) with the same teacher, who is responsible for teaching all the subjects. Apart from this, being civil servants, government schoolteachers are often given many administrative tasks that take away time from teaching (Majumdar, 2011). These include government census work, election duties and other kinds of endeavour outside of the schools. As Ramachandran et al. (2005) comment, these "non-teaching tasks" (p. 2142) often cause teacher demotivation as their job becomes more and more burdensome. Along with these tasks, teachers often are expected to implement different types of 'directives' that come to schools from the administrative bodies at short notice. These activities vary from "participation in a cleanliness drive to involvement in an awareness-building walk in the neighbourhood on any issue, ranging from population control and climate change to combating outbreaks of dengue and administration of the oral polio vaccine." (Gupta & Ahmad, 2016, p. 267). Gupta and Ahmed (2016) add that these 'directives' are expected to be implemented immediately, without consideration for teachers' teaching plans or schedules.

Apart from diverse teaching responsibilities, administrative, non-teaching and ad hoc 'programme implementation' duties that teachers face, teacher status also needs consideration. Due to the universalisation of education in a highly differentiated school system, the poorest and most marginalised students attend government schools that are free of charge. Government primary schoolteachers often belong to a higher class or caste compared to the children they teach, sending their own children to private schools, as they view public schooling to be inferior[13] (Mooij, 2008). Moreover, government schoolteachers often blame the child's socio-economic background (caste, gender, economic) and lack of parental input for their poor learning. They thus find themselves teaching students they deem as "inherently less educable" (Majumdar, 2011, p. 55). Prevailing societal prejudice about students based on their caste, gender and religion thus impacts on teachers' views. As Majumdar (2011) suggests, this means teachers also have to gain understanding of critical social issues and to become "activist professionals" (p. 50) to be able to teach the diverse children attending government schools.

Thus, primary school teachers have many barriers to navigate. They must manage several roles within their profession: handle multiple disciplinary subjects, undertake administrative tasks as government employees, while at the same time being sensitive towards children from marginalised backgrounds. Having a low status government job, and not receiving sufficient pre-service and in-service support (with low emphasis on subject-specific training), they are often not prepared to handle these multiple roles.

2.3 Chapter Summary

In conclusion, in this chapter, the context in which the mathematics textbooks were introduced as been discussed: both in terms of reforms that underline these textbooks as well as the status of the teachers who use them. The chapter started with a short discussion on the history of primary school mathematics in India. It highlighted how during the colonial era the British education system was introduced, which focused on Eurocentric mathematical knowledge. In the years following independence, mathematics took an important position as it became a compulsory subject, yet it was mostly viewed as a supporting subject to science and technology. Innovations in mathematics education slowly started to take hold, being led by science educationalists and activists, who brought in ideas of inquiry-based learning as

[13] Since English-medium schools are often favoured by parents and there is a general perception of 'poor quality' of teaching in government schools, parents who can afford to do so send their children to private schools (see Chapter 4, Subsection 4.3.2 for more details on school types).

well as equity in mathematics education. Special efforts were made to rethink what mathematical literacy can mean through explorations of 'street mathematics' and other local mathematical practices. Alongside this, there were (and continue to be) Hindu fundamentalist groups attempting to 'indigenise' mathematics through the promotion of Vedic mathematics, which was especially reflected in the earlier NCF-2000. The discussion then moved on to introducing the NCF-2005 reforms and explaining how these were unique in the Indian context. First, the aims of mathematics education became much broader than just computational and application skills. The reforms brought in constructivist and critical pedagogical ideals within mathematics education. Second, the reforms also promoted rethinking of resources for learning – calling for both a broadening of the resource system as well as the creation of better quality textbooks. Finally, the status of government primary school teachers in India was considered. In Indian scholarship teachers are conceptualised through two opposing lenses – the professional teacher and the manager teacher. These two discourses produce different types of stories of teachers' lives and work in India. My thesis takes the perspective of viewing teachers as professionals, who develop their professional aptitude through teacher education within their complex working environment. Accordingly, the status of teacher education programmes as well as the multiple work roles of government primary teachers was discussed. In the next chapter, I will review in depth the literature about primary teachers' use of reform-oriented mathematics textbooks.

CHAPTER 3: REVIEW OF THE LITERATURE

3.0 Introduction

In the previous chapter, I outlined both the reforms that led to the publication of the *Math-Magic* textbooks and the role of primary school teachers in India. In this chapter, I review the literature relevant to my study and provide explanations of the key concepts used. The first section outlines the gaps in the literature on textbooks in India, which the study addresses – both in terms of the lack of focus on textbook use (3.1.1) as well as the missing voice of the teachers (3.1.2). In particular, in the context of the reforms, such a study becomes highly significant. In the subsequent section, by focusing on the research from the wider field of mathematics education, the conceptualisation of the teacher-textbook relationship is uncovered (3.2). In section 3.3, I review the literature on textbook research, exploring both the features of textbooks that have been most commonly studied as well as the curricular reform context of those studies. I highlight the key textbook affordances that are important for this study, considering the reforms that have influenced the textbooks. Finally, in section 3.4, I turn my lens to teacher related characteristics and how they have influenced the use of curriculum materials. Here, I argue that while there are several individual dimensions that have been explored in the literature (especially beliefs and knowledge), a more holistic construct of teacher views can encompass both the individual as well as socio-cultural-political aspects of teachers' work.

3.1 Textbook Research in India and the Global South

In the Indian context, as discussed in the previous chapter, textbooks are central to the educational system and there are two types of thinking around them commonly used. First, the notion of 'textbook culture' (Subsection 2.1.2) raises political issues regarding the prescription of an official hegemonic curriculum (Apple & Christian-Smith, 2017; Kumar, 2005). This contributes to a lack of teacher autonomy, who feel restricted in terms of bringing different types of knowledge into the classroom (Kumar, 2015). The second type of conceptualisation of textbooks views them as 'educational inputs' and focus on their availability, distribution and output from an economistic perspective (Read, 2015; Smart & Jagannathan, 2018). Several recent studies in the global South have continued to view the

textbook primarily from this perspective[14]. For instance, in the Global Monitoring report GEMR-2014 (UNESCO, 2014) on quality of teaching and learning, only the distribution and printing of textbooks were discussed (p. 88). In fact, the few studies that focus on textbooks (as an input), compare their availability with learning outcomes; assuming a simplistic relationship between this 'input' and 'output' (Beatty & Pritchett, 2012; Frölich & Michaelowa, 2011; Glewwe, Kremer, & Moulin, 2009). While several World Bank reports show a positive impact of textbooks (availability is often used as proxy for use) on students learning (Fredriksen & Brar, 2015; Read, 2015), there are also studies with contradictory results, such as the case of Kenya, where textbook availability did not show improved learning outcomes (Glewwe, Kremer, & Moulin, 2009). There are also other issues related to textbook use, for instance, in Sierra Leone, one study showed that, despite textbooks having been distributed they had been stored away rather than used in lessons (Sabarwal, Evans, & Marshak, 2013). However, these two conceptualisations of textbooks highlighting their political and economic dimensions, do not help in fully understanding their usage or the relationship between textbooks and teachers' pedagogical possibilities. Hence, there have been recent calls for research beyond textbook availability studies, with the focus being on textbook use (Milligan, Koornhof, Sapire, & Tikly, 2018; Milligan, Tikly, Williams, Vianney, & Uworwabayeho, 2017; Opoku- Amankwa, 2010). In India, Majumdar and Mooij (2011) commenting on this distinction, highlighted that while understanding the "macro-politics" (p. 133) of textbooks are important, the more "micro-dimensions" (p. 134) are equally important.

3.1.1 Gap 1: Need for focus on textbook use

Most studies on the 'micro-dimensions' of textbooks in India, consider their 'worthiness' based on linguistics (and) or presumed social implications for the child, with only a few specifically focusing on mathematics learning in the context of textbook use from the point of view of the teacher. This can be seen in Nawani's (2010) literature review on textbook research in the Indian context. Nawani (2010) identified three types of textbook research studies: first, 'worthiness' studies of textbooks based on external criteria; second, studies exploring psycho-social assumptions about the reader (child) within the textbook; and third, textbook use studies within the learning context. The first type of worthiness studies focus on

[14] Note that even in the US context, studies trying to find causation between resource allocation (including textbooks) and educational output were rampant in the 1970s. Since then there has been a considerable shift in this conceptualisation of the textbook as a resource, and its pedagogical value has become centrally important (see Cohen, Raudenbush, & Ball, 2003; Ruthven, 2013).

comprehension and assess them against an 'external' set of criteria, which are quantifiable (Kaul et al., 1995) or qualitative in nature (Ali, Mukherjee, & Rajan, 2007; Batra & Nawani, 2008). Kaul et al.'s (1995) analysis of primary school mathematics textbooks (along with other subjects) quantitatively evaluated the 'readability[15]' of a textbook by focusing on its linguistic features, categorising words and sentences as 'easy' or 'difficult'. This study also involved interviewing teachers regarding the readability of the textbook, but the authors did not clearly state how the interviews were analysed and they hardly feature in the results. More recently Gupta (2014) similarly analysed primary school English textbooks using quantitative methods to explore their linguistic features. NCERT's own textbook analysis report seems more like a review of errors, rather than a systemic textbook analysis. For example, the report on the analysis of Bihar's primary school textbooks, lists suggestions such as "Printing errors (P.84) in unit place 15 is written in addition problem [which] should be avoided" (Panda, 2016, p. 8). As Nawani (2010) contended, not much can be deduced from such a quantified approach regarding the complexity or comprehension of textbooks.

The second category of studies focuses on the reader (assumed to be the student) and her psycho-social world, assuming that she brings with her some ideas when approaching the text, and takes away certain ideas of the socio-cultural world after reading it. Such studies assume that the textbooks themselves have a social impact on the reader, thus maintaining the focus on the book instead of its use. As noted by Stray (1994), texts "are the bearers of [cultural] messages, which are multiply coded" (cited in Haggarty & Pepin, 2002, p. 569). Since the 1990s, there have been several studies in India focused on the socio-cultural messaging within textbooks. Scrase (1993) explored the cultural hegemony of middle-class ideologies in them, whilst Harris's (1999) analysis of primary mathematics textbooks considered the gender bias engrained within. Bhog et al. (2009)[16] used an innovative feminist framework to study primary textbooks to understand the construction of gender, caste and nation. More recently, Roy (2017) explored language textbooks (English, Hindi and Sanskrit) to understand how these bring in historical perspectives that construct certain social narratives.

Moreover, since the introduction of the NCF-2005 based mathematics textbooks (*Math-Magic*), textbook research focusing on 'worthiness' as well as the 'socio-cultural' messaging

[15] They use Dale and Chall's (1949) notion of readability in their study.

[16] They explored 'power' within the textbook and refrain from a naïve understanding of bias in textbooks (number of instances of usage of certain terms), which was common among earlier studies.

have both continued. For instance, Majumdar and Mooij (2011) explicitly claimed that their analysis fits into both these categories, as delineated by Nawani (2010). They looked at both the effectiveness of textbooks as well as the equity dimension by exploring the issues of "[mis- or under-] representation" (p. 138). In their textbook comparison of Grade 1 textbooks used in Andhra-Pradesh, West Bengal with the *Math-Magic* textbooks, they found that while the former two textbooks focused more on algorithmic procedures, the *Math-Magic* textbooks focused on conceptual understanding. They also highlighted that *Math-Magic* textbooks make an attempt to facilitate students to move beyond the textbook through working in groups, and by using locally available materials to organise games etc. Gandhi, Dewan, and Ahuja (2018), using the notion of 'didactical transpositions' (Kang & Kilpatrick, 1992), conceptualised a textbook analysis framework, both for the mathematical content as well as the socio-psychological implications. Jayathirtha (2018) focused on a domain-specific analysis to investigate the intended geometry curriculum represented within the *Math-Magic* NCERT textbooks. Bapat and Takker's (2016) analysis of the *Math-Magic* textbooks involved taking the reader as being the teacher and analysing the books from the perspective of teachers' pedagogical content knowledge (PCK) (see Shulman, 1986). They found that while the textbooks give teachers the opportunity to use their autonomy, they also require a high level of teachers' PCK. This is a particularly unique perspective, as unlike other textbook analysis studies, which focus on mathematical content or the student as reader, the focus was on the teacher (Subsection 3.1.2 discusses in detail studies that have attempted to capture teachers' voices in relation to the curriculum). Thus, even after the introduction of the *Math-Magic* textbooks the focus on worthiness studies and on the reader as the student has continued. However, unlike the focus on linguistics and readability of the mathematics texts, 'worthiness' is gradually being analysed using a wider range of frameworks, particularly from the perspective of mathematics teaching and learning.

The final category of research looks at the text in the learning context, i.e. classroom setting, bringing its use to the fore. There are considerably fewer studies of this kind, which not only give emphasis on the text and its implications, but also to its actual usage. Kumar's (1989) study was focused on the terms used in textbooks for heterogeneous groups, such as 'tribals', and their usage in the classroom. Kaul et al. (1995) studied classroom interactions where DPEP (District Primary Education Programme) textbooks[17] were being used. Since the

[17] This is an example of work aimed at studying the usage of a textbook specially designed for a certain kind of pedagogy; in this case it being the DPEP pedagogy promoting 'active learning'.

introduction of the NCF-2005, despite the interest in reform-based pedagogies, there have still not been many studies that focus on textbook use. One recent study by Mili and Winch (2019) explored geography teaching in schools in Bihar, India. These researchers recognised the role of the teachers' knowledge in the way teachers use textbooks. They found different pedagogic strategies that teachers use when they engage with them: "ostensive teaching, acquaintance knowledge and memory" (p. 16). Their analysis was focused on the ways in which knowledge, pedagogy and textbook intersect. Another study in India looking at mathematics textbook use, in the context of NCF reform, was conducted by Banerjee (2015). Her study, based in English medium government run schools[18], where teachers were trained on the reforms, explored how the topic of Algebra is dealt within the *Math-Magic* textbooks (for upper primary) and then taught in the lessons. She found that while the textbooks have attempted a different treatment of Algebra, this does not simply translate into reformed classroom teaching. She further warns that in the absence of any teacher guidebook to support these textbooks, this translation becomes even more difficult. Given she focused on particular mathematical content and upper primary textbooks[19], these findings are critical for my study.

Two important issues surface from the above discussion. First, as Nawani (2010) commented, there is a lack of *textbook use research* in the Indian context. Lately, there have been some studies trying to engage with textbook use, many of which are influenced by the NCF-2005 and the textbooks emanating from this. Yet, these are very few in number. As discussed above, only two studies would appear to have been aimed at understanding textbook usage explicitly. Secondly, studies focusing specifically on mathematics textbooks are rarer. There are some researchers starting to use different frameworks related to mathematics to explore textbook 'worthiness', as discussed above. However, a focus on the usage of mathematics textbooks remains lacking: only one study was found by Banerjee (2015), which explicitly aimed to do so in the upper primary context. The current study fills this gap by focusing on mathematics textbooks and teachers' usage of them.

[18] Her study was conducted in Kendriya Vidyalayas (KV), which are government run schools primarily for government employees and are often viewed as good quality government schools. See Chapter 4, Subsection 4.3.2 for an in-depth discussion on different school types.

[19] Note that Tripathi (2009) in her textbook review discusses the different nature of the upper primary textbooks compared to the primary textbooks, even though they are within the same textbook series. This could be because of the different teams of authors responsible for the primary (Grades 1-5) and upper primary (Grades 6-8) textbooks.

The lack of textbook usage studies can also be understood within the general scarcity of classroom studies in India (Behar, 2016) and within mathematics education, in particular (Banerjee, 2012). With the vast diversity in India in terms of school type, regions, language, there is a need for many more studies exploring teachers' work in "real terms" (Majumdar, 2011, p. 34), thus shedding light on teaching and learning processes in ordinary school contexts (see Chapter 4, Subsection 4.5.2 for detailed discussion on classroom observation methods in India). Given this background of the growing need for classroom based research as well as lack of textbook use studies, this study on teachers' use of reform oriented textbooks becomes even more relevant.

3.1.2 Gap 2: Missing voice of the teacher

As discussed above, the use of textbook has been less explored than the worthiness and characteristics of the book itself. Additionally, most textbook analysis studies have assumed the reader to be the student and thus, investigation of the notion of teachers as potential interpreters of the text is lacking in the Indian context. In the literature discussed above, only Bapat and Takker's (2016) analysis of the *Math-Magic* textbooks takes the teacher perspective into account, for the other such studies have analysed the textbook from the students' point of view. Thus, there is a lack of inclusion of teachers' role in textbook use within textbook studies in India. This lack of inclusion of teachers' voice is also found in policy. As Batra (2005) argued, the NCF-2005 reforms themselves failed to include the voice and agency of teachers. She remarked: "It [NCF-2005] however, glosses over the fact that teachers are the crucial mediating agents through which textbooks (good or bad) are transacted" (p. 4350). Thus, the teacher, their role and voice is critically missing both in policy and research.

Since the introduction of the NCF-2005 reforms, apart from textbook analysis studies, there have been some studies aimed at capturing teachers' thinking and professional practices in mathematics education. My study becomes a part of such a movement. Kumar and Subramaniam (2015) conducted a professional development programme to help teachers proactively move "beyond the textbook" (p. 86). Through the analysis of teacher talk during professional development sessions, they found that they were slowly being able to rely on their own knowledge of important ideas around integers instead of what was in the textbooks. Takker and Subramaniam (2018) further extended their work on professional development and knowledge by exploring teachers' 'in situ' practices. While the aim of the study was not explicitly to understand teachers' relationship with the textbook, they did view the *Math-*

Magic textbooks as a springboard for developing teachers' pedagogical knowledge. Through a case study of one teacher's work, they found that the teacher taught 'all' the methods in the textbooks, but failed to explore its meanings, justifications and connections. Moreover, Takker (2011), in her study using a questionnaire-based survey and in-depth classroom observations, found a dissonance between mathematics teachers' perspectives on the intentions of the NCF-2005 reforms and their implementation. She also elicited that while the teachers agreed with the pedagogical ideas behind the reforms, they found it hard to actualise them, being only able to do so in a limited capacity. In science education, there are again a few studies, such as those of Sharma and Chunawala (2011) and Nargund-Joshi (2012), which have sought understanding regarding teachers' thinking in the context of curriculum reform. Thus gradually, the exploration of teachers views, beliefs, knowledge and professional development in relation to the NCF-2005[20] reforms is taking place and the textbook being its crucial manifestation has become an important aspect of these studies.

In this section, I have discussed the lack of emphasis on teachers' voice within the policy discourse of the NCF-2005 reforms and have also discussed some of the Indian studies aimed at studying teachers' roles in relation to reforms and the textbooks. To probe teachers' views, the producers of these studies have used both questionnaire-based surveys to as well as in-depth case studies. My study extends these efforts, being explicitly aimed at gaining a comprehensive understanding of teachers' views in relation to the reform-oriented mathematics textbooks. In the following subsections, I consider the wider Anglophone literature on mathematics education in terms of the different conceptualisations of the teacher-textbook relationship, whilst also identifying and defining the constructs that are useful for the current study.

3.2 Conceptualisation of Textbook Enactment: Participatory Relationship between the Teacher and Textbook

The notion of 'textbook' (contrary to economic input or political tool) in the literature in mathematics education asserts its pedagogical meaning (Adler, 2000; Gueudet, Pepin, & Trouche, 2011; Ruthven, 2013). Many studies have focused on the relationship between the textbook and the teacher who mediates the text in the classroom (Ball & Cohen, 1996;

[20] Apart from the NCF-2005, studies have also explored teachers responses to other global reforms, such as child-centred learning, activity based learning etc; however, analysis of these is beyond the scope of this literature review (See Brinkmann, 2016; Miglani, Subramanian, & Agnihotri, 2017; Smail, 2014; Sriprakash, 2011).

Brown, 2009; Remillard, 2011; Sherin & Drake, 2009). These studies not only view the textbook as an important artefact in teaching and learning, for they also accept that teachers are central to its use. Further, research on mathematics textbooks is a growing field in the mathematics education literature (Fan, Zhu, & Miao, 2013; Schubring & Fan, 2018; Trouche, Gitirana, Miyakawa, Pepin, & Wang, 2019). In the next subsection, I describe these conceptualisations from the field of mathematics education and delineate the conceptual framework for this study.

To conceptualise textbook use, it is important first to understand where textbooks are positioned within a curricular system. Here, the tri-partite conceptualisation used by the TIMSS (Trends in International Mathematics and Science Study) study of textbooks is useful (Schmidt, 1996; Thompson & Usiskin, 2014; Valverde, Bianchi, Wolfe, Schmidt, & Houang, 2002). They conceptualised the curriculum at three levels: *intended*, *enacted or implemented* and *attained*. While the intended[21] curriculum is the textbook developer or policy makers' intentions of an ideal curriculum, the enacted or implemented curriculum signifies what teachers do in the classrooms. Finally, the attained curriculum refers to what students eventually learn from the curricular experience. Within such a categorisation, textbooks lie in the intersection of the intended and enacted curriculum as the *potentially implemented curriculum.* Thus, not only is it influenced by the intended goals of the textbook developers, but also, by the enactment of the book in the classroom. For the current study, the potentially implemented curriculum is investigated by focusing on the reform-oriented *Math-magic* mathematics textbooks as well as the curriculum's enactment by exploring textbook use.

Keeping this curricular positioning of the textbook in mind, I move to conceptualising how teachers use them within their enacted curriculum. Remillard's (2005) meta-analysis of the conceptualisations of curriculum use sheds light on the different ways in which teachers interact with textbooks (or other curriculum materials) during its enactment. She broadly discussed four conceptualisations of the relationship: *following or subverting; drawing on; interpreting; and participating with*. This provides a spectrum of use where on the one side teachers are conceptualised as the implementers of the textbook, with the objective of achieving fidelity in use (following), whilst on the other, they are viewed as active collaborators with the textbook, both using and designing their own curriculum (participating

[21] In other conceptualisations of the enactment process, the term 'intended curriculum' often refers to teacher-intentions (Remillard & Heck, 2014). However, here, when talking about teachers' objectives and goals, I will be using the 'teacher-intended curriculum'.

with). The dominant perspective consequently taken up in research studies uses this fourth conceptualisation, where teachers enact the curriculum by participating with the textbooks. This approach views the teacher as the "collaborator with the curriculum material to design enacted curriculum" (Remillard, 2005, p. 217). Central to the *participate with* conceptualisation is that textbook characteristics influence the teacher and their use; conversely teachers also actively interpret the textbook impacting textbook use. My study too is based on this assumption about the teacher-textbook relationship.

To operationalise a participatory conceptualisation of textbook enactment, one of the most influential frameworks was introduced by Brown (2002, 2009) called the *design capacity for enactment*. It is based on the premise that the teacher-textbook relationship is a participatory one, placing agency both on the textbooks' affordances and teachers' own resources. Through this framework, teachers' pedagogical design capacity (PDC) can be understood, which is defined as a "teacher's capacity to perceive and mobilize existing resources in order to craft instructional episodes" (Brown, 2009, p. 29). In the conceptualisation of textbook affordance, the textbook is viewed as an artefact which provides affordances, i.e, a "range of possibilities that artefacts present to human activity" (Brown, 2009, p. 34). Brown's key categorisations of enactment theorise whether teachers use them in a literal manner and place agency primarily on the textbook (*offloading*), utilise them to direct the overall goal of the activity, but changing it based on their own needs (*adapting*), or finally changing the course of the work, while attempting to use the material, which becomes very different from the designated aims of the textbook (*improvising*). Apart from the context of United States (US), where Brown's work originates, more recent work can be seen on South Africa, produced by Leshota and Adler (2018). Extending Brown's framework, they have added key conceptions of injection and omission. These refer to the parts of the text that are omitted and those where teachers insert totally different tasks.

Another study by Kim and Atanga (2014) related Brown's (2009) notion of PDC with teachers' fidelity[22] decisions, claiming that 'good' fidelity decisions, i.e, better alignment

[22] While Remillard (2005) conceptualised the notion of fidelity (faithfulness with the textbook's form and ideals) as being incompatible with the participatory perspective of teacher-textbook relationships; other works do not view them as being contradictory. For instance, within a participatory conceptualisation, Chval, Chávez, Reys, and Tarr (2009) talk about fidelity in terms of 'textbook integrity'. Similarly, Brown, Pitvorec, Ditto, & Kelso (2009) discussed two forms of fidelity: fidelity to the literal lesson and fidelity to the authors ' intended lesson. In this study, while I do not use the term fidelity to identify alignment of teachers' work with the textbooks' affordances; I do discuss how their views or use may differ or be more productive in comparison with the textbooks' ideals.

between textbook/curriculum ideals and the teachers use, depend on teachers greater PDC. They find that teachers use, modify, add to and omit the curriculum when using it, but not all of them are pedagogically effective or positive. For instance, only 17% of the additions they made were positive (judged based on whether they maintained the cognitive demands of the tasks), whilst 68% of the additions were considered negative. They used both classroom observations and teacher interviews, along with teachers' curriculum reading logs, which detailed teacher plans for the lesson. In a quantitative analysis of pre-service science teachers' PDC, Forbes and Davis (2010) explored how teachers plan, use and adapt curriculum materials designed from an inquiry-based pedagogical perspective. They identified different types of changes to curriculum materials: "insertions, deletions, substitutions, duplications, inversions, relocations" (p. 826). They found that whilst teachers adapt curriculum materials, they are able to maintain their inquiry-based elements. Thus, unlike Kim and Atanga's (2014) findings, these pre-service teachers' adaptations seem in-line with the curriculum ideals. Thus, there seem to be different types of findings in different studies. In Section 3.4, I discuss the different explanations (both from teachers' individual and institutional characteristics) given for these varying outcomes.

Apart from exploring teachers' PDC and different ways of mobilising the textbook affordances, other studies also based on the principles of participatory use have focused on other aspects of textbook usage. Sherin and Drake (2009) divided textbook use into three stages: before the lesson, during the lesson and after the lesson. Reinke and Hoe (2011) also identified three stages of textbook use, as: 'making sense, evaluate, and plan'. Important in such conceptions is the distinction between teacher objectives or teacher-intentions (before/after the lesson) and their actual implementation (during the lesson). My study is focused primarily on teachers' 'during the lesson' enactment rather than capturing other stages of textbook in detail[23]. In Chapter 4, Subsection 4.5.3, I detail my strategy for capturing teacher intentions to some extent, using post-observation interviews; however, these were not very successful.

[23] An important upcoming field of curriculum ergonomics must be mentioned. Within the participatory framework, there has been a movement to understand more carefully how best to 'fit' the curriculum for teachers' needs. Specifically, the aim of such studies is to understand how to reduce the gap between 'design' (intended curriculum) and 'use' (teachers use) (Choppin, Roth McDuffie, Drake, & Davis, 2018; Dietiker & Riling, 2018; Edson, Phillips, Slanger-Grant, & Stewart, 2019; Remillard, Reinke, & Kapoor, 2019). While this study is only focused on 'teacher enactment', there is also a need to start thinking more in terms of curriculum ergonomics in the Indian context as well, which are currently completely absent.

3.3 Affordances of Textbooks: Common and Neglected Aspects

In this study, textbooks are conceptualised as *artefacts* (Wartofsky, 1973) with *affordances* (Gibson, 1977) that provide a range of possibilities for their use. Within Brown's (2002) conceptualisation of curriculum resource affordance three elements are in focus: physical objects, domain representations, and procedures. Here, the first 'physical object' refers to the different components of the curricular resources[24]; the latter two are based on pedagogies and content included within the resources. Similarly, other frameworks such as those used by Charalambous Delaney, Hsu, and Mesa (2010) and Son and Diletti (2017) also analyse the 'horizontal' aspect of the textbook viewed from the perspective of mathematical content and the 'vertical' aspect focused on the pedagogical aspect of the book. Fan, Zhu and Miao (2013), in their review of mathematics textbook research studies, found that there is a greater emphasis on exploring particular mathematical content and a lesser one on pedagogical affordances. For example, Charalambous et al. (2010) analysed addition and subtraction of fractions across Cyprus, Taiwan and Ireland; Jung Kang (2014) compared numbers and operations in textbooks of South Korea and US; Kar, Güler, Şen, and Özdemir (2018) compared multiplication of fractions in Turkish and US textbooks and; Li, Chen, and An, (2009) compared Chinese, Japanese and US textbooks with regard to fractions. As can be seen, the comparisons were mostly limited to the content of mathematics and commonly, East Asian and European textbooks were compared (see Son, Watanabe, & Lo, 2017). In India too, a few studies have been focused on domain specific content (Bapat & Takker, 2016; Jayathirtha, 2018). There is both a lesser focus on the pedagogical aspects of textbooks as well as mathematics textbooks from countries of the global South. In this section, I explore the pedagogical affordances within textbook research literature from the last two decades, outlining which of these affordances my study is focused on.

3.3.1 Cognition and context

As Fan, Zhu and Miao (2013) pointed out, apart from mathematical content analysis, *cognition* and its implied pedagogies is an important theme for textbook analysis studies. Regarding which, work by Stein, Grover, and Henningsen (1996) has been influential in exploring the relationship between the cognitive demand of tasks[25] presented within the instructional materials, its use during instruction and its impact on student learning. Thus, the

[24] This is relevant when the focus is on a curriculum package, as is the case in US, where the reforms were manifested into one that typically included at least the student textbook as well as teacher guidebook.
[25] The notion of task as a unit of analysis for textbooks has been an important way of studying affordances. This is explored and defined further in the Methodology chapter (Subsection 4.6.1).

study of cognitive demand of tasks became central to textbook analysis, which sought to classify tasks as having high versus low demand. For example, in comparing five mathematics textbooks, Remillard et al. (2011) labelled tasks: "high demand tasks as *Doing Mathematics*, which involve non-routine thinking, or *Procedures with Connections*, which emphasize underlying meaning within procedural routines or practices. Low demand tasks can be classified as *Procedures without Connections* or *Memorization*, both of which focus on routine and procedural elements of mathematical tasks, often in isolation, and without connections to mathematical sense making." (p. 3). This categorisation has been used in several studies in the US context (Jones & Tarr, 2007; Remillard et al., 2011; Stein & Kim, 2009; Tarr et al., 2012), as well as other country contexts (Charalambous et al., 2010; Hsu & Silver, 2014; Tan, Ismail, & Abidin, 2018). Even in studies not directly using Stein et al.'s (1996) categories, the notion of cognitive demand is applied. For example, Li (2000) used a three-dimensional framework of textbook analysis, exploring: "mathematical features, contextual features, and performance requirement" (p. 234). Within the mathematical features of the problems, the author looked at whether the tasks required a "single computation procedure" or "multiple computation procedure" (p. 237), which becomes another way of judging its cognitive complexity.

In Li's (2000) study, the second category of contextual features was another important approach to understanding the tasks within the curriculum material/textbooks. He identified tasks either as "purely mathematical context" or "illustrated or story context" (p. 237). A recent study investigating the contextual task in Indonesian textbooks, categorised questions based on the "the type of context used in the tasks, the purpose of context-based tasks, the type of information provided in the tasks, and the types of cognitive demands of the tasks." (Wijaya, Heuvel-Panhuizen, & Doorman, 2015, p. 41). It is imporant to note that this study was initiated in Indonesia, where students were identified as struggling with 'contextual tasks' within the PISA (Programme for International Student Assessment) framework (see Wang & Yang, 2016; Widjaja, 2011). Their analysis found that not only were there very few opportunities in the textbook for contextual tasks (only 10%), for 85% of them had the exact information needed for there solution, with there thus being little or no room for students either to select relevant information or bring their own to the piece. Given many of the international assessments, especially PISA, have placed emphasis on 'contextual tasks' (see OECD, 2004; Sáenz, 2009), this is, perhaps unsurprisingly, strongly reflected within textbook analysis studies. It should be noted that the cognitive demands and contextual aspects of the

tasks are also mutually exclusive. For example, in Barcelos Amaral and Hollebrands' (2017) analysis of US and Brazilian textbooks, they rightly analysed the cognitive complexity of contextual tasks which might have superfluous information. They found, much like Wijaya et al. (2015), that the cognitive complexity of contextual tasks was generally low and that there were not as many tasks with a contextual element to begin with. Even in studies, such as that of Charalambous et al. (2010), which are interested in the mathematical domain of fractions analyse the 'connections' within the tasks linking the content to the outside world. Hence, the notion of 'context' within mathematical texts (and its interlinks with cognition and mathematical content) is also an important affordance that is frequently analysed within textbooks.

The above discussion on textbook analysis literature might give the impression that the textbook analysis frameworks can be used universally, as their creators failed to identify their origins and specific reform affiliations. For my study, which foregrounds the socio-political context of the textbook, this is central to the discussion. From the 1990s onwards, influenced by the reforms in the US context, there have been many studies exploring the use of 'reform-oriented curricular resources'[26]. This notion of 'reform' needs to be defined and understood within the policy context in which the study is conducted. For example, Stein et al.'s (1996) framework of cognitive demands of tasks was developed in the US, where the notion of reform in mathematics placed emphasis on introducing more challenging problem-solving based mathematical tasks. Studies, such as QUASAR (Silver & Stein, 1996) and the ICUbiT project (Kim & Atanga, 2014; Remillard et al., 2011), conducted both to improve mathematical instruction and curriculum materials in the US, are based within the NCTM *Standards* and its ideas of reform mathematics. Both these studies, for instance, used the cognitive levels of tasks introduced by Stein et al. (1996) and hence, the criteria chosen for the textbooks analysis are situated within US reforms as well. Even the emphasis on contextual tasks and their related cognitive demands stems from the PISA tests, which emphasise mathematical literacy, as discussed above.

The *socio-political aspects* of the textbooks are crucially important in the Indian context (both within the notion of textbook culture and the study of the social reading of textbooks, as

[26] Note that, as Remillard (2018) commented, in the US context there has also slowly been a move away from using the term 'curriculum materials', which was more common about five to ten years ago, to a use of the term 'resource', which is becoming more prominent, being slowly influenced by the European and South African theorization. In this thesis, I will be using curriculum materials/resources interchangeably. I will use textbooks specifically to mean the printed curriculum material for students.

discussed above in Subsection 3.1.1; see also Subsection 2.1.2 for a discussion on the NCF-2005 reforms that underlie the focal textbooks). These are not as widely researched in the Anglophone literature. As Fan et al. (2013) pointed out in their review of textbook research, while attention to gender and equity issues was given in earlier studies (Clarkson, 1993; Garcia, 1990; Kuhnke, 1977; Seah & Bishop, 2000), more recently this has not been the case. This growing de-emphasis on social issues, such as gender and equity, in mathematics textbook analysis, could also be because of the lack of attention to these aspects in the US reforms, which have influenced reform in other parts of the world. Apple (1992) argued that the mathematics reforms in the US do not pay sufficient attention to issues of equity and social justice. Hence, Delpit (1988) and Lubienski (2000a) contended that these reforms might be particularly inaccessible for children from marginalised backgrounds (see Boaler, 2002). This distinction between 'reform' curriculum and 'critical' curriculum was operationalised in Brantlinger's (2011) analysis of the geometry curriculum. He saw 'critical/radical mathematics' aimed at social justice as being in opposition to both traditional and *Standard*-based reform mathematics in the US. Thus, it is important to keep in mind that the notion of 'reform mathematics', 'reform-based curriculum' or 'reform-oriented textbooks[27]' is contextually defined. Hence, whilst these might be used as neutral terms in the research literature on mathematics education, they hold different meanings across contexts.

In India, notions of critical mathematics as well as ethnomathematics, which foreground issues of equity and social justice, are central to the mathematics reform as promoted by NCF-2005 (see Chapter 2, Subsection 2.1.2). This is similar to some post-colonial African countries that have attempted to reform their mathematics curricula not just from a cognitive perspective, but also a social justice and equity one. For instance, scholars, such as Schubring (2017), Gerdes (1996) and Vithal and Skovsmose (1997), have pointed to the role of colonialism in mathematics education, especially in former colonies and the countries of the global South. Thus, scholars such as, Namukasa, Kaahwa, Quinn, and Ddungu (2012), have called for an emphasis on using critical and post-colonial perspectives to understand

[27] Reform has meant many things in the research of mathematics curriculum and textbooks. For instance, Sawada (2002) called it: "The reforming of instruction and learning is a movement away from the traditional didactic practice toward constructivism (Anderson et al., 1994)." (p. 246). While this is a general domain non-specific definition of reform, specific studies have used their own versions. For instance, Parks (2010) considered questioning and ideas of questioning in 'reform' and 'traditional', defining them as: "teaching that includes process skills as well as content, and the word traditional to describe teaching that is more narrowly focused on content." (p. 1872). Similarly, reform is also country-specific and can have different contexts. For instance, in the US context, NCTM Standards and its goals form the basis of reforms, and in the Netherlands Realistic Mathematics Education (RME) has been the basis of textbook reforms (see Gravemeijer, 2014).

curriculum development. Accordingly, recent studies of textbooks in such contexts have been focused on more critical and ethnomathematical aspects of the curriculum. For instance, Draisma (2018) analysed primary school mathematics textbooks developed in Mozambique, finding that they were not only published in local languages (one of the first such textbooks), but also included local mathematical practices, such as the use of base-five rather than base-ten. Similarly in the South African context, the Relevance of School Mathematics Education (ROSME) project involved analysing different kinds of content used in mathematics literacy textbooks and found categories such as: mathematical, financial, socio-political, geographical, lifesciences and environmental, technology (Mbekwa & Julie, 2009). This incorporation of 'relevance' was key for the matheamatics reform ideal in South Africa (Nyabanyaba, 1999). Again, in the South African context, Bowie (2014) probed the post-apartheid curriculum based mathematics textbooks, discovering that they focused on "social redress, mathematical and learner-centred pedagogy" (p. 243). She elicited that while these have been key to the reforms in South Africa, the focus on social issues was side-lined in view of accommodating the mathematical content, thus raising some conflict between the two. Similarly, in Namukasa's (2018) paper on the analysis of Ugandan reform-based textbooks, she used a post-colonial and critical perspective to investigate the ways in which the textbooks have been designed. Thus, in these studies, it can be seen that while 'context' continues to be discussed, unlike earlier studies which focused on cognitive demands, other questions such as relevance and social redress, are considered more important.

An important aspect to consider while including socio-political contexts within the textbooks, is that some of these can often be controversial. In India, school history textbooks have been a site of constant dispute where different ideological perspectives have competed to find space in the curriculum. As briefly mentioned in Section 2.1.1, the narratives promoted by Hindu nationalists comes in contrast with those of the secular-nationalists promoting very different ideas about India as a nation (Bhattacharya, 2009; Mukherjee & Mukherjee, 2001). However, inclusion, deletion, and teaching of controversial topics are mostly focused on for social sciences curriculum (Batra, 2008). Mathematics as a subject is often thought of as 'neutral' and uncontroversial, which is not the case when viewed through a socio-political lens (Ernest, Sriram & Ernest, 2016). For instance, the NCF-2005 reforms and *Math-Magic* textbooks have made explicit efforts of including 'socio-political' realities, bringing forth the politics of curriculum topic choices and shedding the 'neutrality' associated with mathematics textbooks. Some of the controversial issues that the textbook

explicitly addresses is gender inequity, casteism, and economic inequities; issues which can polarise teachers (examples of this can be found in Chapter 5, Section 5.2.2). Interestingly, unlike history textbooks, the *Math-Magic* textbooks did not get enthralled in media or academic controversy. However, these questions remain relevant for teachers who have to negotiate socio-politically charged content and make choices on its treatment. Studies such as Simic-Muller et al. (2015) in the United States reveal that often teachers are least willing to engage with 'controversial' contexts, while other types of contexts (career oriented contexts, family backgrounds) are more likely to be used in mathematics teaching. In the Indian context, Takker's (2017) study to understand teachers approaches to social justice issues in *Math-Magic* textbooks shows that teachers often ignored the underlying social contexts and instead focused on the 'mathematics'. This shows that inclusion of 'social justice' issues in textbooks is hardly straight-forward and can be perceived in different ways by the teachers. In my study, I foreground the *notion of context*, not only from a cognitive perspective, but also from a more social perspective, by looking for and analysing the themes of equity within the NCF-2005 textbooks.

3.3.2 Support and voice of the textbook

Another significant study in the last two decades is the TIMSS 1999 study of mathematics textbooks, which both analysed mathematical content of textbooks (Schmidt, McKnight, Valverde, Houang, & Wiley, 1997) as well as their pedagogy (Valverde et al., 2002). For the analysis of the textbooks' pedagogical disposition, Valverde et al. (2002) focused on the *structure* of the textbook. They described this approach as focusing on the "form and style not the substance" (p. 17). They analysed both the 'macro-structure' and 'micro-structure' of the textbook, using the analogy of a body, where the macro-structure is the skeleton and the micro-structure the bones. While the macro-structure focused on: physical features of the textbooks, structure of the textbook, content presentation, textbook expectation for performance; the 'micro-structure' pertained to the lesson structure in terms of the blocks of "narratives, exercise/question sets, activities, worked examples" (p.144).

Different studies consequently have focused on different aspects of the structure of the textbook. For example, Rezat (2006), in his analysis of the micro-structure of German mathematics textbooks, found that most had the format of: "introductory tasks – exposition – kernels - worked examples - exercises" (p. 483). In South Africa, Leshota (2015) identified key micro-structural elements, including "narrative; an explanatory text; a note box; a graphic; worked examples; practice exercises; an introductory exercise; summary table" (p.

70) in her textbook analysis. Within curricular reforms, the ways in which textbooks are 'structured' can also be deliberately altered. For instance, Ben-Peretz (1990) spoke about two types of curricula "structured, sequential" or "unstructured, modular" (p. 28) based on the ideals of pedagogical reforms. In the previously mentioned textbook analysis on Ugandan reforms, Namukasa (2018) analysed the structure of mathematics textbooks to explore to what extent these reflect the national Ugandan reforms. She found that typically the structure of textbooks has remained: "background, content explanation, a few examples followed by exercises then followed by review exercises." (p. 945). However, there were some textbooks that delayed providing explanation and presented the content in an interactive manner. That is, instead of following the traditional deductive formats of providing explanations and then problems a few textbooks used different formats. Another study by Sood and Jitendra (2007) conducted in the US, involved comparing traditional and reform-based textbooks to identify the key structural differences of these textbooks. They explored whether the instruction within the textbook was provided conspicuously or not, whether scaffolding supported the instruction (feedback, representations) and finally, whether there were opportunities for students to review what they had learnt (within lessons practice, across lesson practice). Bryant et al. (2008), in their analysis of textbooks, rated the key features of textbooks on the scale of 1 to 3, including – the level of instruction (direct or guided or discovery based), clarity of objective, use of manipulatives, adequate practice questions, review of the prerequisite mathematical skills etc. Thus, the structure of textbooks includes the level of explicit instruction, feedback and opportunity for practice as well as providing prompts for teachers. As Howson (2013a) commented, textbooks provide a "coherent framework to guide their [teachers'] work" (p. 648), thus supporting them in complementing their own teaching in relation to the textbooks. For the current study, exploring the *micro-structures* and thus, the embedded *prompts* for teachers is considered important.

Apart from the structure of textbooks, and prompts provided through the sequencing and structuring of tasks, the text also has a 'voice'. In Subsection 3.1.1, I discussed studies in India that focused on the readability of the text (in terms of easy or difficult) and in Subsection 3.3.1, I reviewed the mathematical content and its cognitive and contextual aspects. However, O'Keeffe & O'Donoghue (2015) have argued that textbook analysis studies have focused on content, structure, cognition and context used within the books, very little attention has been given to the *voice* of texts in mathematics. According to Remillard (2005), "voice refers to how the authors or designers are represented and how they

communicate with the teacher and the students." (p. 233). The analysis of the 'voice' of a curriculum or textbook is typically about investigating the ways in which the author presents herself to the reader and constructs their relationship (Herbel-Eisenmann, 2007; Love & Pimm, 1996). It, thus, involves exploring implicit assumptions about the language used in the texts, which might hinder or afford certain kinds of student learning. Such an analysis is typically operationalised using linguistic approaches, as theorised by Halliday and Hasan (1989), Bakhtin (1986) and Eco (1979). Drawing on a Hallydian framework, Herbel-Eisenmann (2007) analysed the interpersonal voice of the textbook by exploring three linguistic elements: "imperative, personal pronouns and modality" (p. 349). Through this analysis, she explored whether the objective of the US reforms of shifting the authorial role away from the textbook had been achieved. Wagner (2012), in his analysis of his self-authored textbook for the Bhutanese curriculum, analysed the use of 'open[28]' and 'closed' texts, using Eco's (1979) notion of the linguistic openness of texts. He argued that despite using genres that might suggest openness, the linguistic characteristic is such that it still 'seduces' the reader in a particular direction. Another study by Alshwaikh and Morgan (2015), compared Palestinian and English textbooks to analyse the ways in which language was used. They found that, whilst the Palestinian textbooks used a specialised language, the English textbook use a mix of specialised and practical language. Along with the analysis of the verbal mode of the text, they also analysed the visual elements of the 'voice' of the text.

Apart from the voice used within student textbooks, Remillard (2011) analysed the voice of teacher guidebooks – trying to understand the ways in which teachers are being positioned and whether the text is speaking *to* the teachers or *through* them. Typically textbooks, rather than explicating *to* the teachers the rationale and ideas within the textbook, instruct *through* the teachers, prescribing what they should do with students (see Ahl & Koljonen, 2017). Davis and Krajcik (2005) in their seminal paper on 'educative curriculum materials', discussed the ways in which the materials themselves can talk *to* teachers and become the means for teacher learning about reforms – rather than just merely being instructional tools. For example, they brought out four heuristics that educative materials can support doing: (1) support teachers in anticipating and interpreting student responses to the materials; (2) support in gaining subject-specific knowledge; (3) support them in seeing the larger learning objectives linked to the curriculum materials (4) explicating the developers own rationale and

[28] Open tasks in mathematics can mean several things (see Yeo, 2017). In this context, Wagner (2012) used open texts, as employed by Eco (1979), as texts that provide an openness to the way the text is interpreted, thus bringing in a sense of ambiguity.

theories about the materials (see Davis, Palincsar, Smith, Arias, & Kademian, 2017). Thus, analysis of voice not only explores the authorial roles promoted by the text (as highlighted by studies such as that of Herbel-Eisenmann, 2007), for it also helps in understanding the pedagogical support that textbooks might provide to support teachers in both understanding and their usage.

Since NCF-2005 (reforms underlying the *Math-Magic* textbooks) was also aimed at changing the way that textbooks are positioned within teaching and learning as well as challenging the authority relations between the teacher and the student, it becomes important to investigate the voice used within the textbook (see Chapter 2, Subsection 2.1.2). In the Indian context such analysis is rare. One interesting study was carried out by Setty (2014), who analysed the teacher education policy document (NCFTE-2009) using Bakhtin's (1986) notions of dialogism to identify the document's linguistic characteristics. He found that an authorative voice was used to identify teacher education problems and to suggest remedies, yet effort was made to include some open texts inviting dialogue. For the current study, I focus on the voice of the student textbook to investigate both how the text specifies the degree of student engagement, as well as the ways in which they are expected to engage with the content (See Figure 3.1). As the *Math-Magic* series does not come with a teacher guide and does not explicitly mention integrating 'educative' components, it is important to identify support elements within the textbook for teachers (See Chapter 5, Subsection 5.3.2, where there is analysis of the teacher notes provided within the textbooks). Thus, voice of the student textbook (those addressing students) and support elements (those addressing teachers), both are important analyse.

So far, I have reviewed common types of textbook affordances analysed within enactment studies as well as the influence of reforms on such frameworks. I have further delineated the affordances that are important for this study. First, notions of critical mathematics and use of relevant and meaningful context are important for NCF-2005 as well as many post-colonial countries. Thus, one of the main foci of this study is the *context* used within the textbook. Second, the less explored aspect of the *voice* of the textbook is also to be investigated. Finally, as there are no textbook guides accompanying this textbook series, the *support* elements within the textbook are also explored. This is achieved through an investigation of the structure, prompts in the textbooks as well as the voice of the teacher-directed text within the books. Accordingly, I arrive at the following textbook analysis framework (Figure 3.1).

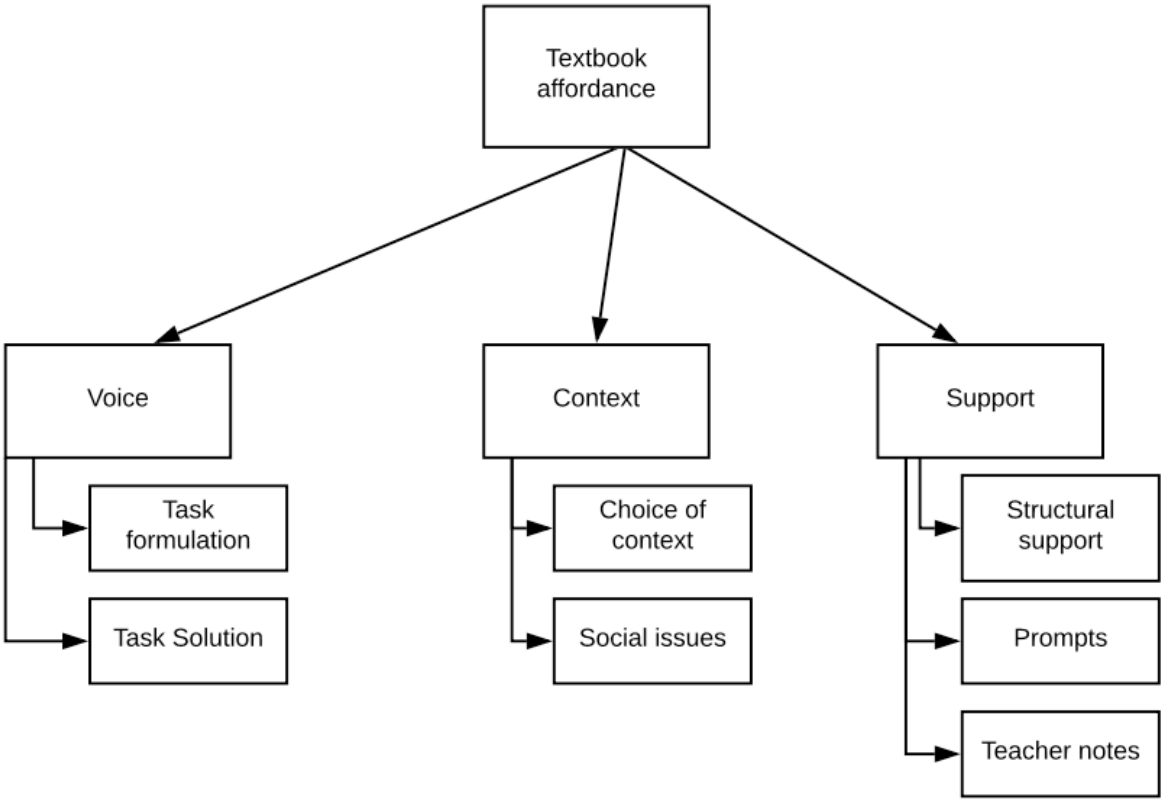


Figure 3.1: Textbook analysis framework

3.4 Teacher Characteristics Influencing Textbook Enactment

Within the participatory approach of textbook use, as adopted for this study, teachers and their characteristics influence the way a textbook or curriculum is enacted. While the affordances of the textbook influence the opportunities for teachers and students, teachers' own interpretations of these are critical to the textbook enactment. Different studies conceptualise this influence in different ways – by either paying attention to individual teacher characteristics (beliefs, knowledge, professional development, experience, affect, concerns), or contextual aspects (institutional realities, cultural context) or both. In the following, I locate my study within these approaches.

3.4.1 Individual characteristics: beliefs and knowledge

In the literature on teachers' influence on textbook enactment (or other curriculum materials), studies have identified several individual teacher characteristics and related them to their textbook use (Charalambous & Philippou, 2010; Manouchehri & Goodman, 2000; Roehrig & Kruse, 2005; Son & Senk, 2014). For example, Brown's (2002) (see Subsection 3.2.1) enactment conceptualisation focuses on: 'beliefs', 'subject knowledge' and 'pedagogical content knowledge'. In other words, how teachers use or enact the curriculum is assumed to

be influenced by what they believe, the depth of their subject knowledge, as well as their knowledge about the content and its related pedagogy. Within this tradition, teacher *beliefs and knowledge* are often studied, which, as Lloyd and Wilson (1998) explained, are "mental structures[29]" (p. 249) or individual cognitive features of teachers that influence their practices. Regarding which, Manouchehri and Goodman's (2000) study of two seventh-grade teachers using US *Standards*-based curriculum materials found that teachers' mathematical knowledge was the most important influencing factor in their implementation. Hill and Charalambous (2012), using a multiple-case study (four cases), explored the interaction between mathematical knowledge for teaching (MKT) and curriculum materials. They found strong associations between MKT and enactment, also eliciting that teachers with higher MKT seemed to use the curriculum more meaningfully. Moreover, they also reported that since the curriculum they studied was ambitious, it created particular difficulties for teachers with low MKT. Subsequently, researchers have tried to identify the particular aspects of knowledge that influence curriculum enactment. Remillard and Kim (2017) conceptualised the notion of *knowledge of curriculum embedded mathematics*, which encapsulates the type of knowledge that comes into play during curriculum enacted.

Knowledge is often studied along with teacher beliefs, as they are viewed as interrelated[30] (Demosthenous, 2015; Holstein, 2012; Lloyd & Wilson, 1998). Roehrig and Kruse (2005), in their study of a science inquiry-based curriculum and its implementation, found that teachers' positive beliefs about the curriculum, strongly influence their successful implementation. Similarly, in mathematics, Stipek, Givvin, Salmon, and MacGyvers (2001) conducted a study to explore the beliefs and practices of 21 primary teachers in the US, finding consistency between the two. However, this has not always been observed, as several other studies have reported inconsistencies/contradictions between what teachers espouse (espoused beliefs) and enact (enacted beliefs). A seminal finding of the mismatch between what teachers 'think' they are doing or want to do and their practice, is the case of Mrs Oublier in the US (Cohen, 1990). Through the analysis of her supposed enactment of reform, Cohen talks about the stickiness of the old practices and thinking about mathematics pedagogies that hinder and feed into perceived reformed practices. Similar findings have been seen in different parts of

[29] Beliefs have been viewed from many different perspectives. While the cognitive perspective has dominated mathematics education (see a comprehensive literature analysis in Schoen & LaVenia (2019)); beliefs can also be viewed from a more cultural perspective, which is explored in the following Subsection 3.4.2.

[30] This is influenced by a much larger field of study aimed at understanding the relationship between teacher beliefs and their classroom practice (Philipp, 2007; Schoen & LaVenia, 2019; Stipek, Givvin, Salmon, & MacGyvers, 2001; A. G. Thompson, 1984).

the world as well within different curriculum reform contexts. For example, in Cambodia, Song (2015) discovered a mismatch between teachers' beliefs about child-centred learning pedagogies and their practice, ascribing this inconsistency to shallow understanding of the reform ideals. Similarly, in the Indonesian context, Wijaya et al. (2015) using a survey of 27 teachers, elicited that while teachers espoused that context-based tasks were useful their understanding about these was low (they equated these to word problems) and their practices around the use of context-based tasks were weak. In the Indian context too, as discussed above (See Subsection 3.1.2), studies, such as that of Takker (2011), reported a mismatch between teacher perceptions and their implementation.

However, these studies aimed at finding alignment between beliefs or knowledge and teacher practice, focusing on inconsistencies, have been accused of creating a false notion of teachers as "inconsistent beings" (Leatham, 2006, p. 91). Leatham (2006), for instance, argued that this 'inconsistency' is a failure of the researcher and their methodologies, which fail to understand teachers' work. He instead appealed for adoption of the view of teachers' beliefs as "sensible systems" (p. 91). More recent studies have taken this into consideration (Cross Francis, 2015; Palmér, 2018; Ren & Smith, 2018). For instance, Cross Francis (2015), in her study, explored these perceived inconsistencies with the teachers' contextual characteristics. Palmér (2018) further used the notion of teacher identity to understand beliefs about good mathematics textbooks (and instruction). That is, instead of talking in terms of inconsistencies she considered identity formation (or changes in identity). Sawyer (2017) adopted the notion of 'teacher choice' – which positions teachers in agentic roles, rather than the researcher obtaining information on their 'beliefs' and reporting inconsistencies.

For this study, I follow Leatham (2006), who argued for the need of both contextualising the belief literature, as well as rethinking the methodologies that are typically used to study beliefs. Moreover, as discussed in the Subsection 3.1.2, in the Indian context, there is a lack of teacher 'voices' and agency when it comes to curriculum design and use. In this context, it also becomes important to understand their views and voices (instead of their cognitive beliefs and knowledge). For instance, Martinie, Kim, and Abernathy (2016), in their exploration of teacher voices in the context of reform found four types of teachers: the hardcore adopter, the anxious adopter, the cautious adopter and the critical adopter. Using Spillane's (1999) notion of zones of enactment, they analysed teacher narratives to understand their experiences of the reform based curriculum. Such approaches to teacher views are closer to my study, which instead of trying to construct their mental structures, has

the aim of creating a space for teacher voice and narratives to come through. Thus, instead of limiting this study's scope to individualistic and cognitive understanding of 'beliefs' or 'knowledge', I use the notion of 'views', with the objective of bringing forth teachers' voices and agency. This construct is situated beyond the teachers' individual characteristics and takes into account the institutional as well as cultural context of the teachers' work, as discussed in the next subsection.

3.4.2 Beyond individual characteristics: collective, institutional and cultural

Apart from the individual teacher characteristics, especially beliefs and knowledge, there are several studies that have investigated other teacher-related characteristics that also influence curriculum use. The first important trend in mathematics education studies on curriculum-use is the *collective* aspect of teachers' work (Gueudet, Pepin, & Trouche, 2013; Pepin, Gueudet, & Trouche, 2013). The importance of this can be assumed by the fact that the seminal book on resource and its use *'From Text to 'Lived' Resources'* (Ghislaine Gueudet et al., 2011) has a dedicated section on 'collective use'. Similarly, a section "Teachers' Collective Work Through Resources" (p. vi) is integrated within a recent book: '*Research on Mathematics Textbooks and Teachers' Resources'* (Fan et al., 2018). Primarily using ideas of Wenger (1998) to understand community of practice, these studies view resource use through the lens of teachers' collective interaction with the resource rather than their individualised use. These 'collectives' can be in the form of interactions with colleagues or other teacher online forums. For instance, in a recent study in the French context, Trouche, Gitirana, Miyakawa, Pepin, and Wang (2019) highlighted the practices of two teachers who collaborated and built resource systems using collective approach. Wang (2018) further conducted a comparative case study between Chinese and French teachers and their collective resource use. Interestingly, teachers' work culture in the Chinese context itself was characterised as having a collective nature (Yang, 2013 as cited in Wang, 2018). Further, a collective approach to professional development around resource use has also been adopted in several studies (Besamusca, 2013; Van Steenbrugge, Larsson, Insulander, & Ryve, 2018; Visnovska & Cobb, 2013). In India, there is both a lack of multiplicity of resources as well as a lack of teacher collectives in teachers' work, which tends to be highly isolated (Batra, 2009). Typically, professional development programmes do not integrate or encourage collective aspects, as they are usually one-off events, where an external agency provides some training and does not develop either within- or cross-school collaborations (See Chapter 2, Subsection 2.3.1).

Another important dimension in teachers use of textbooks is *institutional reality* (McClain, Zhao, Visnovska, & Bowen, 2009). McClain et al. (2009) argued that 'institutional realities' capture teachers' "*perceived* institutional demands, constraints, and affordances" (italics in the original) (p.61). This construct is similar to the notion of 'curricular context' explored by Herbel-Eisenmann, Lubienski, and Id-Deen (2006) in the US context. In their case study, they found that the same teacher used two very different approaches to the same curriculum in two different classroom settings. This revealed that teachers 'perceive' demands of their institutional contexts (which include students and parents' demands) in different ways, which influences their use of the curriculum. They, thus, concluded that teachers make decisions in complex and contradictory situations, by assessing institutional realities (irrespective of their beliefs and knowledge). It is important to note that these 'realities' differ in different contexts.

In countries of the global South, the conditions of implementation need to be equally interrogated along with the individual enactors (Mohammed & Harlech- Jones, 2008; Ying, Kathryn, & Young, 2007). Some of the common issues raised by teachers in the global South are the pressure of covering the syllabus as well as completing administrative tasks. For example, in the context of Jordan, teachers spoke of institutional pressures of "getting through the textbooks" (Mustafa & Cullingford, 2008, p. 86), which deterred them from using their own autonomy in pedagogy. In the context of the South African post-apartheid outcome-based curriculum, Stoffels (2005) found that despite the change in the curriculum (encouraging teachers to use their own autonomy) and teachers agreeing with these, they still felt constrained due to various 'forces'. Issues, such as work-overload and lack of comprehensive training, were creating 'forces' beyond the teacher's personal willingness, hindering the implementation of the curriculum. Even in Northern contexts, scholars such as Bartlett (2004) have argued that, while reforms expand teachers' work role, they also lead to overworking. In terms of textbook use, studies have shown that teachers continue to use them in traditional ways due to these 'institutional' reasons, such as: in South Africa teachers talk about their "ease of use" (Stoffels, 2005, p. 541), and in Hong Kong teachers talk about their helping them to "save time" (Ying et al., 2007, p. 5) or just due to "expediency" (Chien & Young, 2007, p. 158). As discussed in Chapter 2 (Subsection 2.2.2), teachers in India are often under enormous burdens of non-teaching tasks and other kinds of constraints. These institutional issues are, thus, also immensely important for Indian teachers as well.

While institutional realities might change[31] (sometimes drastically), bringing with them new expectations and roles for teachers; a stickier construct is the notion of *culture*, which also influences teachers' use of reform-oriented curricular materials. In South Africa, Westaway and Graven's (2019) recent study of the reasons for the lack of 'take up' of progressive pedagogies integrates notions of 'structural' and 'cultural' mechanisms, and locates teacher identities in contexts of curricular change. While the teachers might have been expected to move into a 'new role' (change in structural mechanisms), cultural mechanisms are harder to change. They found that teachers who were trained and taught in a different institutional context, become protectionists and "hold on" (p. 44) to certain cultural beliefs. They identified the following beliefs that they seemed to hold on to: "mathematics is difficult and not for everyone" (p. 35), "mathematics is about taught procedures" (p. 38) and "these children are slow" (p. 42). This is an extremely astute analysis of teachers in flux and contradiction. In India, Sarangapani's (2003) work focused on the cultural and historical significance of teacher authority, with the author arguing that this creates hindrances to moving towards more reform-oriented practices, which redefine the authority relations. Similarly, research by Clarke (2003) also reported the culture of classroom practices as significantly influencing the way in which reforms are perceived. In her analysis, she discussed four cultural constructs that influence curriculum reform enactment. One of the significant findings suggests that teacher can be receptive to top-down reforms, for they well feel a "sense of duty" (p. 27) to comply. This means that they might attempt to engage with the reforms to an extent, as they feel obligated to do so. More recently, Brinkmann (2018) wrote about the lack of engagement with teachers' culturally shaped beliefs in the reform discourse, which she argued seems to be the missing piece significantly inhibiting the 'take up' of reforms. Given mathematics teachers' cultural beliefs regarding teaching and learning and classroom cultures is under-studied in India, this is an important dimension to consider.

In conclusion, while the literature on mathematics education emphasises the beliefs and knowledge of teachers in terms of influencing teachers' use of curricula, this thesis uses the notion of 'teacher views' to explore their experiences with textbooks. This construct encompasses, from the perspective of the teacher, different individual beliefs and knowledge

[31] With curricular and policy reforms, institutional obligations also change. This study, for instance, is located around the NCF-2005 reforms, which brought with them different institutional expectations. These expectations, however, might differ dramatically from teachers' 'perceived' institutional demands, which can be both 'local' (school demands, student demands, parent demands) as well as global (reform demands, policy demands).

as well as the socio-cultural-political (institutional structures, collectives, culture of teaching) aspects of the textbook-teacher relationship.

3.5 Chapter Summary

This chapter began by identifying critical gaps in the textbook research literature in India. While such research has been extensive in India, this has remained mostly confined to exploration of the quality of textbooks and their socio-cultural implications. Textbook use research is largely absent in India. Further, in textbook research, the teacher, who is the primary mediator of the textbook in classrooms, also has not been the focus of studies. Filling this gap, this thesis is focused on mathematics textbook use from the perspective of primary school teachers. The chapter then moved on to conceptualising textbook use for this work. A participatory approach to textbook was preferred, where both the agency of the textbook as well as that of the teacher is viewed as central to the relationship. In particular, Brown's (2002) notion of design capacity for enactment which operationalises this relationship was called upon. Based on this relationship, the affordances of textbooks that are most useful in their enactment as well as teacher characteristics were explored. In terms of textbook affordance, the literature on mathematics education focuses on mathematical content and context of tasks within the textbook. For this thesis, the affordances that are in focus in this thesis are those that are most relevant for the NCF-2005. Accordingly, the voice of the textbook, the context of the textbook, as well as support within the textbook are to form the focus of the current study. Finally, in terms of teacher characteristics, the literature shows an overwhelming emphasis on the individual teacher beliefs and knowledge in explaining their textbook enactment. While these are important, in this thesis, the inquiry is expanded to include institutional and cultural aspects of teachers' work as well. The next chapter present the methodology of this thesis in detail.

CHAPTER 4: METHODOLOGY

4.0 Introduction

In this chapter, the focus is on explaining and justifying the methodological decisions taken during the study. The first section delineates the research questions that are addressed. In the subsequent sections the epistemological stance (Subsection 4.2) as well as the methodological approach (Subsection 4.3) are articulated. An important aspect of the research are the ethical considerations as the investigation was conducted at a site where the researcher-teacher relationship is highly political and thus, my responsibility of creating a transparent and reflective relationship was essential. Accordingly, Section 4.4 deals with issues of reflexivity and ethics that I encountered as I positioned my 'self' in the research (Subsection 4.4.1) and also positioned the study in the larger field of educational research (Subsection 4.4.2). Section 4.5 describes the three methods of data collection and section 4.6 details how the three distinct types of data were analysed.

4.1 Research Questions

In the previous chapter, I conceptualised the key constructs utilised in the study. The overarching question for this work is:

> *How do primary school teachers view and use reform-oriented mathematics textbooks in government run schools in Delhi?*

The sub-questions that I address are presented and explained below.

RQ1: How are the key *reforms represented* in the mathematics textbooks?

As highlighted in the literature review, curricular reforms are contextually defined and their representation in textbooks take different forms. To address this research question, I explore the reforms represented within the textbooks through constructs highlighted in Chapter 3 (voice, context and support) (See Section 3.3).

RQ3**:** How do teachers *use* the reform-oriented mathematics textbooks in their lessons?

The second research sub-question explores teachers use of these textbooks, by focusing on their classroom lessons. As discussed in the previous chapter, use is conceptualised as a participatory relationship between the teacher and the textbook, where both are agents influencing the classroom activity (See Section 3.2).

RQ 2: How do teachers *view* the reform-oriented mathematics textbooks?

The third and final sub-question involves exploring teachers' voice by capturing their views about these reform-oriented textbooks.

4.2 Epistemological Stances of the Study

'Research paradigms' refer to the researcher's assumptions about the social world and the methods, which influence every aspect of the research process, from designing the research, to conducting it and finally, drawing conclusions (Punch, 2009). According to the categorisation by Connole, Smith and Wiseman (1993), educational research can be grouped into four main research paradigms: positivism, interpretivism, critical, and postmodern. However, in recent years there are many schools of thought that have developed from these broad somewhat ambiguous categories. A broadly interpretivist paradigm guides this investigation (O'Donoghue, 2006). As O'Donoghue explained, within the interpretivist view: "Knowledge, is constructed by mutual negotiation and it is specific to the situation being investigated" (p. 10). In this study, it is presumed that 'knowledge' is constructed in the interaction between the researcher (who is a social being) and the teacher, within a wider socio-politico-cultural context. Such a belief is aligned with an interpretivist paradigm, which aims to understand the "subjective world of human experience" (Cohen, Manion, & Morrison, 2013, p. 21). This is particularly fitting for the participatory approach of the textbook use that is the conceptual basis for the study (See Section 3.2).

Such a perspective lends itself to naturalistic methods of research, and broadly falls under a qualitative lens. Most crucially, as is the case of my study, an interpretive paradigm creates meaningful knowledge based on the understanding and interpretations of individuals within the particular situation, including the researcher. Further, for this thesis, the socio-cultural-political (Planas & Valero, 2016) aspect of the context is an important consideration (See Chapter 2), and my own role and positionality as a researcher is critiqued (Section 4.4).

4.3 Methodological Approach, Research Site and Sample

4.3.1 Methodological approach: multiple case study

Textbook usage has either been researched using large scale studies (McNaught, Tarr, & Sears, 2010; Tarr et al., 2012) or in-depth qualitative case studies (Chávez-López, 2003; Leshota, 2015; Remillard, 2000). An in-depth approach is more appropriate for my study, since there is a lack of studies on teachers' work in the Indian context and a need for an in-depth examination of textbook use (Behar, 2016; Majumdar, 2011). From a policy perspective too, there is a need for an understanding of the complexity of the textbook use phenomenon within real-world school settings. To address my research questions, I adopted a multiple case study approach (Yin, 2017). Yin defines one as "an empirical method which investigates a contemporary phenomenon (the "case") in depth and within its real-world context" (p. 45). In the real-life context of *government primary schools in Delhi*, the study explores the phenomenon of *teachers using textbooks*. These two aspects of the case study: type of case and type of context are further discussed below. I end this section by discussing one of the concerns that is often raised about case studies, namely its generalisability and explain how my study attempts to address this concern.

For exploring the 'phenomenon' of interest, Yin (2017) distinguished between two case types: *single-case* and *multiple-case*. Single-case studies are recommended for studies where some prior information about the phenomenon is available. For instance, the case could be an extreme one, but some knowledge about what makes it so is known to the researcher[32]. On the other hand, a *multiple-case study* is more suitable in the absence of any prior knowledge of the outcome, in order to obtain a wider range of instances. Since very little is known about the teachers and their work with textbooks in the contexts where my study is conducted, I chose a *multiple-case study* approach, including ten cases of teachers using these textbooks.

Another notion that Yin (2017) discussed is that of the 'context'. As he noted, the phenomenon and the context are often difficult to distinguish and separate, yet it is important to bound the case. For my study, which was conducted across four schools, I believe it was important to describe the 'context' in terms of the *school system* as well as the *site* within

[32] The single-case rationales including choosing a critical case, extreme case, representative case, revelatory case or longitudinal study.

which the teachers were functioning. This is a limited view of context[33], since the context of teachers is beyond the space and time they function in, and there are several other historical, social and political aspects at play (Lesley Bartlett & Vavrus, 2016). However, I focus on the school context at that particular site (Delhi) because by looking at the location and characteristics of the school, one can discuss teachers' immediate work – within which the focal phenomenon of textbook usage lies. The research design is illustrated in the figure below.

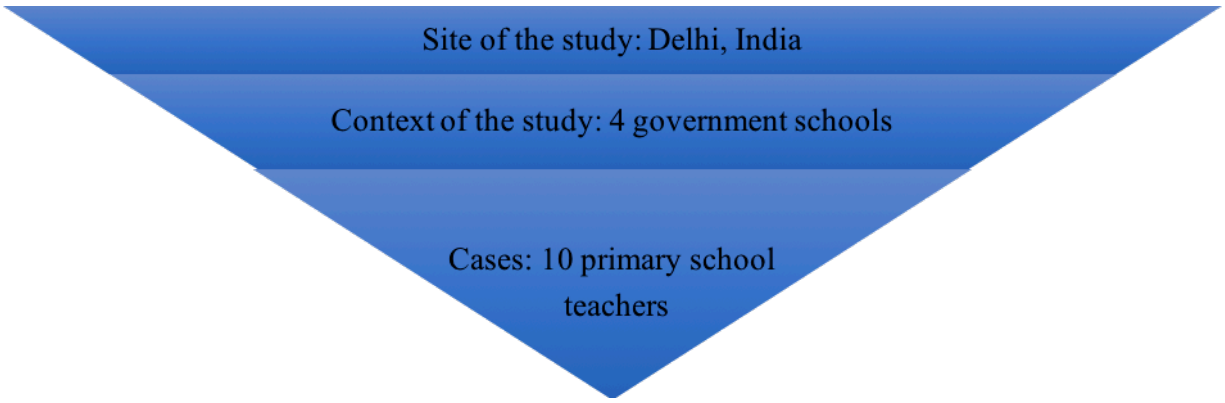


Figure 4.1: Multiple case study of the phenomenon of teachers using reform-oriented textbooks in the context of government primary schools in Delhi, India

A common concern about case studies is the 'generalisability' of the findings. Flyvbjerg (2006) pointed out that case studies produce "practical context-dependent knowledge" instead of "generalizable context-independent knowledge" (p. 221). This leads to the question whether case studies are primarily descriptive and useful only for context specific phenomena or does it have potential explanatory powers. Here, I believe that the idea of 'fuzzy generalisation' is very useful (Bassey, 1999). As this author claimed, unlike scientific generalisations which have no exceptions, case studies can produce fuzzy generalisations that have built in uncertainty. These are useful, since they become claims that future studies can study and eventually also lead to theorisations. With this research study, like most case studies, it is not possible to claim to have come up with any generalisable knowledge. However, it creates a pool of fuzzy generalisations about teachers' work in relation to the reformed textbooks, which becomes the basis of future theorisations.

[33] Note that Yin's ideas are often viewed to be based on positivist traditions. This particular notion that the 'phenomenon' and 'context' *can* be distinguished comes from such an influence. I do not subscribe to such a view. However, even within an interpretivist paradigm there is a need to bound the case to enable us to focus and define the scope of the study. See Bassey (1999) and Bartlett & Vavrus (2016) for detailed comparison of the different epistemological understandings regarding case studies.

4.3.2 Research site, school context and sample of the study

In the above subsection, I described the *multiple case study* design of my research: a case of teachers using textbooks within the context of schools at the given site. In this section, I will delineate each of these aspects and justify my choices for the site, schools, and teachers.

Research site: Delhi, India

Delhi provided an ideal site for the study in terms of the better *teachers*, greater *reform influence*; as well as the *researcher's background*. First, unlike many states and other rural contexts, Delhi government schools have much lower levels of teacher absenteeism, with an average rate of about 7% compared to a national average of 22% (Tooley, Dixon, & Gomathi, 2007). Further, unlike other states, which hire 'para-teachers' with much lesser qualifications, the average qualification of teachers is higher in Delhi (Govinda & Josephine, 2005). In this city, it is mandatory for government teachers to hold a teacher training qualification (both contract and permanent teachers), and to have successfully passed the teacher qualification test (CTET) (Bagchi, 2015). In terms of qualification and school attendance, the 'quality[34]' of teachers in Delhi is better than many other parts of the country.

Second, in terms of the reforms, NCF is also likely to have had a much higher influence on Delhi schools compared to other states. Unlike other states, which introduced state level curriculum frameworks, such as Bihar (BCF) (See SCERT 2008) or Kerala (KCF) (Nath & PS, 2009), Delhi has not developed its own state curriculum framework or textbooks. Hence, all government schools were mandated to follow the NCF-2005 and use the NCERT *Math-Magic* textbooks. Further, the NCERT itself is located in Delhi and a large proportion of the academics who were engaged in developing the curriculum and textbooks are based at the University of Delhi, thus making it the hub of these curricular reforms. The University also runs its own teacher education programme (BElEd), which mirrors many of the pedagogical philosophies promoted by the reforms (Batra, 2009). Hence, greater influence of these reform ideas on the teachers and schools in Delhi was expected (via their pre-service or in-service training) when compared to a context further away, both in terms of distance and ideation. Finally, being born and raised in Delhi, I have spent most of my academic and professional life there, giving me a sound understanding of the educational and curricular context. I also have a strong command of the Hindi language, which is the medium of instruction in most schools in Delhi, thus making it an ideal choice.

[34] Note that, as discussed by Sarangapani and Mukhopadhyay (2018), this does not imply that teaching and learning quality is 'better', yet these are important indicators to consider in relation to sampling.

Research context: four schools

While it was clear that Delhi would make a suitable site for the study, it was also important to identify the ideal *type of school*. There are several types of schools in Delhi, including: government, government aided[35] or private schools. At the primary level, according to the DISE 2014-2015[36] census, 1,321,751 children (52% of the total of eligible children) attended the 2,265 government primary schools (45% of the total) (NUEPA, 2015). Thus, almost half the school-going population accesses private schools. While government schools are mandated to use the NCERT textbooks (including *Math-Magic*), the other types are free to choose from a variety of privately published textbooks. Apart from differences in management systems, an important difference between these types of schools is the socio-economic background of the children who attend them. Historically, only the elite accessed privately run schools, but the recent influx of "low-fee private schools" (Srivastava, 2008a, p. 185) has meant that there is now a range of choices for schooling: from those charging exuberant fees to medium and minimal fees. This has thus segregated schools which are now catering to children based on their ability to pay for these options. There is also evidence that indicates that the poorest and the most marginalised students go to government schools, which are free of charge (Alcott & Rose, 2015). Thus, while the national education policy calls for a common schooling system, in reality what there is today is a highly segregated system.

For this study, government schools were chosen as the site for schools for two reasons. Firstly, these schools are mandated to use the focal textbooks and secondly, being accessed by the most marginalised brings the stated aims of the reforms to the fore for examination. Thus, choosing schools where children from historically disadvantaged backgrounds are getting to access education becomes appropriate for understanding the use of these textbooks designed keeping in mind the issues of access and equity (See Chapter 2, Subsection 2.1.2).

Within the government system in Delhi, different management bodies run the different types of schools[37]: the central government (Kendriya Vidyalaya, KV), the state government (Directorate of Education, DOE) and the municipality run government schools (Municipality

[35] Government aided schools: part-managed by government bodies and part privately. Additionally, there are unaided recognised (or unrecognised) private schools; referred to locally as public schools.

[36] District Information System for Education database (DISE) is a database for each school district of India on students' enrolment, characteristics of schools, teachers, school buildings etc. For more details on DISE see: http://udise.in/

[37] India has a federal system, and while the provisioning of education is a state responsibility, it is also that of the federal government. Thus, the provisioning is provided at all these three levels: central, state and local.

of Delhi, MCD). Schools run by the central government (KV) are accessed by children whose parents have government jobs and are considered the most prestigious; DOE[38] run schools viewed as better than MCD cater for upper primary and secondary, whilst the MCD schools, which are responsible for primary education, are the least resourced and most neglected, being accessed primarily by the most marginalised (Banerji, 2000). There are further differences between government schools on the basis of their location (located in wealthier part of the city versus located in the city's fringes). For this study, I chose the most marginalised category of schools, namely MCD schools, which gave the opportunity to explore the 'possibilities' for the most marginalised children.

MCD is divided into three zones – East (EDMC), South (SDMC) and North (NDMC), which are indicated in the map below as the pink, green and yellow zones[39]. Four Municipality schools (MCD schools) were chosen. These schools were selected by approaching official channels as well as by using local contacts of educational researchers and teachers (See section 4.4.1).

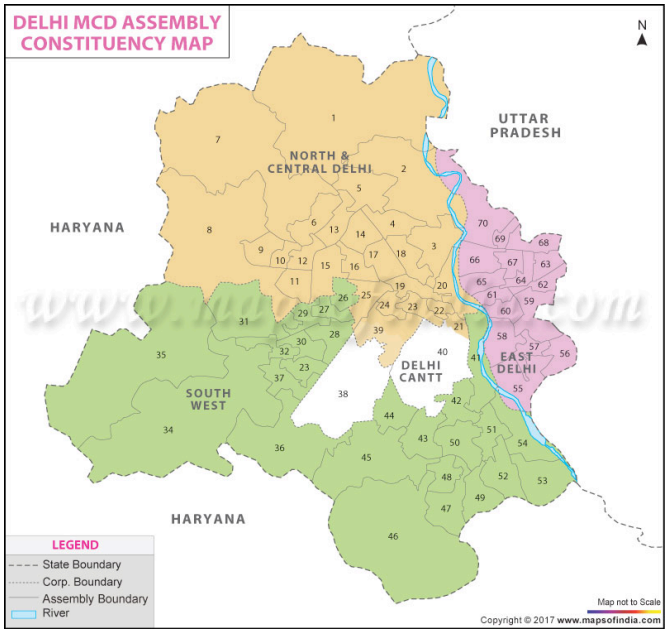


Figure 4.2: Zones of municipality in Delhi[40]

[38] The current state government (DOE) has also increased the education budget three-fold and started several new programmes for school improvement.

[39] Note that these three zones are administered separately and most importantly, their funding is also maintained within the zone. The zonal location and within zone location (urban/rural/slum) also determine the nature of the school.

[40] Retrieved from https://www.mapsofindia.com/maps/delhi/mcd-corporation.html

I got access to two schools in EDMC, and one school each in SDMC and NDMC. The location of the schools is critical as school catchment depends on availability of private schools in the neighbourhood, level of prosperity, as well as the socio-economic composition. Despite there being more schools from East Delhi than other zones in my sample, the individual school location and characteristics were considered more important. For instance, the two schools in EDMC despite being in the same zone were very different from each other. School 2 was located in a more prosperous locality School 3 in a more deprived neighbourhood. Overall, the four schools provided a range of different types of schools within the MCD schooling system. As shown in Table 4.1, School 3 had a high proportion of children from the scheduled or other backward castes[41] category, while School 2 had no children from such a background. On the other hand, School 2 had a high proportion of Muslim children (another minority community). The other two schools, School 1 and School 4, were located on the city's fringes in the South and North zones and also had the largest enrolment rates. These schools had overcrowded classrooms (45-55 children per class), as opposed to School1 and School 3 where the class sizes were much smaller (15-20 children per class). They were both all-girls schools with 70% general category girls. This was not surprising since literature suggests that most deprived schools often serve minority communities, and those with some social advantage (based on gender, religion or caste) choose private schools (Alcott & Rose, 2015). Thus, overall the characteristics of the four schools were diverse, providing a sample with a wide range of different types of schools.

Some of the schools under the MCD are also given a special privilege and made into 'Pratibha' schools, which means they can create a section in the English medium and get some additional funding. S1 and S3 were not Pratibha schools and thus exclusively, with the Hindi medium. S2 and S4 being Pratibha schools had one separate English medium section for each grade. However, owing to the fact that S2 had very low enrolment, the school was only able to run one section, which meant combining the Hindi and English medium children. Thus, both teachers taught students in both mediums at the same time. Some children had the Hindi medium textbooks (*Ganit Ka Jaadu*) and the others, English medium one (*Math-Magic*) for mathematics. S4 being a Pratibha school, had one English medium section, which was not included in the sample.

[41] These categorisations indicate the socio-political background of the children, in terms of marginalized communities in India. SC indicates Scheduled caste, OBC Other Backward castes, Muslim minority, and the rest of the children are termed to fall within the General category. See Subramanian (2017) for detailed analysis of influence of caste and mathematics education.

Table 4.1: Characteristics of the four schools in the sample

School	Zone	Number B=Boys G=Girls T=Teachers	Gen=General category ST=Scheduled Tribe SC=Scheduled caste OBC= Other backward castes M= Muslims	Medium of instruction/ *Pratibha*/ non-*Pratibha*	State of the building/ other features	Particularities/ Location
S1	South-west zone	G: 1533 T: 39	Gen:77% SC: 13% ST: 2% OBC: 1% M: 7%	Hindi/ non-*Pratibha*	Building under construction; lack of space; overcrowding	Located in the fringes of the city
S2	East zone	B: 104 T: 3 G: 123 T: 2	Gen (B): 57% M (B): 43% Gen (G): 36% M (G): 64%	Mixed (Eng and Hindi)/ *Pratibha*	Well maintained, spacious building	Connections with MCD, low enrolment, located in wealthy neighbourhood
S3	East zone	B: 173 T: 4 G: 146 T: 5	SC(B): 57% OBC(B):10% M(B): 5% Gen(B): 27% SC(G): 34% OBC(G): 0.6% M (G):1%	Hindi/ non-*Pratibha*	Spacious building, no staff room for teachers, small office	Struggling with leadership, high student absenteeism, located near an urban slum
S4	North zone	G: 1335 T: 35	Gen (G): 64% SC: 13% ST: 0.1% OBC: 3% M: 10% Others: 1%; Gen: 73%	Hindi/ *Pratibha*	No tables and chairs in classrooms, overcrowding, teacher absenteeism	Located in the fringes of the city

Selection of the cases: ten teachers

Hitherto I have discussed the selection and context of the site of the study, now I will move on to the discussion on the teacher or the '*case'*. Given the difficulty in getting access and permission to work in schools, I decided to include all teachers willing to participate from the four schools where I managed to get it, thus a *convenience sampling* approach was taken (See Subsection 4.4.1). The Table 4.2 below lists the characteristics of the sample teachers. All the names of the teachers have been anonymised in this study using pseudonyms. During the research process, it was also shared with all the teacher-participants that their names would be anonymised during every part of the data handling.

Years of experience and gender: As the choice of schools and teachers was based around the reformed textbooks, it was important that the teachers had been using them since their rolling out in 2010. That is, I wanted to ensure that teachers had minimum of seven years of teaching experience. Six teachers had 7-8 years of experience (early career), two had 11-14 years (mid-career) and two had 20-30 years (experienced), thus providing a wide range of experiences. Early career teachers only had experience of using these textbooks and had not previously taught using older books, whilst those who had taught for over 11 years had worked with the previously prescribed books as well. There were two male teachers in my sample and eight female ones. This is representative of the primary teachers' community in Delhi, where only about 27% of the teachers are male (DISE 2015-2016).

Grades: I chose teachers currently teaching *grades 4 and 5* for several reasons. Looking at two textbooks from the series helps in drawing more comprehensive conclusions about the textbooks' pedagogical approach. From the classroom usage perspective, there are also several similarities between these two grades. First, students would have learnt basic reading and writing, and thus, could engage more fully with the textbook. Secondly, in grades 4 and 5, the state-level scholarship examinations (*Medhavi*) are also conducted and this gave the opportunity to understand the textbooks' relationship with these assessments. Another important consideration is that grades 4 and 5 are often seen as landmarks in terms of primary education, as many of the large-scale evaluations about basic numeracy focus on this age group.

Teacher qualifications: Another important criterion of the teachers' background is their qualifications. All teachers in the MCD schools had to have a minimum qualification of a

diploma or degree in elementary teaching (See Section 2.4 for more on the context of teacher education in India). Seven out of the ten teachers had the basic Elementary Teacher Training Diploma (ETE). Of the remaining three, one had obtained her qualification from the Bachelors in Elementary Education (BElEd) course, which is significantly different from the other courses and consistent with the reform ideals (Batra, 2009). The most experienced teacher, with 30 years of teaching, had additional masters and bachelors degrees in commerce. As can be seen, only one of the teachers was a hired on a contract-basis, which meant that his appointment was subject to renewal every year. Due to his tenuous contract, he had already taught in three schools in three years, unlike the permanent teachers, who had been teaching in the same school for majority of their teaching years.

Teachers' professional development: As discussed in chapter 2, section 2.2.1, in-service teacher training is often one-time training events that teachers have to attend. Teachers are often nominated within their schools to attend these compulsory trainings. None of the teachers in my sample had received any training specific to the *Math-Magic* textbooks. Mohini, a few years back had received a two-year training to understand inclusive education for children with special needs. She was thus a trained special educator. Apart from Mohini, two other teachers, Kanchan and Afreen (both in school 1), stood out in that they had recently won teacher awards given out by the MCD in collaboration with an NGO. As a reward, they received teaching and learning materials packages developed by a mathematics education NGO called – *Jodo Gyan*[42]. Kanchan was also involved with the Delhi SCERT (State council educational research and training) in curriculum designing. In schools 2 and 3, there was NGO presence in terms of running a library project and conducting remedial classes, respectively, but none of the focal teachers was directly engaging with them in any way.

[42] *Jodo gyan* is one of the few NGOs that work in developing mathematics learning materials based on the principles of Realistic Mathematics Education. The important role of *Jodo gyan* is that unlike many other private publishers or developers, they often work with governments and other NGOs to support government schools. See Menon (2012) to understand their work further.

Table 4.2: Characteristics of the ten case study teachers

Teacher/ School	Year	Average Number of students	M=Male F=Female	Years of Experience	Teacher status	Qualification
Bhumika (S1)	5	40	F	8	Permanent	2-year diploma (ETE, DIET Delhi)
Afreen (S1)	4	50	F	8	Permanent	2-year diploma (ETE, DIET Delhi); MA Political Science
Kanchan (S1)	4	45	F	8	Permanent	2-year diploma (ETE, DIET Delhi)
Deepali (S2)	4	20	F	14	Permanent	2-year diploma (ETE, DIET Delhi); BEd
Sonali (S2)	5	25	F	11	Permanent	2-year diploma (ETE, DIET Delhi)
Mohini (S3)	4	15	F	20	Permanent	3-year degree (BEd, DU Delhi); MA Political Science, BCom
Ganesh (S3)	5	25	M	7	Contract	2-year diploma (ETE, DIET Maharashtra)
Neetu (S3)	5	25	F	30	Permanent	3-year diploma (JBT, DIET Delhi)
Mahesh (S4)	4	45	M	8	Permanent	2-year diploma (ETE, DIET Haryana)
Sanchita (S4)	4	45	F	8	Permanent	4-year degree (BElEd, DU, Delhi)

4.4 Reflexivity and Ethical Considerations

Whilst the idea of reflexivity is typically used and developed in the fields of feminist and critical theories, I believe it is important for this study. Despite the growing recognition that mathematics education research produces knowledge located within a "particular social, economic, and political context of society" (Foote & Bartell, 2011, p. 46), research regarding it continues to ignore ideas of reflexivity. As Foote and Bartell (2011) have argued, there is a critical need to prioritise 'positionality' in mathematics education. With such a 'socio-political' turn in mathematics education research, it becomes important to question the positionality of the researcher as well as the research itself. As Valero and Zevenbergen (2004) in their book contended, researchers' awareness of the research process is central to such an approach. This issue becomes even more significant for an under-researched and under-theorised context, such as government schools in India. This approach of criticality towards the activity of research in the field of mathematics education, where the majority of study has occurred in a Northern context (See Atweh et al., 2007), is deemed necessary for my study.

There are multiple ways in which reflexivity can be integrated into qualitative research. I follow Luttrell's (2009) conceptualisation of reflexivity, which views it as central to all qualitative research, labelling it as "research relationships" (p. 160). This gives me an opportunity to reflect on the different 'relationships' during the research process and not just being limited to what Pillow (2003) critically called "recognition of self[43]" (p. 181). Apart from reflecting on the researcher-participant relationship, it also enables me to explore aspects of the positioning of the study in relation to the field of educational research. Reflexivity is, thus, viewed from two perspectives for the purpose of this study. Firstly, as an interpretive qualitative researcher, exploring *my positioning as a researcher* in relation to the study and its repercussions on the research processes, such as issues of access. Secondly, reflexivity is also used for reflecting on the *positioning of the study* in the global South context and field of mathematics education. Through these explorations of 'relationships', I will be highlighting the ways in which ethical dilemmas were navigated in the field.

[43] Pillow (2003) warned against excessive use of such reflection, which she argued serves no methodological purpose other than a self-indulgent catharsis of the researcher.

4.4.1 Positioning 'self' in the study: seeking permission and consent ethically

Positioning your 'self' in research and the data analysis process is a complicated task, since the 'self' impacts not just on how the participants interact with the researcher, but also what (and who) they can access. Merton's (1972) classic categorisation of 'insider/outsider' has often been used as a simple way of dichotomising whether the researcher is a member of the 'group' being studied, or outside it. This is contested, not only at the level of defining the participants' identity boundary, but also at that of the researcher's identity as well (See Mohammad, 2001). Such a deterministic view of identity has been criticised by both feminist and critical theorists. For instance, Maher and Tetreault (1994) instead defined *positionality* as "an idea in which people are not defined in terms of fixed identities, but by their location within shifting networks of relationships which can be analysed and changed" (p. 164). Such a relational positionality of the researcher is much more relevant for my study. Srivastava (2006) in her discussion on researching educational settings in the context of global South, specifically India, used an important construct of 'multiple positionality' which she suggested are used as currencies in different situations and locations. In this study too, multiple positionalities came into the relationships between me and the gatekeepers, the teachers, the principals and other researchers I met in the field. In the next two subsections, I discuss how these multiple positionalities were navigated to gain access permission, both at the official as well as local level.

Permission at an official level

Whilst I had previously worked in the field of curriculum development in Delhi, my work focused on privately run schools and thus, my engagement with the government school system only started with my MPhil thesis. I conducted a small-scale interview based research, for which I used local contacts of educational researchers, as well an NGO working with government schoolteachers. I was unaware, at that time, of the complications and politics in accessing permissions to research school sites. At that time, since I was only to carry a one-time interview with teachers, I was able to find willing teachers. However, since my PhD project was going to be a long-term engagement with teachers and would include classroom observations, it was recommended that I seek permission from the appropriate government bodies. Fellow PhD students (affiliated with Indian public universities) warned me about issues of access they had encountered, yet I hoped that my affiliation with a prestigious foreign university would offer some advantage in negotiating permission. This belief of how

my positionality as a UK university PhD candidate would be perceived by government officials turned out to be highly naïve. As I embarked on my pilot study in March-April 2016, I simultaneously started the process of seeking permission. Slowly, as I spoke to other educational researchers and with my own experiences in the field, it became clear that this was not going to be an easy task. At the end of my pilot study, all the 4 zones of MCD and the DOE had denied me access. SDMC out-rightly said that they do not give permission to student researchers (even from Indian institutions) for such studies and only allowed government bodies to conduct such research. They added that the only permission they granted was for workshops or interventions that directly benefitted school sites (on the basis of which many NGOs[44] often enter schools), but not for independent research. NDMC denied permission on the basis of the fact that I resided in a different municipality zone. Regarding the DOE, even though I had previous correspondence with the advisor to the Minister of Education, I was denied permission on the grounds of it being a matter of policy (this was the formal reason for rejection given to me). EDMC asked me to obtain permission from the University of Cambridge vice-chancellor, claiming that only if it was a University and Municipality that had some formal partnership, would it allow my research. I was left slightly confused by such hostility. I used my positionality as a University of Cambridge student as *currency*, as suggested by Srivastava (2006), to "ease the exchange between the researcher and the participant" (p. 211) and yet, did not get much success.

During this visit, I started becoming acutely aware of the lack of trust towards university based researchers. I found my experiences being echoed by several other researchers. In a report on the status of RTE by Sarangapani et al. (2013), these researchers found themselves in a similar situation while investigating in Delhi for their multi-sited study. Despite being a government-funded project, different state agencies in the city seemed to act in isolation and hence, the permission from a higher authority (MHRD[45]) did not seem to make a difference. I too heard of stories of MPhil and PhD students[46] from public universities struggling to

[44] This is not surprising since government schools for several years have actively been partnering with various private (profit and non-profit) organisations for support – including teacher training, or other resource support (Kumar, 2008). These NGOs carry on their own research as well, but since they have MOUs with the local administrators it is easier to do so. It is also becoming more common for independent researchers to affiliate with NGOs (rather than universities) to conduct research in schools.

[45] The Ministry of Human Resource Development (MHRD) is the central ministry that overlooks education since there is no Ministry of Education in India. There is a separate Ministry of Child and Women's development, which oversees some other critical child development programmes.

[46] The most troubling experience I encountered was of a teacher-researcher, who despite having taught in a government school for 18 years, also faced issues while accessing permissions to conduct research in her own school for her doctoral thesis.

undertake their research in Delhi schools. This clearly indicates an urgent need for relationship building between public universities in Delhi and state authorities (Sarangapani et al., 2013). Furthermore, as I spoke to teachers about it, many of them informed me that they had got strict notification from the authorities not to allow any outsider to research in their schools without an official permission letter. Sarangapani et al. (2013) attributed this reluctance to the excessive criticism of Delhi government schools by the media, activists and researchers. As discussed in the context section, numerous issues have been plaguing government schools (ranging from being under-resourced to being neglected by the state), thus giving a fatalistic view of these institutions. Such conditions are no state secret: from journalistic reports, PILs to other academic work, they been repeatedly reported extensively in the last 20 years. Delhi, in particular, being the national capital, has often been studied and the criticism of the state apparatus for education has been frequent. To conduct research in these contexts is, thus, viewed with scepticism by government officials, who are not willing to support studies with any possibility of their contributing to the bad reputation of the system.

Robinson-Pant and Singal (2013) problematised educational research in the context of global South, when carried out from the 'North' and the lack of engagement with the micro and macro politics of the context. Using the case of teacher research in India and the nature of knowledge research produces, Sriprakash and Mukhopadhyay (2015) also encouraged researchers to use a second level of reflexivity, which questions the political positioning of their study. Keeping such approaches in mind, while I was becoming aware of the micro-politics in the context of Delhi, I also started reflecting on the often-used deficit discourse of teachers and state institutions. This impacted on some crucial decisions about my research design. Conceptually, I did not want to use a comparative framework (comparing reforms to practice) and instead, created a more relational framework, where the decisions of the teacher and the reforms were both under scrutiny (See Chapter 3, Section 3.2).

Secondly, during the choice of sample, I consciously did not include any school comparison – private with state schools – since this is highly contentious debate impacting on local politics[47] (Subsection 4.3.2). I had also decided that both these decisions would be communicated to the teachers and officials to ensure that they understood my approach (See Appendix F). After consciously stressing these decisions as I spoke to the authorities during

[47] To engage with the debates on quality and its different interpretations see: Sarangapani and Winch (2010) as well as Tooley, Dixon, and Gomathi (2010).

my second pilot phase (August-September 2016), I met with some success. My consistent effort of turning up at offices and repeatedly approaching the concerned authority, seemed to work. A personal assistant of the Director of Education (EDMC) showed sympathy and arranged for a meeting with the director. This is not unusual in a bureaucratic set up, such as India, where face-to-face interaction and some level of personal persuasion is necessary in getting things done (See Varma, 2011). This advice of 'turning up' was also given by a fellow researcher, who had previously struggled with the bureaucracy of permission seeking. During the meeting with the director, it became clear that, indeed, the authorities were highly suspicious of researchers. He spoke of the myriads of 'fake' NGOs that had approached him for permission to work in Delhi schools, and he claimed he could judge that I was genuine. This test of 'genuineness' was thus central to the authorities giving permission. As discussed above, suspicion is common in this field creating a complex interaction between NGOs, NGO researchers, academic researchers in these spaces. The authorities seem to define what is "acceptable" research (Hett & Hett, 2013, p. 505), based on these suspicions, as either concretely benefitting schools via resources or training or producing acceptable results[48].

In this way, I obtained *official level permission* for four schools in the EDMC zone[49] (See Appendix G). Thus, what I had assumed would be a one-time permission seeking from authorities turned out to be a long-drawn process of negotiating the politics of educational research and navigating relationships with multiple gatekeepers, taking a total of one year of such endeavour. As Feldman, Bell, and Berger (2004) have described, 'gatekeepers' are not those guarding just one door, which gives direct access to the field, but a "long hallway with multiple doors" (p. ix). Such an image gives the idea of layers of permission that one needs to seek. I too was navigating multiple gatekeepers (Deputy director of Education, Director of Education, advisor to Minister of Education, personal assistants), each having their own powers, which I had to understand and negotiate to finally get some access. As Hett and Hett (2013) go on to say, there are further interconnections between these gatekeepers, thus making it important to know who to approach and in which order. Such 'layering of permissions' is common in organisational setups, such as the highly bureaucratised system of

[48] For example, we see a growing interest of the current Delhi government to affiliate with prestigious universities such as Harvard University for research, which indicates an interest in prestigious international universities and yet, there is mistrust in independent researchers (see AAP, 2017). They have also partnered with various NGOs for the purposes of professional development, such as STIR, Pratham etc. The politics of how these universities and NGOs are chosen is beyond the scope of my study. See Kumar (2008) and Subramanian (2019; 2018) to understand the politics of NGOs in school sites.

[49] Interestingly, even in Sarangapani's study, they had permission from this zone. As mentioned before, EDMC is the least resourced out of the three zones, since most of its constituency consists of slum areas.

government schools (See Buchanan & Bryman, 2007). The layering of permissions does not end at the level of administrative gatekeepers, for it extends to the site, where one needs to further negotiate consent with participants. In the next subsection, these *local level permissions* are discussed in detail.

Permission at a local level

Despite getting permission from the EDMC, two out of the four schools did not allow me to audio record any of the observations or interviews and continued to see my presence as somewhat threatening (See Subsection 4.5.2). That is, the teachers thought that what they said or I observed might get reported to the authorities. One of teachers in these schools expressed vehemently that she would not feel comfortable talking about these issues on a recording, since that would restrict them from being honest about their views.

> She refused to be audio recorded, because she said that she is a government employee and on paper she is supposed to follow government orders and not disagree with them. As employees, they can't express any personal opinions either political or about government policy. She added that if I wanted a 'flowery version', then I could record, but if I wanted her true opinions then she could not give permission for recording. (field notes, 01.05.17)

As the above paragraph from my field notes indicates, suspicion about the research persisted even at the teacher level. Due to all the uncertainty around obtaining official permission, I decided to simultaneously approach educational researchers from Delhi based in universities and to access their contacts in schools. I relied on these contacts, to obtain what I term *local permissions*. I was fortunate to find teachers, who had themselves engaged in research work (MPhil/PhD) and had dealt with many of the abovementioned issues first-hand. In this way, I got access to two schools where researcher-teachers[50] opened their schools and gave me access. In relation to Srivastava's (2006) framework, positional currency that worked in favour of easing this exchange, was the shared experience with the difficult administration and shared sensibilities towards research. The teachers, who often had to deal with the unpredictability of the system, sympathised with my experiences and were keen to 'help' me out. This also helped me gain their trust. In my interactions with teachers, I used my positionality as a local student from Delhi, who has experienced the difficulties of the system. One of my teachers, Kanchan, commented in her first interview:

[50] These teachers were not directly in my sample, but they gave me access to their colleagues who eventually participated in the study.

If we don't help each other out, then who will. (interview 1, Kanchan)

My consent seeking process thus took a teacher-centric turn. Informed consent is more than the customary signatures on consent letters, for it also incorporates the idea of the researcher being accepted within the community after conscious and constant negotiations (Robinson-Pant & Singal, 2013). Agreeing with Swartz (2011), the strategy that I adopted (especially in these schools) was actively to extend the phase of consent approval. As I had been privileged with obtaining official or local permission, the lack of research or trust at such sites added extra responsibility for me to be clear about my agenda and hence, the effectiveness of the research. Since my research itself was teacher-centric, it helped to be totally open and honest about the aims and objectives of the study. In addition to asking for permission and explaining my research at its beginning, I also engaged with the participants at the end of the final interviewing about my methods. This was a particularly important discussion, since the teachers not only discussed their participation, but also honestly expressed some initial apprehensions as well as their hope about such research. Finally, at the end of the interview process I explained how the recording would be used and detailed the next steps of my research. By so doing, the teachers who granted local permission came to trust me based on their position of seeing themselves as 'helpers'. In case of the other teachers, my ongoing negotiations and explanations of the aims of my study enabled a reduction in suspicion, thus easing my access to their schools.

4.4.2 Positioning the study in the research context: 'disruptions' in the research process

As I have already mentioned briefly in the subsection above, while I started off believing that the way permission or consent would be granted based on the positionality of 'self', I soon realised that the politics of educational research in the context of Delhi seemed to be influencing my research process. That is, more than my 'personal' self, what seemed to be playing out as my positionality was my identity as an independent researcher attempting to work in public institutions, which had their own history and politics. In this subsection, I expand upon this idea and problematise the field of mathematics education research in India. The development of a socio-politically contextualised perspective, while remaining within the discipline of mathematics education, is a significant goal of this project (Valero & Zevenbergen, 2004). I believe that this approach accommodates importation of theories and practices from the discipline of mathematics education mostly developed in Northern contexts, but also "problematizes" (Valero & Vithal, 1999, p. 8) them. I specifically explore the idea of "disruptions" (Vithal, 1998, p.33), which Vithal (1998) discussed in her paper

about conducting mathematics research in the global South. She questioned the assumption of 'stability', which sets the standard of good research in mathematics education. She argued that the possibility of encountering unpredictable situations is much more in contexts of global South and instead of aiming to sanitise and ignore the 'disrupted' data, the challenge is to incorporate these into the research process. As I entered the schools, I realised that government schools too were highly unstable sites. Planning and scheduling visits became one of the biggest challenges of my project.

Whilst I had planned initially to chart out a schedule with the teachers and focus on a few of the chapters from the textbook (one number based and one non-number based), it turned out to be much harder than anticipated. Firstly, there were several 'disruptions' in my data collection process. In the months of April-May (the academic year in schools start from 1st April), there were three main reasons why very few observations could be conducted. Firstly, the schools were slow in receiving textbooks and different schools were receiving books at different times. School 1 received the books by end of April, while the other three did not get theirs until the first week of May and the schools were closing for the summer holidays from 10th of May. This meant that very little teaching from the textbooks occurred in April and May. One of the teachers from School 4, did not receive the textbooks until August 21st. She was going to be a part of my study, but since the textbooks came so late, I could not include her. Also, it should be noted that since admission is on a rolling basis (according to RTE no child can ever be refused admission), this meant that children kept joining the classes. Since receiving the textbook was a one-time activity, many of the children, especially those in School 4 (where there was high enrolment), did not receive enough textbooks. Thus, in both of Mahesh and Sanchita's (school 4 teachers) classes, there were children without any books. Secondly, the municipality elections were being held on the 23rd of April 2017. The MCD schools not only became polling booths for that day, for the teachers also had to perform election duty. For this, they had to attend training sessions, organise and help out in making the schools booths, which took up an entire week in April, thus resulting in no teaching that week. Teachers discouraged me from coming to their schools at all in these months, since they would be too busy to even talk to me. Finally, the teachers complained that there was low attendance during this time, since most students go to their village or take leave after exams, and often don't come back until the end of summer vacations (July). This meant that no 'serious' teaching started until July.

I, thus, decided to set up my schedule on a week by week basis, calling up teachers and enquiring about their availability[51]. Also, school 1 (which was in the South Delhi zone) had a particular constraint. Their scholarship exams were conducted in the month of December, which meant teachers were in a hurry to complete their syllabus. The three teachers from this school were the only ones who, thus, attempted to cover more than seven chapter by the end of the first term (end September). Hence, I decided to focus on this school in the month of July (See Table 4.3). Also, Mahesh had gone for a 15-day seminar on physical training in July-Aug, which is why I decided to go to School 4 in the latter half of August and September. Moreover, in August, S3 and S4 had visits by the MCD officials in their schools. S3 especially asked me not to come for almost two weeks of this month, since they had repeated visits organised. Mohini complained that the focus of these visits is often on all other kinds of activities, such as cleanliness, opening bank accounts, instead of teaching and learning. As a result, they not just end up losing the time which could have been spent on teaching, but also felt that teaching was not considered as important by the authorities as other non-teaching components of their work. For another two weeks (under the orders of the MCD) S3 and S4, had to get all their students registered for *Aadhar cards*[52] and ensure their bank accounts were open[53]. This time, again, my visits were interrupted since the teachers had to leave their schools and visit the banks with parents to ensure the accounts were opened.

[51] It has already been discussed above that teachers often also could not work based on a timetable and thus, scheduled their work on a day to day basis as a result of disruptions caused by non-teaching tasks. Thus, it was most reasonable to plan my visits on a weekly basis.
[52] *Aadhar cards* are a unique identification number given to beneficiaries of social welfare schemes by the Unique identification authority of India. It was introduced to ensure smooth transfer of social security benefit, however there are several data privacy and implementation concerns that are often raised.
[53] Other non-teaching tasks have been discussed in Subsection 3.2.3, which all lead to site 'instability'.

Table 4.3: Fieldwork schedule from April 2017 – September 2017[54]

Codes	April-May'17	July'17	Aug'17	Sept'17	Total observations
Bhumika	5.NA	5.4, 5.6, 5.6	5.5	5.10	6
Afreen	4.2	4.NA, 4.4, 4.6, 4.6	4.7		6
Kanchan	4.2	4.4	4.5	4.10	4
Deepali		4.2	4.4, 4.4, 4.4		4
Sonali		5.2	5.4, 5.4, 5.5		4
Ganesh		5.6,5.6	5.10, 5.10, 5.7		5
Mohini		5.2	5.2, 5.3, 5.4		4
Neetu		4.2,4.4	4.NA, 4.NA		4
Mahesh		4.2	4.3, 4.4	4.5	4
Sanchita	4.2		4.4	4.7	3

Methodologically, the lack of studies in the global South contexts in mathematics education, makes it a prerogative of researchers to be "dynamic in changing research methods and focus" (Valero & Vithal, 1999, p. 10). In the case of my research as well, as discussed above, I had to accommodate the teachers' schedules, which meant that I could not predetermine which topics I would be focusing on and aimed to collect as many classroom observations as possible. Due to the precarious nature of the field, and the challenging issues about gaining permissions, I wanted to make the research methods as non-intrusive as possible. As Sarangapani et al. (2013) have warned, often teachers feel disturbed by the demands of researchers, adding to their reluctance to participate. I, thus, did not put any additional burden on the teachers, such as asking them to make teacher diaries, which is a common method used in mathematics education studies, including work on teachers' use of curriculum material (Tarr et al., 2009; See Subsection 4.5.3). If on days I visited and for some reason the teacher was not available, I simply rescheduled my visit. In this way, by reorganising my schedules, by not specifying chapters and using non-intrusive methods I accommodated the 'disruptions' into the research design. Having discussed how my methods evolved by actively using reflexivity of 'self' and 'positioning of the study', I now move on to discussing the data collection methods in detail.

[54] 5.NA means that the observed grade was 5th, but no specific chapter from the textbook was used; 5.6 means that the observed grade was 5th, and observed chapter was chapter 6.

4.5 Data Collection Methods

In this section, I discuss in detail the methods chosen for data collection. In line with the interpretivist approach of the study, I used naturalistic methods for this (Cohen et al., 2013). Keeping the conceptual framework of a participatory approach in mind, I collected data on textbook affordances (the textbooks themselves), as well as teachers' textbook use and thinking (through classroom observation and teacher interviews). Overall, three methods were employed to address the research questions: textbook analysis, classroom observations and semi-structured interviews (Table 4.4). Supplementary to this, I took field notes (in classroom and school settings) to add depth and context to the cases. Field notes are important in qualitative research, especially in case studies (Yin, 2017). As Delamont (2016) articulated, "regular, sustained, detailed written records are central to qualitative research" (p. 58). Taking notes, rewriting them as write ups and keeping analytic memos during data collection and analysis, added contextual depth to my study. It also ensured that I was dynamic in responding to the needs of the situation, as necessary for studies in under-researched global South contexts (Subsection 4.4.2).

Table 4.4: Research questions and the corresponding data collection methods

Research questions	Data collected
RQ1: How are the key *reforms* represented in the mathematics textbooks?	Textbooks (grades 4 and 5)
RQ2: How do teachers *view* reform-oriented mathematics?	Semi-structured interviews of teachers (two interviews each)
RQ3: How do teachers *use* the reform-oriented mathematics textbooks in their lessons?	Classroom observations

4.5.1 Textbooks

To address the first research question, both grade 4 and 5 *Math-Magic* textbooks were collected. These books were accessed from the NCERT website[55], where all the books in English, Hindi and Urdu are made available for free. Despite the official documents, such as NCF-2005 and the position papers that were published along with them, being the basis on which the textbooks were developed, these policy documents were not analysed. This is because teachers did not come to use these documents directly in any form (most schools

[55] See http://ncert.nic.in/ebooks.html

didn't even have copies). Teachers only had access to the textbooks, which they directly used in their lessons. Secondly, as discussed in the literature review, the study focus was on teachers' response to the textbook (relationship between potentially implemented and enactment), rather than probing the alignment between the intended curriculum (policy level) and the potentially implemented curriculum (textbook) (see section 3.2).

4.5.2 Classroom observations

One of the main sources of data for the study was classroom observations. These, although somewhat intrusive, are a good method of engaging with a phenomenon directly without relying on a participant's (in this case the teacher) account of the phenomenon (Cohen et al., 2013). There is a lack of studies in the Indian context engaging with the teaching processes within classrooms (O'Sullivan, 2006). Amongst the limited studies using classroom observations in the Indian context, the researchers used structured observations schedules to measure teacher 'effectiveness' or 'quality' (Aslam et al., 2019; Sankar & Linden, 2014; Singh & Sarkar, 2015) or more ethnographic approaches to observations to explore pedagogical relations within the classroom (Iyer, 2013; Sriprakash, 2010). There has also been a growing number of studies trying to develop more semi-structured observation schedules to both capture the quality of classroom pedagogies (see Alexander, 2001) and compare them to those of a large number of other classrooms (Brinkmann, 2015; Sarangapani et al., 2013).

In particular, studies focusing on textbook use have tended to use open approaches to observations since there is a lack of teacher-textbook theorisations in the Indian context (Mili & Winch, 2019; Takker & Subramaniam, 2018). Having reviewed these approaches, I chose to use a more open classroom observation approach. I audio recorded the classroom lessons, so that, instead of relying on 'on the spot' observations, I got the opportunity and time to go back to the data and investigate the lesson in more detail (Graddol, Maybin, & Stierer, 1994). In mathematics education, there is increasing use of video recording of classroom lessons, the primary benefit of which is that they not only record verbal, but also non-verbal aspects of an interaction (Derry et al., 2010; Powell, Francisco, & Maher, 2003). However, these methods are less common in India. Methods that are suitable for the context of the study depend on the nature of the site. As I have already discussed, the permissions I received were highly precarious, and there was suspicion among teachers, some of who had already refused to be recorded (even audio recording). For this reason, I was engaging with the teachers carefully, and did not propose video recording since I did not want to jeopardise further my positioning

in the schools. Hence, I just chose the least conspicuous and intrusive recording method: audio recording. I used both my smart phone as well as an audio recorder to record the teacher talk[56]. During the lessons, I placed the recorder beside me, as I sat among the children (in the last row), trying not interrupt the class in any way. In doing so, I could capture the teachers' talk which was projected to the whole class. Since the classrooms were very noisy (especially classes in S1 and S4, which, as aforementioned, had large class sizes), this did not capture all the student responses and not all the teacher talk was clear during smaller group discussions. I kept my focus on whole-class discussions (as opposed to smaller group or one-to-one interactions, as classified by Alexander, 2000), which was the majority of the classroom activity and was captured well through audio recording. In cases when students spoke in whole class discussion, I recorded this in my observation notes (see Appendix H) and often teachers themselves repeated and projected loudly the student's contribution that they were bringing into the discussion.

4.5.3 Teacher interviews

While classroom observations were collected to capture the phenomenon of textbook usage directly, teacher interviews were aimed at understanding their perspectives as expressed by them. There are several types of interviews defined by researchers (see LeCompte and Preissle, 1993; Bogdan and Biklen, 1992; Lincoln and Guba, 1985 as cited in Cohen, Manion, & Marrison, 2013). One of the major differences between the types of interviews lies in their "degree of structure" (Cohen et al., 2013, p. 270). The argument for using a more open interview over a structured one depends on how much the researcher is aware of what she does or does not know about the research question, around which interview questions can be formulated (Cohen et al. 2013). My choice of a more semi-structured approach, rather than an open one, was based on the fact that I wanted to focus on teachers' work of the textbooks, with respect to the themes emerging from textbook analysis. However, I also did not want to assume that my textbook analysis would have covered all the relevant issues from teachers' perspectives. Consequently, I used a semi-structured approach, asking questions about the themes I had identified as well as a few open-ended ones.

[56] Children and teachers are used to smart phones, but some of the children were very curious about the other audio device. They often surrounded me and asked how it worked and assumed that it was a kind of a smart phone. One girl even mentioned that this was the same device used by the police. It was interesting to see the interaction of the device in the class, and one time some children wanted me to record their singing and hear it back. After a few visits, however the students were comfortable with my presence with the device.

There were two main goals of using interviews: first, to understand teacher views on the textbooks, in general and second, to gather their views related to textbook use. The first helped in directly addressing the second research question, while the second goal facilitated complementing the findings from the classroom observations, thus making more informed interpretations for tackling the third research question. Accordingly, two different interviews were conducted. The first interview was focused on the views the teachers held about the textbooks and primary mathematics teaching. That is, it was about their perception of the key reforms of the textbooks, their perceived applicability in their classrooms, and the way they attempted (or not) to introduce them in their practice. The second semi-structured interview was conducted so that teachers' work in the classrooms and their decisions regarding the textbooks could be better understood. In this interview, I asked them to describe their teaching of the chapters they had covered during the duration of my fieldwork, expanding on which ones they found easier to work with and which they found more difficult. By ranking the chapters based on which one they preferred (and why), I could have a deeper conversation on the kind of pedagogical implications of the design of the chapters (see Appendix E). Furthermore, the two interviews were taken at two different points in time. The first was carried out right at the beginning of my fieldwork which also overlapped with the beginning of the school's academic year. Teachers thus shared their initial impressions of the textbooks and their previous years' experience of using the textbook. The second interview on the other hand could capture more clearly teachers' views of their current textbook use.

As discussed in the context review, the aim of the study was to bring forth teachers' voice and not reproduce notions of the 'teacher-deficit' (see Chapter 2, Section 2.2). Thus, instead of using a fidelity model (comparing teachers' practices against policy aims), for the study, I utilised a participatory perspective on the teacher-textbook relationship, which placed equal agency on the textbook as well as teachers. In line with this approach, one of the methods I attempted to incorporate was post-observation interviews. I tried to ask teachers at the end of each observed lesson, questions about their intentions and rationale for their textbook related decisions. However, this turned out to be much harder than anticipated. Apart from lack of time in a disrupted setting (as discussed in Subsection 4.4.1), teachers also did not seem to be able to articulate their rationale behind classroom decisions as clearly as hoped for (see Chapter 7, Section 7.1 for a discussion on teachers' general lack of articulation of the rationale behind the textbook affordances). It is interesting that in Leshota and Adler's (2018)

study of the textbook-teacher relationship in the South African context, they met with a very similar challenge:

> Unfortunately, despite coaxing teachers' reflections on their use of the curricular resources, the post interviews did not move beyond general information. (p. 97)

Just like Leshota and Adler's study, I too decided to draw primarily from the two teacher interviews discussed above and the lesson observations. However, not having teachers' insights into each of their lesson can be viewed as a methodological limitation of this study. It also opens up important questions about which methods may or may not work in what type of investigation. For instance, in the Indian context, Takker (2017) was successfully able to conduct post-lesson interviews within a professional development context. In my case; however, where already my positioning as an independent researcher was precarious (as discussed in Section 4.4), I was unable to conduct "pre-, and post- lesson interviews, informal chats and systemic interactions" (as done by Takker, 2017, p. 938). In Takker's study, which was a part of a professional development intervention, through long term engagement with teachers they became more comfortable to reflect on and articulate their practices. However, since my study was not aimed at any teacher learning, this was not feasible. Other quantitative studies, such as Tarr et al. (2012), explored teacher-textbook relationships through their examination of teacher-use diaries. The government schoolteachers that I worked with did have teacher diaries, but these were formal books that they had to maintain for administrative purposes and were often not reflective of how they taught in actuality. Hence, these were also not helpful for the study. Further, I did not want to add another burden on teachers of having to fill reports for me within the already time constrained and demanding environment of their worked. Overall, the study primarily involved drawing on teachers' perspectives through two formal semi-structured interviews.

4.6 Data Analysis Methods

In this section, I discuss in-depth how I analysed the data collected using the above described sources.

4.6.1 Textbook analysis

In the literature review chapter (section 3.3), the various studies that have focused on textbooks and analysed different aspects of them were discussed. In this section, I explain how the textbook *Math-Magic* was analysed for this study.

Unit of analysis: Identifying the unit of analysis for the textbook analysis was important for two significant reasons. Firstly, the appropriate unit of analysis helps in modelling the textbook in a way that particular reform ideas, which are central to the textbooks, can be foregrounded and discussed systematically. Secondly, for this study using multiple data sources - textbook, classroom observations and teacher interviews - it was particularly important to find a unit that was relevant across these data sets. To this end, *tasks*, which are often used as a unit of analysis in mathematics education research, was deemed a fitting choice. *Tasks* have been used to mean several things in the literature – from the perspective of what students' experience in classrooms in the form of 'academic tasks' or mathematical tasks (Doyle & Carter, 1984) to a more fluid definition by Watson and Thompson (2015). The authors defined task as "written presentation of a planned mathematical experience for a learner, which could be one action or a sequence of actions that form an overall experience" (p. 143). This is a suitable definition for my analysis, since the notion of task is related to how the author imagines this 'overall experience' and not dependent on a priori conventions of what mathematical activity might look like. This 'experience' can be explored in ways that relate to the reform ideas and how the authors represent them in the textbooks.

As previously mentioned, I focused on grades 4 and 5, exploring the use of the textbook during half the academic year. I, thus, analysed half (7 chapters) of the textbooks. Within each chapter, a task was identified as content between two consecutive headers[57]. Overall, in the seven chapters analysed of Math-Magic Book for grade 4 (referred as Book 4), there were 75 tasks, whereas in Book 5 there were 117. Within the textbook tasks there were *action eliciting components*, which presented what students had to do and the *supplementary non-*

[57] The task is labelled in the format: *Book.chapter.task*. For example, the 5th task in the 14th chapter in Book 4 is labelled as *4.14.5*.

eliciting components, which supported the readers (students or teachers) when attempting the tasks. These were analysed based on the larger conceptualisation of the textbook as having three types of affordances: support; voice as well as context (see Section 3.3).

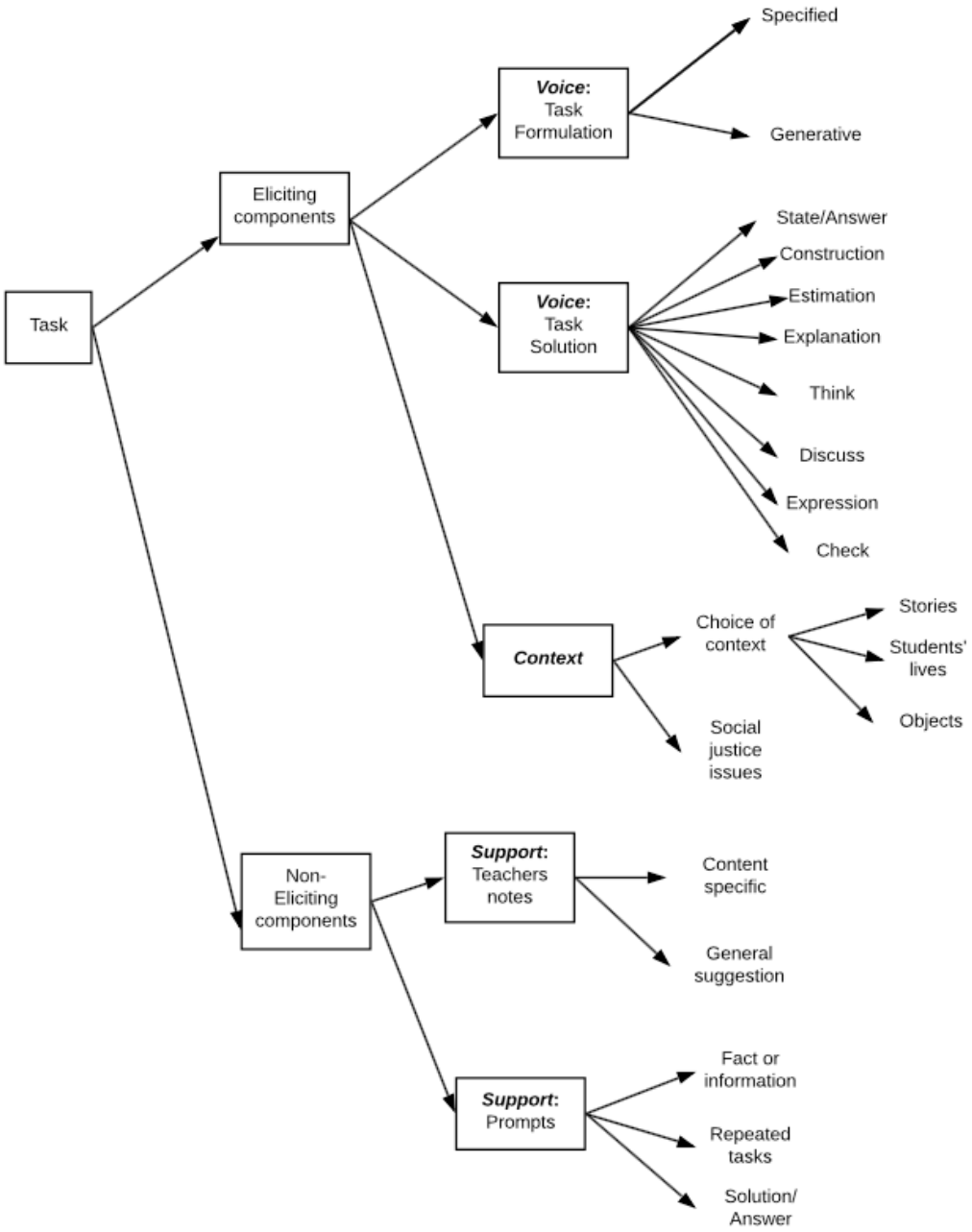
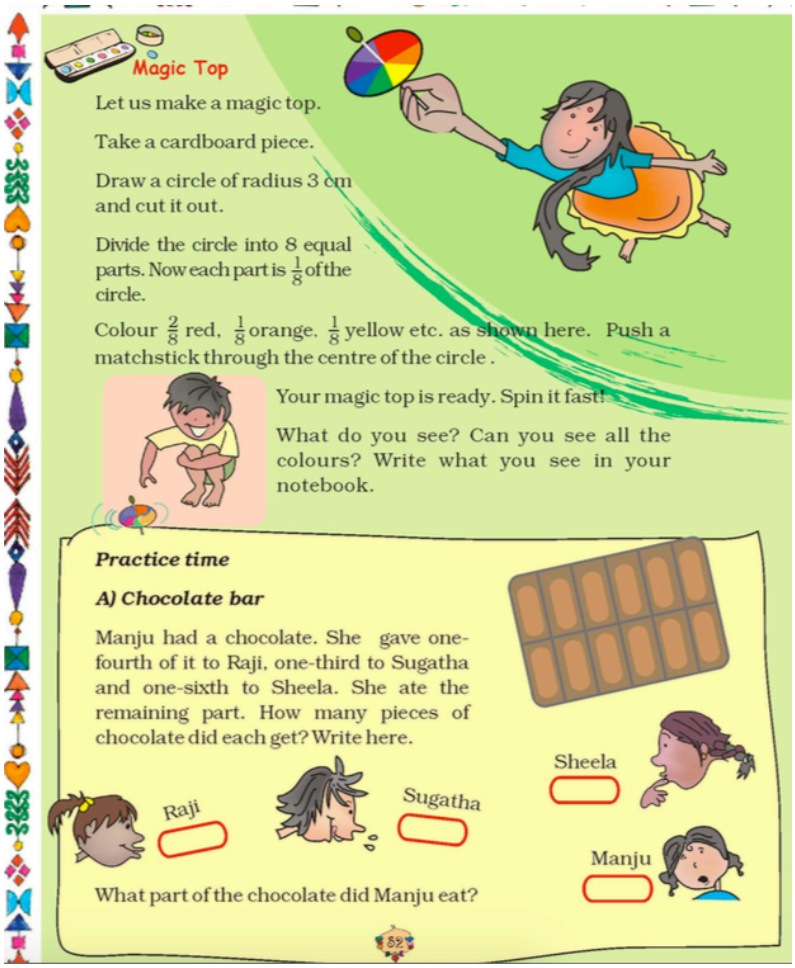


Figure 4.3: Process of analysis of the textbook task (see Appendix B)

Coding scheme: Regarding coding during textbook analysis, several approaches can be taken. Either a rating scale can be used (Bryant et al., 2008; Tarr et al., 2012) or the number of occurrences can be counted (Remillard et al., 2011; Herbel-Eisenmann, 2007). I chose the latter, but instead of counting the number of occurrences of particular linguistic elements in total (as done by Herbel-Eisenmann, 2007), I counted its presence within each of the tasks.

This helped in two ways. First, since I was not just focusing on the linguistic aspects, but also, on the contextual themes and support elements, it was more manageable to focus on presence of these elements rather than further dissecting and counting its occurrences. The latter did not seem to add much value to the analysis. Second, it was becoming particularly difficult identifying a suitable smaller unit of analysis (‘sub-task’ or ‘verbs/nouns/imperatives’ or ‘questions’ or ‘statements’) within the tasks and thus, focusing on presence or absence was most appropriate for the nature of the textbook. Also, it should be noted that the structural support is not investigated through analysis of the tasks (eliciting or non-eliciting), but by looking at the task headers and their sequencing. This type of analysis comes from the notion of ‘micro-structure analysis, as undertaken by Valverde et al. (2002) and discussed in the literature review.

Illustrative example: To illustrate how the coding scheme was used in the textbook, the following figure and table show how for each task, the presence or absence of each of the elements in the coding framework were listed.


Magic Top

Let us make a magic top.

Take a cardboard piece.

Draw a circle of radius 3 cm and cut it out.

Divide the circle into 8 equal parts. Now each part is $\frac{1}{8}$ of the circle.

Colour $\frac{2}{8}$ red, $\frac{1}{8}$ orange, $\frac{1}{8}$ yellow etc. as shown here. Push a matchstick through the centre of the circle.

Your magic top is ready. Spin it fast!

What do you see? Can you see all the colours? Write what you see in your notebook.

Practice time

A) Chocolate bar

Manju had a chocolate. She gave one-fourth of it to Raji, one-third to Sugatha and one-sixth to Sheela. She ate the remaining part. How many pieces of chocolate did each get? Write here.

Raji

Sugatha

Sheela

Manju

What part of the chocolate did Manju eat?

52

Figure 4.4: Book 5, Chapter 4, page 52

Table 4.5: Coding for the illustrative example of textbook analysis

Textbook Affordances		**Task 5.4.3** Magic top	**Task 5.4.4** Practice time: Chocolate bar
Task formulation	Specified	Yes	Yes
	Generative	No	No
Task solution	State/Answer	Yes	Yes
	Construction	Yes	No
	Estimation	No	No
	Explanation	No	No
	Think	No	No
	Discuss	No	No
	Expression	No	No
	Check	No	No
Task context	Students lives	Yes	No
	Stories	No	Yes
	Objects: (CI, SS, SI)[58]	CI, SI	CI, SS, SI
	Social justice	No	No
Task support	Teachers tip	No	No
	Prompts	No	No

4.6.2 Classroom observation analysis

In studies using structured observations in India, researchers have evaluated 'time on task' (Sankar & Linden, 2014) or used basic characterisations of quality of the teaching by categorising these times as "student-centred", "traditional teacher-centred" or "rote learning" (p. 1). Smith, Hardman, and Tooley (2005) used discourse analysis of the IRF (Initiation-response-feedback) model developed by Sinclair and Coulthard (1975), which focused on teacher-student talk. While characterisations of 'student-centred' and 'rote learning' was not useful for the study, I did attempt analysing teacher discourse by exploring different types of teacher talk (information, Elicitation, direction, uptake, participation, meta-statements) (see Appendix K for an example of this attempt). Such an analysis approach is common in studies exploring classroom dialogue (see Hennessy et al., 2016). However, after attempting such an in-depth analysis of one teachers' lessons, I realised that it was both time intensive and did not answer my question on teachers' use of the textbook accurately. Consequently, as discussed below, I focused on teachers' selection and interpretation of textbooks tasks and then set out to identify patterns of use (using thematic analysis).

Unit of analysis – Episode: I chose the categorisation of observations to be equivalent to the 'task[59]' categorisation in the textbook analysis. This would allow me to not just to analyse

[58] The types of contextual objects that were coded were: cosmetic-illustrated (CI), substantial-illustrated (SI), substantial-schematic (SS). See Appendix B.3.

observations in terms of the features of the textbooks (*interpretations of tasks*), but also, to ascertain whether tasks from the textbooks were being used or not (*selection of tasks*). In other words, within a lesson, episodes were identified as "periods of time during which the class is engaged in one relatively coherent type of classroom activity" (Schoenfeld, 2013, p. 612). Thus, a task-based categorisation was favoured, where the lesson was divided into 'activities' carried out by the teacher. These 'episodes' would be identified using three primary criterions. First, in cases where teachers were using the textbooks directly, the shift could be identified by the change in tasks chosen from the textbooks. Second, the shift in activities could also be identified using a meta-statement (Lemke, 1990), stating explicitly the movement from one task to the other. Still another indication of shift in episode is one marked by explicit actions, such as cleaning the blackboard (Afreen, observation 4, episode 3), or starting to write something afresh on the board without reference to the previous activity (Afreen, observation 4, episode 4). After transcribing and translating the audio recordings (as discussed above), the lessons were categorised into these episodes. A total of 37 lesson observations from the ten teachers were categorised into 148 episodes.

Coding of the episodes (Selection and interpretations): These episodes were coded based on Brown's (2009) notion of offload-adapt-improvise. However, while doing so, two differences arose. First, teachers seemed to be using tasks of their own (or with the help of some other resource material) that were completely unrelated to tasks in the textbook. Thus, a notion of 'insertion' was necessary, which accounted for such episodes, as undertaken by Leshota and Adler (2018) in their adaptation of Brown's framework. Moreover, a second difficulty arose in defining the difference between adaptation and improvisation. One of the findings of the textbook analysis was that clearly stated goals for the tasks were missing, often leaving the tasks open to interpretation (perhaps even purposefully so) (see Rampal & Subramanian, 2012). Thus, any modification to the tasks in the textbooks was coded as adapted use, without attempting to code episodes as being closer to the goals of the textbook task or not. As a result, a suitable adaptation to the 'offload-adaptation-improvisation' framework was made by identifying textbook task use in terms of 'direct use-adapted use-insertion', which closely supported my data. The following table shows the categorisation of episodes based on 'direct textbook use', 'adapted textbook use' and 'insertion outside textbook'. After this categorisation of the tasks, a more in-depth thematic analysis of chosen

[59] Each chapter was split into tasks based on the header used in the text – to enable an analysis of the features of the textbook, as detailed in the chapter on textbook analysis.

activities was undertaken to understand the ways in which the features of the tasks were interpreted by the teachers. Here, similar to the interview analysis, episodes were first thematically coded on the basis of textbook affordances (context, student engagement, structure) and then, sub-codes were created.

Table 4.6: Codes used to categorise episodes within each lesson observation

Direct Textbook Use (DTU)	Episodes in which teachers attempted directly to use a textbook task or at least some of its eliciting sub-tasks. Episodes are direct use if: (a) the teacher explicitly refers to the task in the book (at any point during the episode) *and* attempts to use some eliciting sub-tasks, as given in the textbook (not necessarily all)
Adapted Textbook Use (ATU)	Episodes that are explicitly modified from the tasks in the textbooks. Episodes are adapted if: (a) the teacher directly does or does not refer to the task in the book, and uses the non-eliciting or contextual components of a task (without using the eliciting sub-tasks) (b) the teacher does or does not refer to the task in the book, and uses some modified version of an eliciting sub-task
Insertion outside textbook (INS)	Episodes that bear no resemblance to any textbook task (eliciting sub tasks, non-eliciting components or context). Episodes are insertions if: (a) the teacher does not directly refer to the book *and* the topic or questions or context used in the episode are not from the textbook (e.g. place value)

4.6.3 Analysis of the semi-structured interviews

Transcription and the unit of analysis: All of the interviews were conducted in Hindi, which I subsequently translated and transcribed into English. As mentioned before, being fluent in both Hindi and English, and raised in the bilingual context of Delhi, I am familiar with both these languages. Further, having a supervisor who is also fluent in both these languages meant that she could meaningfully engage with the transcripts and I could discuss different Hindi terms and ideas that I struggled to translate. People in Delhi often use a mix of Hindi and English; where words in English are interspersed within widely spoken-Hindi (Kothari & Snell, 2011). During translations whenever this happened, I retained the original terminology used within the transcriptions. For instance, in the following unit from Mohini's interview, the words in italics were actually used by her in English, as indicated in the brackets. In case significant Hindi words were used, I similarly retained them within the English translations.

> It [textbook] is *related* (E) to their *day-to-day* (E) lives. And sometimes there are such things [references] that are so *local* (E) that even we don't know it. So, some they [the

children can] relate, [and] many children don't relate also. Because not many children are from villages.

Mohini, Interview 1

After transcribing and translating my data (retaining significant Hindi and English terms used related to the textbook use), I moved on to coding. As recommended by Saldaña (2015), I separated the interview data into separate texts of "short paragraph length *units*" (separated by a line break) whenever a different "topic or subtopic appeared" (p. 17). The identification of the change in topic was made based on shifts in what the teachers expressed.

Interviews questions and analysis codes: As discussed above, I conducted two semi-structured interviews with the teachers – one before I started classroom observations, and one after these had been completed. Instead of preparing questions based on the textbook analysis themes directly (voice, context and support), I created a variety of questions that would allow the teachers to express their own ideas without imposing my own analytical terms (see Table 4.7). Thus, while I asked explicitly about the use of context and alternative forms of student engagements, I did not specifically ask about the analytical codes that were developed during textbook analysis (see Appendix D). According to Kvale and Brinkmann (2009), semi-structured interviews are "defined as an interview with the purpose of obtaining descriptions of the life world of the interviewee in order to interpret the meaning of the described phenomena." (Kvale & Brinkmann, 2009, p. 3). Thus, as shown in Table 4.7, each of the questions were followed up by questions asking the teachers to *describe* and explain how these had been used in their own teaching.

Table 4.7: Themes and interview questions

Themes	First interview questions	Second interview questions
List of features Context within text	What are the features of the books? There are some parts in the books that are linked to the child's life. Comment: describe in your teaching and other follow up questions.	
Student engagement within text	Other teachers I have spoken to mention that different activities are presented in which students seem to be engaging with mathematics in different formats. Comment: describe your teaching and other follow up questions.	
Missing features	Other teachers I have spoken to mention that text has deemphasised both memorisation and practice questions. Comment: describe in your teaching and other follow up questions.	
Views on use of the textbook: difficulties and affordances		Which chapters did you find difficult during their usage? Which did you find easier? Rank the chapters, and justify the ranking
Support or hindrances during use	Did you receive any training? Did you reach out for support?	Did you receive any training? Did you reach out for support?

Consequently, I analysed the data in two phases, using a hybrid inductive-deductive analysis method (Fereday & Muir-Cochrane, 2006). In the first phase, which was based on the interview questions, I identified the key textbook features that the teachers spoke about – *structure*, *practice*, *context* and *student engagement*. While context and student engagement were probes that I had directly used, teachers also brought up issues with the textbook structure and issues around practice questions and thus, these were also given separate themes. Hence, using *apriori* themes, at this stage a more 'deductive' style of data analysis was chosen. For this phase of analysis, NVivo was used to chunk the units into these four thematic codes. In the second phase of analysis, a more inductive approach was taken. As shown below, within each theme, open-coding was done to identify the different sub-themes within them. As shown in the Figure 4.5 below, each excel tab indicates a larger theme. These themes were then re-coded to identify the sub-themes (as listed in the codes column).

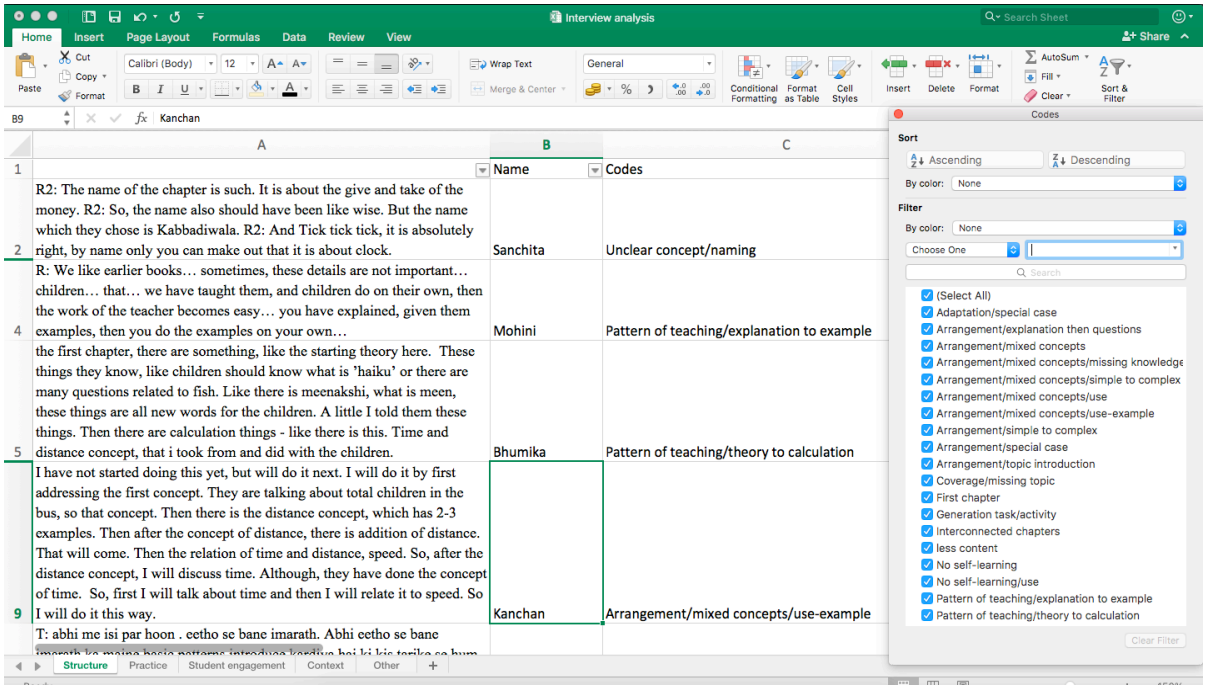


Figure 4.5: Phase 2 of the interview analysis using an inductive approach

4.7 'Validity' of the Findings

A critical question to ask about the knowledge 'produced' is that of its 'accuracy'. Traditionally, this is determined by constructs of 'validity', which are seen as more appropriate for quantitative studies where such measures are built into the research design. In qualitative studies; however, the idea of 'validity[60]' is much more complex and cannot be simply seen as accuracy, since it contradicts its epistemological assumptions, which defies the existence of an objective and retrievable 'truth'. Keeping in mind these contested ideas, I now define what validity means for this study and the ways in which I chose to ensure it.

Since this study is based on accounts of teachers and the researcher's interpretations of the curriculum and observed classrooms, it becomes important to define the construct of 'validity' as how credible the conclusions are to the participants' social reality. Creswell and Miller (2000) suggested choosing validity procedures from two perspectives: the "lens researchers choose to validate their studies" and the "researchers' paradigm assumptions" (p. 134). Table 4.8 below is a helpful two-dimensional categorisation by Creswell and Miller discussing broadly the ways in which validity can be approached depending on the lens and the paradigm chosen. In particular, for my study, the lens of the researcher and the lens of the

[60] There is a wide debate around the terminology to be used for qualitative studies, such as: credibility, trustworthiness or validity. Some of the writers who have expanded upon these debates and created alternative validity constructs are Guba (1981), Angen (2000), Maxwell (1992), Athleide (1994) and Johnson (1997). Also, see Creswell (2012) for a good overview of the debates around validity in qualitative studies.

study participants are the most crucial for validity, within what is called a constructivist paradigm[61].

Table 4.8: Validity procedures in qualitative studies (Croswell & Miller, 2000, p. 126)

Paradigm assumption/Lens	Postpositivist or Systematic Paradigm	Constructivist Paradigm	Critical Paradigm
Lens of the Researcher	Triangulation	Disconfirming evidence	Researcher reflexivity
Lens of Study Participants	Member checking	Prolonged engagement in the field	Collaboration
Lens of People External to the Study (Reviewers, Readers)	The audit trail	Thick, rich description	Peer debriefing

To ensure validity from this perspective they recommend: *disconfirming evidence* and *prolonged engagement in the field*. Disconfirming evidence is similar to Maxwell's (2012) call for treating 'validity threats'. This author claimed that qualitative researchers cannot address these threats in advance, rather they have to "rule out most validity threats after the research has begun, using evidence collected during the research itself to make these 'alternative hypothesis' implausible" (p 280). Thus, unlike treatments like triangulation, member checking and audit trails, which are 'specific criterions' (Angen, 2000) built into the design, qualitative researchers need to treat particulars threats while interpreting the data to ensure credible conclusions. To ensure this in the case of observations and interviews, I conducted the analysis at two levels – first, analysing each data source exclusively and once certain themes and ideas had emerged, comparing them across the data sources. This enabled me to address the same theme from the teachers' voice and also from their action. This provided me with more opportunities for dealing with the 'alternative hypothesis' and helped me to refrain from drawing premature conclusions. In the case of my interpretations of the textbook, special emphasis was given to creating a robust analytic framework after deliberation about the different mathematics education research literature. That is, for each of the items in the framework, definitions from previously established ideas in mathematics education were utilised. To ensure validity from the *lens of the study participants*, I ensured

[61] The paradigm categorisation used in the table is generalised categories, and one can say that interpretivist studies have been collapsed with constructivist paradigms, which are viewed in opposition to postpositivist studies and critical paradigms.

that I had regular and prolonged time in the field. I started getting familiarised with the schools that I was working in and the systems in 2014, when I started my MPhil project and each year since, I have conducted some small project (MPhil study and then first year pilot project). Finally, I spent seven months in the field to ensure that I could follow the teachers for half an academic year. This repeated exposure to the research setting led to my revisiting some of my initial assumptions about the teachers. Having spent such a long time with them, has enabled me to appreciate the complexity of their situations and thus, enriched my understanding of their lived experiences. Finally, having chosen a case study method, I made a strenuous effort to keep in-depth field notes on an ongoing basis, which I have used to draw out a rich description of the cases and the context.

4.8 Chapter Summary

This chapter started by providing the overarching research questions being addressed in this thesis, followed by the three sub-research questions. Then, the interpretivist epistemology that frames the thesis was defined. The methodological approach adopted was a multiple-case study, focusing on ten primary school teachers in Delhi. These teachers taught in four government MCD schools across the three municipality zones of Delhi. These schools, which are free of cost, are mostly attended by children from marginalised communities with lower socio-economic backgrounds. The chapter has also outlined the characteristics of the ten case study teachers, in terms of their qualifications, school information, gender and years of experience. This was followed by discussion on the ethical considerations as well as issues of reflexivity that were crucial during the research process. At first, the site itself was difficult to access, with multiple gatekeepers, who had to be negotiated with. Initially, I believed that through the official channels, I would be able to access schools and find interested teaching staff. However, the entire permission seeking process took almost a year, and through a continuous negotiation of both official and unofficial actors I was finally able to obtain the necessary permission to work with ten teachers. This experience also exposed me to the politically complex domain of Delhi government schools, where research with teachers is contentious. The remainder of the chapter explicate the three data collection methods – textbook analysis, classroom observations and teacher interviews. Details were provided of both how the data was collected as well as analysed. In the final section of the chapter, I discussed the validity of the findings of this thesis. The next chapter presents the findings from the analysis of the first data type, namely textbook analysis.

CHAPTER 5: TEXTBOOK ANALYSIS

5.0 Introduction: Textbook Analysis Framework

In this chapter, I analyse the textbook series: *Math-Magic,* which is based on the NCF-2005 reforms. The purpose is to address the first research question of my thesis:

RQ1: How are the key reforms represented in the mathematics textbooks?

Viewing the textbook as an artefact, its affordances are conceptualised as "range of possibilities and limitations that artefacts may present for human activity[62]" (Brown, 2009, p. 20). The analysis discussed in this chapter highlights these textbook affordances. Before discussing the key findings, it is important to discuss the unit of analysis chosen for the textbook. Identifying the unit of analysis for the textbook analysis is important for two significant reasons. First, the appropriate unit of analysis helps in modelling the textbook in a way that important affordances in it can be highlighted. Second, for my thesis, which has multiple data sources, including textbook, classroom observations as well as teacher interviews, it was also important to find a unit (and consequently codes) that is comparable across these data sets. In respect of this, *tasks*, which are often used as a unit of analysis in mathematics education research, became a fitting choice. That is, they have been used in multiple ways in the mathematics education literature. While Doyle and Carter (1984) introduced the notion of academic tasks from the perspective of student experiences in classrooms, more fluid definitions have been used more recently. Watson and Thompson (2015) defined task as "written presentation of a planned mathematical experience for a learner, which could be one action or a sequence of actions that form an overall experience" (p. 143). This is a suitable definition of tasks for this analysis, since it takes a broad perspective on learners' 'overall experience', thus providing scope for accommodating different expressions of the reform ideas within the textbooks.

In my thesis, I focused on grades 4 and 5, and analysed half of both the textbooks (7 chapters), thus providing an understanding about the nature of the tasks that teachers encountered during the period of my fieldwork. Within each chapter, a *task* was identified as

[62] Note that while typically 'affordances' and 'constraints' are viewed as two aspects of an artefact, I only use the term affordance to encompass both these elements. As discussed by Wertsch (1998), artefacts can both be seen from the perspective of 'half full' or 'half empty'. Thus, affordance or constraint can be the flip side of each other. In this chapter, while I will call the features 'affordances', I will also highlight how these textbook features can both provide possibilities as well as be limiting.

content between two consecutive headers[63]. Overall, in the Math-Magic Book for grade 4 (referred as Book 4), there are 75 tasks in total, whereas in Book 5 there are 117. Within the tasks, textbook affordances were identified as eliciting elements setting the *voice* of the text; *contexts* embedded within the tasks; and the non-eliciting elements that *supported* the readers when attempting the tasks (see Figure 5.1). In Chapter 3, Subsection 3.3.2, the different ways in which textbook affordances have been analysed in the literature was discussed and also, the focus on these particular affordances for this thesis was justified (also see Subsection 4.6.1, which details the process of textbook analysis).

Here it is important to note that my textbook analysis focused on the pedagogical styles included within the textbook across mathematical topics. It did not focus on any particular mathematical domain (such as fractions, algebra, geometry) and its corresponding pedagogical techniques (ways of teaching that 'topic'). Thus, while each chapter in the textbook might cover a different topic (See Appendix C), the focus was to understand the textbook's underlying pedagogical tools in form of voice, context and support used by the authors.

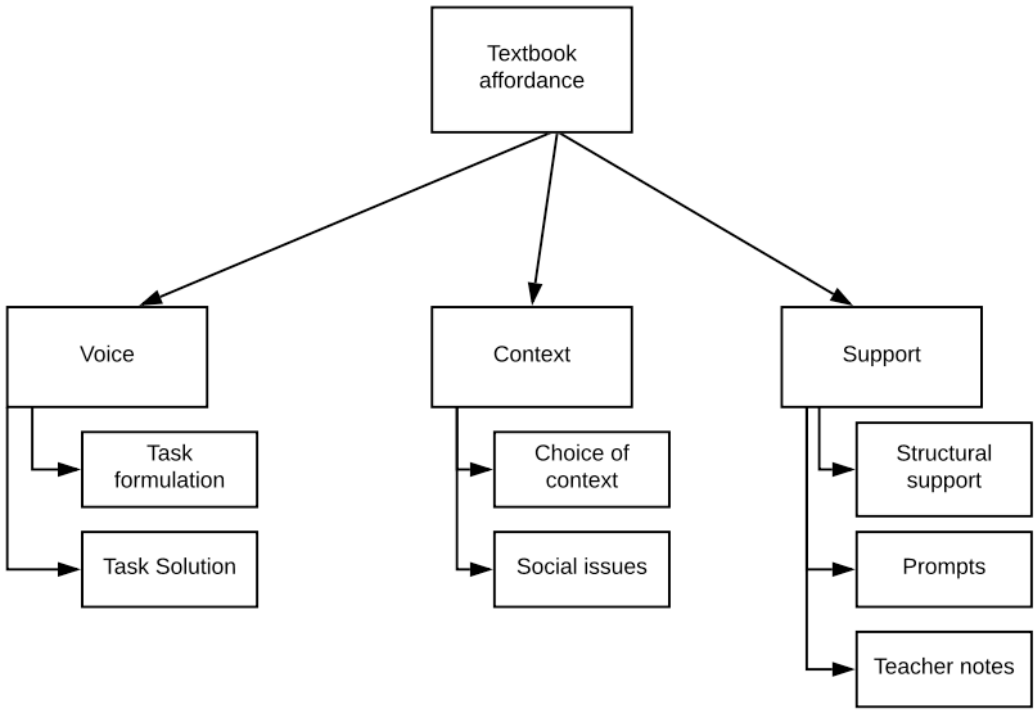


Figure 5.1: Textbook analysis framework

[63] The task is labelled in the format: *Book.Chapter.Task*. For example, the 5th task in the 14th chapter in Book 4 is labelled as *4.14.5*. As discussed in Subsection 5.3.3, the names of the tasks do not always indicate the textbooks' content or pedagogical information. The choice of using *task* as a unit of analysis, thus. arose from this lack of standard headers or signposts within the textbooks.

5.1 Voice of the Tasks

In this section, I discuss my analysis of the language used in the tasks, to explore its 'voice'. 'Voice' is considered through the lens of the eliciting components in the tasks, which are directly aimed at getting a response from the reader (in this case the student). Through this analysis, I will show how the text invites student to share the authorial role in task creation, as well as how it attempts to introduce different types of mathematical activities.

5.1.1 Type of task formulation: specified and generative

One of the striking aspects of the textbook is that almost all the tasks have eliciting components, which directly expect responses from students. Only 3 tasks in Book 5 (out of 117), and 2 tasks in Book 4 (out of 75) do not have any eliciting components. Moreover, in terms of the task formulations, there are two types of eliciting components: those which have enough necessary information provided within the task to attempt some solution strategy (specified); and those which require students to source information on their own to attempt some solution strategy (generative). In the latter case, students are expected to participate both in the task formulation as well as its solution. Thus, this also means that for different students a different task will be formulated, based on the information they bring.

A common type of generative task is the following in Figure 5.2 (left), where students are asked to 'find' something from their lives – such as heights of their peers – and then answer the questions. On the other hand, the example in Figure 5.2 (right) is a specified task, with all the information required to find the answer to the question.

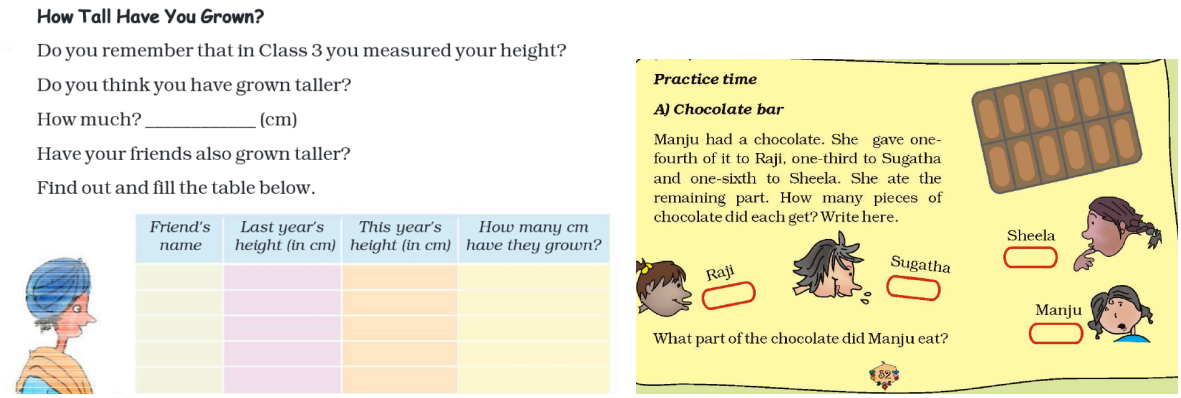


Figure 5.2: Book 4, Chapter 3, Task 4.2.4, page 15 (left); Book 5, Chapter 4, Task 5.4.4, page 52 (right)

Interestingly, in Book 4, 44% of the tasks have some generative eliciting components, while 78% have specified eliciting components. Note that these are not mutually exclusive

since a task can have some aspects of both (see Figure 5.3). This is an important finding, for almost half of the tasks have components that have been designed in a way that students *have* to use their own resources to address them. On the other hand, in Book 5 there are fewer generative component tasks than in Book 4, with only 27% having some eliciting components asking students to source information. Yet, in terms of overall numbers, both the books have around 33 tasks with generative components. These tasks enable students to bring their own individual experiences/understanding into the classrooms, along with the opportunity to 'author' their own tasks, rather than relying solely on the textbook's pre-formulated questions. For instance, the task in Figure 5.2 (left), when attempted by different students will produce different solutions. While these provide opportunities for individual engagement of students, it also means that, in a classroom setting, teachers have to decide how to engage with each of them. For instance, how much of the 'authoring' is shared between teachers and students: Do teachers choose a list of friends for the entire class? Do they ask one or two children to demonstrate? Do they give this as homework? Thus, generative tasks bring along distinctive types of teacher decisions, going beyond those needed for specified tasks.

5.1.2 Type of task solution: scribbler and thinker

The second aspect of eliciting components of tasks, is the different ways in which students are expected to answer the questions. These include stating the answer, explaining, thinking, discussing, checking, estimating, constructing or expressing (see Table 5.1). Note that within a task there can be several types of questions. One such example is shown below in Figure 5.3. Here, while the question 'About how many metres high is your classroom?', is a generative task in terms of its formulation (since students have to source information from their own surroundings to attempt any solution strategy), the question requires being responded to by *estimating* the answer. Thus, this is coded both as 'estimation' while coding for task question type, and 'generative' while coding its task specification type. The subsequent two questions[64] ask students to 'guess' and 'explain' their answer, thus being coded as estimation and explanation. However, these are 'specified' tasks in terms of formulation, since one of the solution strategies[65] could be to use the information of the

[64] Note that the coding of generative and specified formulation was performed by identifying presence within a task, rather than counting each of the questions. Thus, the Task 4.2.10 in Figure 5.3, was coded to both have generative as well as specified eliciting components, instead of counting how many questions of each type was present.

[65] As the question does not explicitly mention any particular solution strategy, students could use other strategies. For example, another way of responding would be to estimate visually from the photograph, using

height given at the start and the guessed height of the classroom – both available to the student at that point.

Table 5.1: Types of task solutions

State/Answer	Eliciting questions (specified or generative) seeking response from students in written or oral work form. The response can be obtained using any mathematical skill or procedure (by measuring, reading the time, using multiplication) and could be in the form of written numbers, oral, by drawing, making a line, marking the correct answer etc.
Construction	Eliciting questions, where students engage with a task in a format other than answering questions, thinking, expressing experiences or justifying their product or process (in the textbook or notebook). These require students to use or (and) create additional materials and artefacts, play games, or conduct experiments.
Estimation	Eliciting questions asking students to guess the answer or process in the task.
Explanation	Eliciting questions (specified or generative) seeking an explanation or justification of the mathematical thinking or process underlying the solution of the task.
Think	Eliciting questions asking students to think about the answer or process in the task.
Discuss	Eliciting sub-tasks asking students to discuss (among peers or with the teacher) the answer or process in the task.
Expression	Eliciting questions (specified or generative) inviting students to express their interests, thoughts or experiences. This is different from the explanation task, which is specifically asking for justification or explanation for the mathematical process, whereas these are mostly to engage students in thinking, feeling and reflecting on experiences from out-of-school contexts.
Check	Eliciting questions asking students to verify or check the answer or process in the task.

the (guessed) height of the people shown in units and then, using this to change to the (guessed) height of the classroom in units.

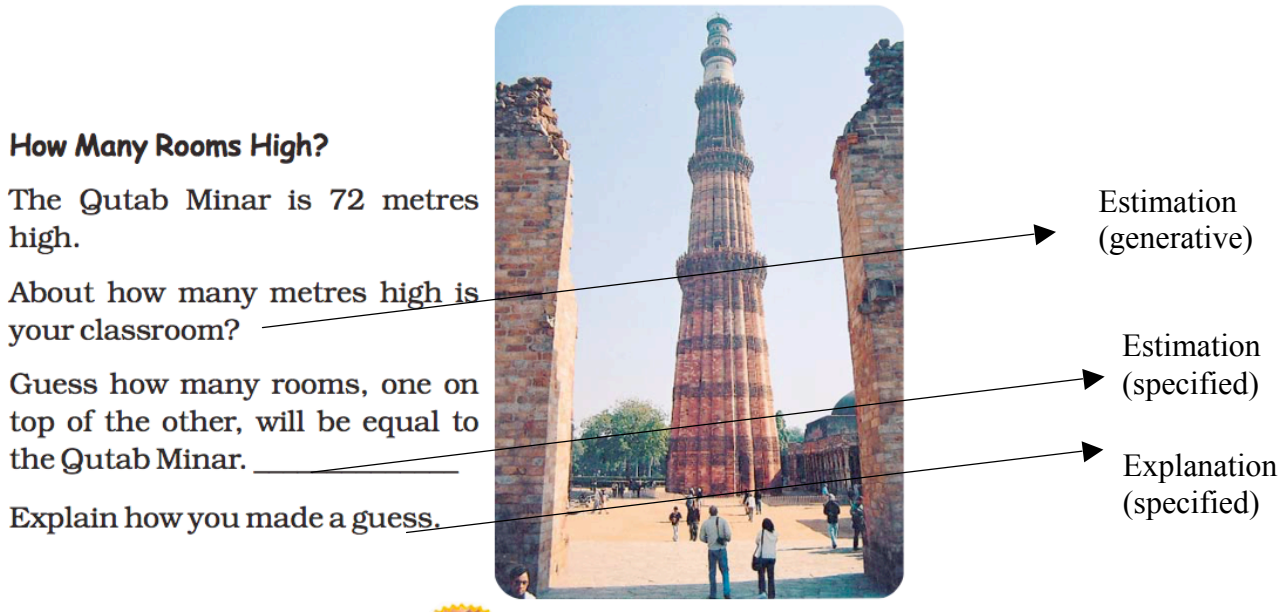


Figure 5.3: Book 4, Chapter 2, Task 4.2.10, page 19

Morgan (2016) and Herbel-Eisenmann (2007) use Rotman (1988) to describe two kinds mathematical activity: 'thinking' and 'scribbling' (p. 10). While scribbling is an exclusive activity, where the reader is supposed to work on her own to apply and use what she knows, thinking is an inclusive activity involving a larger community that includes some level of dialogue or communication. The different kinds of questions identified in the textbook, as shown in Table 5.1, were then classified based on whether they are 'thinking' or 'scribbling' questions. As highlighted in Table 5.2, questions asking students to state/answer, construct, estimate, or check were viewed as 'scribbler' type of questions. Explain, express, think and discuss were coded as 'thinker' type questions. Table 5.2 shows the distribution of these types of questions across the two books analysed. While there are components of 'state/answer' in 90% of the tasks in both Book 4, and Book 5, it is important to note that several other scribbler type questions, including 'estimation', are also commonly posed in the textbook. As can be seen, a small proportion of the tasks (between 3% - 19%) also include 'thinking' questions, which are more explorative, rather than asking students to engage in exclusive activities. This clearly indicates that the producers of the textbook have sought to encourage students to answer in many different ways, including expressing their ideas about the topic, explaining their answers, thinking and discussing, which are different discursive ways of engaging with mathematical processes, such as: mathematics as dialogue and mathematical reasoning.

Table 5.2: Types of expected student engagement

		Book 4 Total	Book 4 Percentage	Book 5 Total	Book 5 Percentage
Scribbler	State/write	68	91%	105	90%
	Construction	10	13%	19	16%
	Estimation	19	25%	13	11%
	Check	7	9%	4	3%
Thinker	Explanation	7	9%	9	8%
	Expression	14	19%	5	4%
	Think	6	8%	4	3%
	Discuss	7	9%	6	5%

Herbel-Eisenmann and Wagner (2007) warned against simplistic findings that focus on merely counting and comparing the total number of scribbler and thinker questions[66] and in turn, characterising the textbook itself as 'thinker' or 'scribbler'. Often, scribbling is an essential activity before thinking, thus the context and placement of 'thinking' questions is equally important. For example, in Figure 5.3, it can be seen that some scribbling activity (estimation) is involved before students are asked to 'explain' the solution. Thus, the high number of scribbler questions does not necessarily indicate that the textbook is focusing only on students' exclusive mathematical activities. On the other hand, the inclusion of this variety of types of activities (both scribbler and thinker) indicates that the textbook seeks encourage different ways of student engagement.

A second aspect that Herbel-Eisenmann and Wagner (2007) pointed to is the 'audience'. If the tasks do expect students to use 'thinking' activities, what is the audience for this? For instance, in Figure 5.3, who is the reader to 'explain' their guess to? In Book 4, for instance, two tasks call for 'discussion' explicitly in groups (Task 4.1.9) or with teachers (Task 4.7.6). Most of the other tasks in the textbook do not explicitly mention the audience in terms of teacher or peers or classmates. Thus, while there are several of these 'thinker' questions mentioned, the textbook does not explicitly situate its reading in a classroom or define the audience for these inclusive activities. In Subsection 5.3.3, there is a lengthier discussion on teachers' notes analysing the explicit information provided to them to support navigating these tasks. However, implicitly many tasks were set up as an activity that humans need actively to engaged in, thus encouraging collaborative classroom activities. For instance, characters are introduced either doing the mathematics, or talking about it, or thinking about

[66] Note that unlike this thesis, in Herbel-Eisenmann and Wagner (2007) they conducted an in-depth analysis of the number of verb forms etc.

it. This strategy, as Morgan (2016) discussed, is aimed at breaking the absolutist understanding of mathematics as happening in some esoteric space (or students' individual minds), by making it a real-world activity. For example, in the Figure 5.4 (Task 5.3.7), we see that two characters - Sameena and Sadiq - discussing the mathematical topic of triangles. This implicitly indicates that mathematical activity is beyond individual students' exclusive scribbling work, being something that takes place as an inclusive activity as simulated within the tasks. Overall, 39% of tasks in Book 4 and 21% of tasks in Book 5 include human agents shown to be engaged in some mathematical activity.

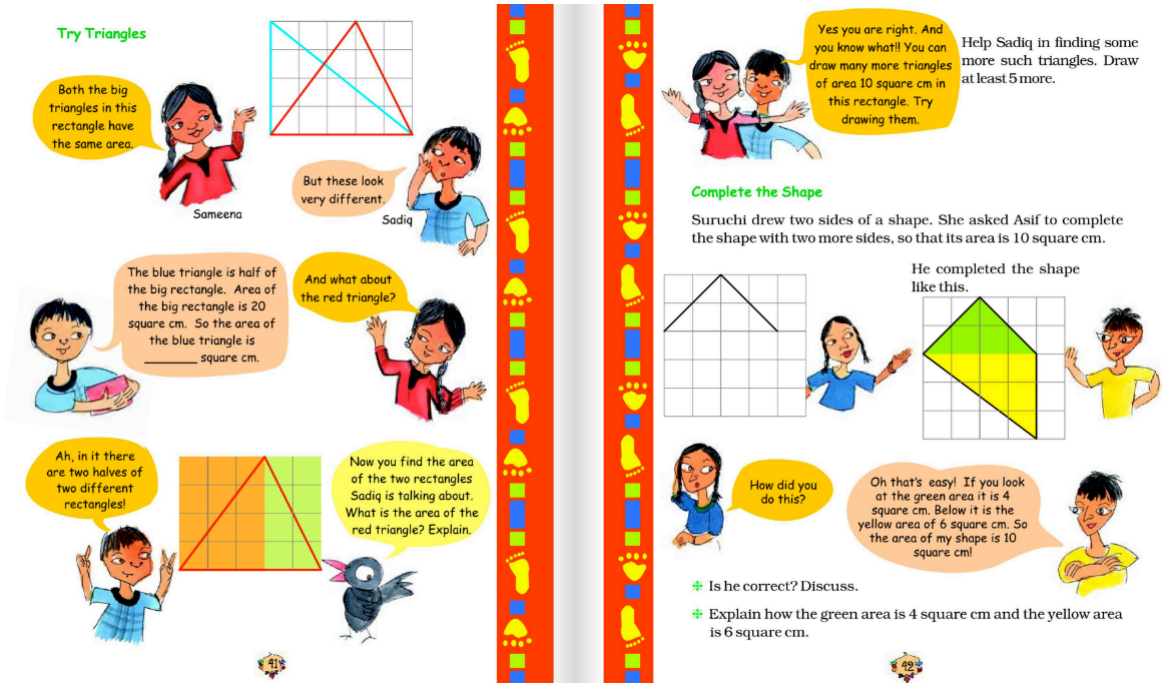


Figure 5.4: Book 5, Chapter 3, Task 5.3.7, page 41-42

5.2 Context of the Tasks

Having looked at the voice of the textbook, another affordance of the textbook is now considered – *context*. In the previous section, it has been shown how via the use of alternative forms of 'voice', the textbook seeks to make mathematics learner a 'thinker' as well as 'scribbler'. Further to this, it not only aims to discuss the mathematical tasks and present variety in the form of the mathematical activity, for it also strives to embed them within different 'contexts'. The idea of 'context' in mathematics education is highly complex. Terms, such as real, realistic contexts, real-life contexts, everyday life contexts, daily life, are all often used interchangeably in the literature (Palm, 2006). Many scholars have engaged in attempts to make contexts authentic (Palm, 2006) and meaningful (Van den Heuvel-Panhuizen, 2000) to improve the teaching and learning of mathematics. Further, from the

perspective of ethnomathematics and culturally responsive mathematics, context is embedded to reflect different mathematical traditions around us, thereby giving it as much legitimacy as school mathematics (d'Ambrósio, 2006; Greer, Mukhopadhyay, Powell, & Nelson-Barber, 2009). Gutstein (2006) also talks about using context in mathematics education for social justice, pointing out the social positioning and roles of different social groups engaged in mathematical activity. Thus, the role and meaning of 'context' can be different when viewed through different mathematics education traditions.

My analysis involves using Borasi's (1986) broad definition of context as: "the situation in which a problem is embedded" (p. 128). This definition enables me to differentiate between contextual tasks and 'de-contextualised' ones, where numbers or operations are purely being manipulated in an 'esoteric domain' (Dowling, 1996). For example, a question asking: 'what is 2 + 2?' is considered a 'de-contextualised' problem. However, if the question was rephrased as 'Seema gives two oranges to Reetu, who already had 2 apples with her, how many fruits does Reetu have in total?' makes it a 'contextual task'. Yet, this dichotomy is not always as simple. There are several different ways of embedding context apart from just creating 'story problems' distinct from decontextualised mathematical operations. In this textbook, context is either identified as *students' lives*, *contextualised stories* or *contextualised objects*, being interrogated through a mathematical lens. These three types of contexts are discussed below in section 5.2.1. Given this discourse, I now consider how the textbook deals with questions of '*authenticity'* of context: both from the perspective of the range of contexts included, as well as the depth of its treatment. Finally, I discuss themes of *social justice* included within the tasks (section 5.2.2). Before moving to a detailed discussion, it is important to note that only four tasks in Book 4, whilst 29 in Book 5, were coded as being completely 'decontextual', with no presence of the above described elements. This is significant and highlights that the textbook authors actively have attempted to integrate students' lives, contextual stories, and objects into almost all the tasks. In the following Table 5.3, how frequent these elements are within the textbooks can be seen.

Table 5.3: Use of context in the textbooks

Types of context	Book 4 Total	Book 4 Percentage	Book 5 Total	Book 5 Percentage
Students' everyday lives	34	45%	20	17%
Contextual stories	37	49%	48	41%
Social justice issues	9	12%	7	6%
Contextual objects	56	75%	99	85%
Total	71	90%	89	75%

5.2.1 Choice of context: students' lives, contextual stories, contextual objects

The choice of context is critical from the perspective of what might be viewed as the role of context to begin with – is it introduced to bring students lived realities into the classrooms? or introduced to provide rich and meaningful pre-defined contexts (which the students might not have experienced) to help explore underlying mathematical notions? The three types of choices of context most common in the textbook are: students' own lives, contextual stories and contextual objects, which are now discussed below.

Students' everyday lives

Generative tasks as well as expression tasks, which directly encourage students to formulate and address the task questions based on their own experiences, have been discussed above. These are clearly dimensions that encourage students to bring their own life experiences into the textbooks. Book 4 includes more expression (19%) and generative tasks (44%); compared to Book 5 (4% expression; 27% generative). These tasks not only challenge the authorial roles of the text, for they also would appear to envision diminishing the distinctions between students' own experiences, understanding, environment and school mathematics. Even if students may or may not have experienced these, they are encouraged to go 'out' and 'find' information (which is presumed to be available around them) and bring it into the classroom. For example, the following Figure 5.5 encourages students to collect leaves from the garden and identify angles in them.

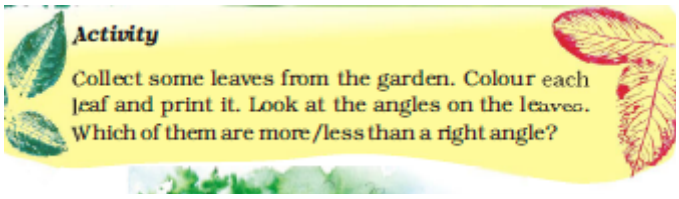


Figure 5.5: Book 5, Chapter 5, Task 5.2.9, page 24

Contextual stories

In both Books 4 and 5, real-life contextual stories are heavily used in the tasks (Table 5.3). This has implications in terms of how the textbooks view the tasks in terms of their role in mathematical teaching and learning. Many of the 'contextual stories' are similar to a traditional 'word problem' (Verschaffel, Greer, & De Corte, 2000), where students are expected to strip the context from the problem and then solve it mathematically (Figure 5.2, right). Such tasks are familiar types of contextualised tasks common in mathematical teaching. However, for some, the textbook makes an explicit effort to build a richer context, rather than giving short contextualised work problems. Often these contexts are spread across tasks, building from one to another. For instance, Figure 5.6 (left) shows a page from the chapter 'Trip to Bhopal' (Book 4), where the context of a school trip is used across the entire chapter. In this particular task, 'To Bhimbhetka' (Task 4.3.4), the task provides details about prehistoric caves of India. Similarly, in the chapter 'Fish Tale' (Book 5), the different types of fish are detailed (see Figure 5.6, right). Such information is not necessary from the perspective of solving any 'mathematical' question, but it does provide additional information about the contextual theme of the chapter. This kind of 'extra mathematical' information has been discussed in the literature as developing the authenticity of tasks. A more conprehensive discussion on this can be found in Chapter 8, Subsection 8.1.3.

Figure 5.6: Book 4, Chapter 3, Task 4.3.4, page 28 (left, one page); Book 5, Chapter 1, Task 5.1.3, page 4-5 (right, two pages)

Contextual objects

Another aspect of the textbooks that is immediately striking is the use of illustrations, graphics and photographs throughout. Almost every task has accompanying illustrations. Many of them are only for aesthetic purposes and are not used directly to support the task

(labelled as cosmetic in Table 5.4). However, a sizeable number of illustrations (both illustrated and schematised) are used directly to support the eliciting components of the text. In other words, these illustrations are crucial parts of the task itself and some level of interpretation of these is required to address the questions. In the rest of this subsection, I will discuss the use of contextual objects for which particular mathematical properties are called upon for completing the tasks.

Table 5.4: Types of illustrations and the proportion of their presence

Illustrations/Graphics	Book 4 Total	Book 4 Percentage	Book 5 Total	Book 5 Percentage
Cosmetic	34	45%	32	27%
Substantive-*illustrated*	16	21%	31	26%
Substantive- (semi/) *schematic*	12	16%	55	47%
Total	56	75%	99	85%

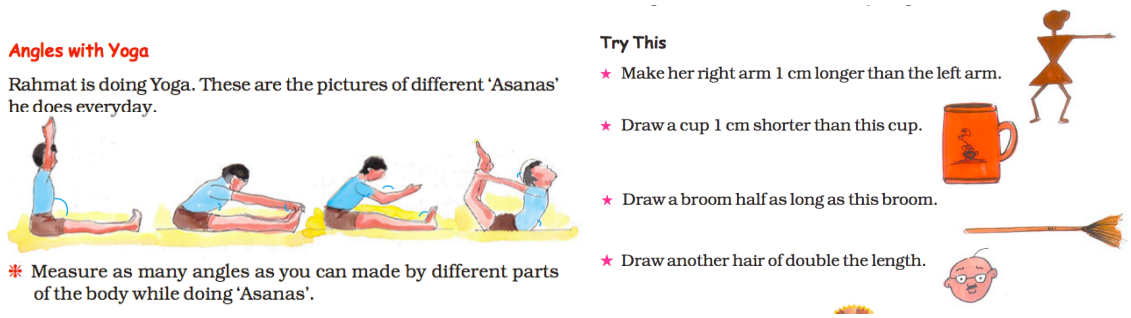


Figure 5.7: Book 5, Chapter 2, Task 5.2.18, page 33 (left); Book 4, Chapter 2, Task 4.2.3, page 14 (right)

An important question of representation comes in: are the objects 'authentic' (illustrated/photographed) or are they shown more 'mathematically' (semi-schematic/schematic)? Book 4 contains very few schematised versions of objects (16%), while in Book 5, the authors taken a much more schematic approach (47%). However, the effort to deliver authenticity seems similar in both the books (21% of tasks in Book 4 and 26% in Book 5). Nevertheless, when looking at how these are treated, in some cases the '*authenticity*' seems to be tokenistic or even meaningless. For example, in Figure 5.7, the task is about discussing the measurement of angles (left) and length (right) through contextual objects: as represented by the illustrations of students doing yoga (left) and everyday life objects (right). Here students are asked to perform mathematical processes on 'authentic' illustrations, which ultimately render them meaningless. How are students to 'measure' angles while doing yoga? How are students to double the length of the hair as shown in the illustrations? Further, it is not clear in these cases, if the measurement needs to

be made ‘on’ the illustrations or, if students are to find real life objects or poses and then measure the angle or length. Neither the purpose, nor how students are to engage with these is clear – making such contextual illustrations tokenistic. Even though the textbook authors talk about rejecting “pseudo contextual” tasks (Rampal & Subramanian, 2012, p. 73), forcing mathematical processes onto seemingly contextual objects also seems tokenistic. On the other hand, the textbook also includes illustrations of objects that are ‘*schematised’* using mathematised version of them, which whilst being less ‘authentic’, does make the mathematical processes more explicit and apparent (see Figure 5.8).

Figure 5.8: Task 5.3.2 (left), Task 5.5.4 (right)

This indicates that authors were struggling with the question of authenticity and how to portray contextual objects to discuss mathematical processes. A perfect example of this confusion is reflected in the following illustration (Figure 5.9) – where a more schematised arrangement of pebbles has been superimposed on top of a hand-drawn illustration.

Figure 5.9: Book 5, Chapter 6, Task 5.6.7, page 93

5.2.2 Social justice: role of the textbook

In Subsection 5.2.1, the types of contexts (objects, stories, students’ lived experiences) were discussed, whilst in this section I focus on the topics of these contexts. Themes of the context can play an important role in legitimising diverse contexts, while making mathematics meaningful. Such an analysis is especially important for texts that claim to portray both

culturally relevant as well as critical pedagogical values (see Rampal, 2015). In mathematics education, the importance of 'transfer' and 'application' has been discussed for a long time. Even in the context of India, mathematics for application to the real world has been central in previous curriculum frameworks (see Chapter 2, Subsection 2.1.2). That is, 'useful' contexts, such as consumerists situations – shopping, loans, profit and loss have been typically used in textbooks for some time now. Gray (1991) argued that these are important from the perspective of preparing students for a functional adult life. However, the *Math-Magic* textbook seems to go beyond these 'typical' consumerist settings which are used in mathematics from a utilitarian perspective. Instead, they engage with rich contexts of students' (assumed) lived reality. Themes such as nature, games (carom, playing with bangles), stamps, animals, flags and different parts of India (location) are explored throughout the textbooks. Thus, breaking stereotypes, not just about the ways in which maths is used (away from market based contexts to wider contexts), but also having more representation of diverse people who might engage with mathematics. That is, a wide *range of contexts* is used.

Furthermore, the authors also claim to focus on addressing stereotypes about marginalised social groups and questioning ideas of power and oppression. In Rampal's (2015) description of the *Math-Magic* textbooks, she points out that the textbooks do not just use "non-problematic situations from the presumed everyday lives of pupils, but problematize daily life to enable 'problem posing instead of problem solving'" (Freire, 1970 as cited in Rampal, 2015, p. 107). She goes on to claim that the textbook attempts to make students more critical and political about the world and enable them to 'read' the world (Gutstein, 2006 cited in Rampal, 2015). However, unlike Gutstein (2006), the textbook does not discuss the tension between teaching mathematics with the intention of giving students access to powerful mathematical ideas and the endeavour of explicitly discussing oppressive structures of the social world (see Chapter 5, Gutstein, 2006). It is also not clear whether these 'critical' elements examining socio-political issues of the world are aimed at students or whether they are meant to sensitise teachers to enable them to deal better with children from diverse backgrounds. If it is the former, the extent to which these can be discussed with primary school children needs examination and in case of latter, it is important to see how explicitly the textbook communicates this to the teachers. For instance, when discussing a socio-political issue, which is the story of the junk-seller (Figure 5.10), the authors point out:

Through this visual narrative with on-site photographs, the unit deals with her loans, her junk sorting and selling, hiring of collectors, recycling of materials, etc. It challenges several prevailing notions of gender and mathematics, the stigma of "dirty work" attributed to certain castes and their supposed low position in society, and also the traditional focus on a "great man" as a role model. It inspires young women with a sense of "social agency" to develop their entrepreneurial abilities to transform lives. (Rampal, 2015, p. 104)

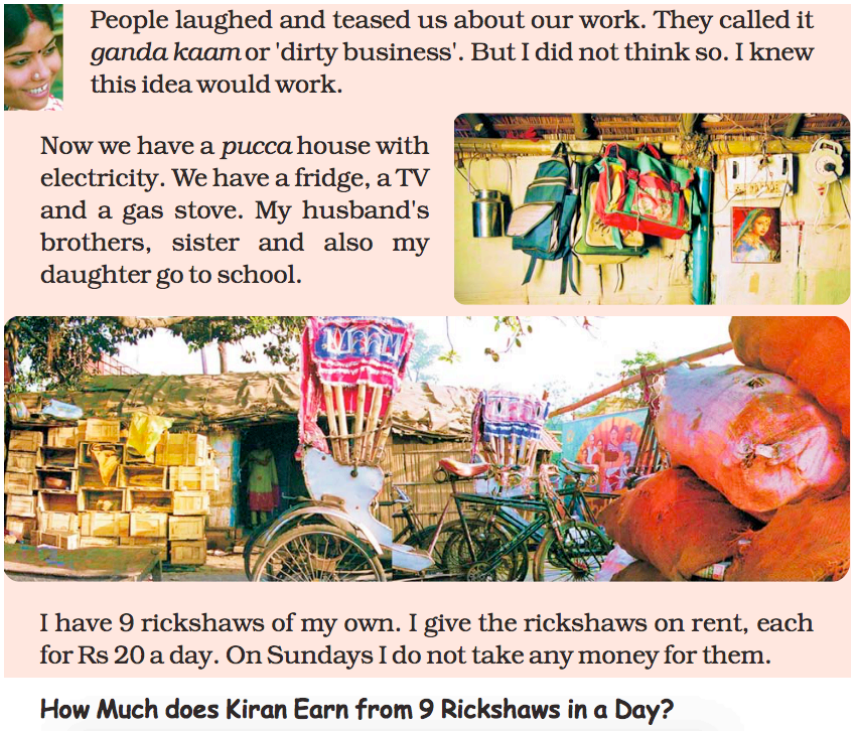


Figure 5.10: Book 4, Chapter 6, Task 4.6.3, page 62

Looking at the text, neither do the teachers notes[67] nor the text itself pose any direct questions on how to engage with these issues. It is unclear how the teachers should discern those intended aspects from the text and problematise them. Furthermore, while the text focuses on gender and caste inequities, it fails to discuss the equitability of the economic relations between the small capitalist who hires and seeks rents from the rickshaw pullers and extracts profit. Even the abovementioned explanation of this chapter by Rampal (2015) is not available to the teacher, leaving the task's interpretation to the teacher's discretion. Overall, very few tasks in the first seven chapters of Book 4 and Book 5 have themes that could

[67] The two teachers' tips in this chapter both discuss how the teacher must encourage the students to use multiple strategies to solve the problems and that there should be a discussion around how they arrived at the answers.

possibly be used to talk about social issues. Only 11% of the tasks in case of Book 4 and 6% of those in Book 5 have this feature. Also, these issues are concentrated in the "special thematic chapters" (Rampal & Subramanian, 2012, p. 69) of both the books – the Junk Seller, and Fish tale, where one theme is used across the chapter for multiple mathematical concepts (see Subsection 5.3.1).

5.3 Support for the Tasks

In the above sections, I explored the voice of the text as well as looked at the context within which tasks were embedded. These already indicate the 'alternative' forms that the textbook has introduced; rejecting stable authoritative texts as well as attempting to engage with real-life contexts. I have also discussed 'what' students are expected to do (with the tasks and contexts). In this section, I look at whether there are 'instructions', 'prompts', 'solutions' or some structural cues as to 'how' this is to be done. For this reason, analysis of the 'supporting' elements is important. Here, mostly focusing on the non-eliciting components of tasks, I discuss the elements in the textbook that help the reader to navigate these alternative forms of engagement. In the next sections, I focus on: 'structural support', 'teacher notes', and 'prompts'.

5.3.1 Absence of explicit structuring devices

One of the characteristics of a textbook that supports teachers and readers to access it is the arrangement and presentation of the content and pedagogical elements within (Remillard, 2011). These help in providing a "coherent framework to guide their work" (Howson, 2013b, p. 648). The first structuring element is often the names of chapters, which indicate the mathematical domain being 'covered'. Unlike traditional textbooks which list the mathematical topics in the index (e.g. numbers up to 100, addition and subtraction, fractions etc), the textbooks use 'contextual' names for chapters (Jugs and Mugs, Junkseller, etc) (see Table 5.5). This is more common in Book 4 than Book 5, which also aligns with the earlier finding that more contextual tasks are included in Book 4 than Book 5. In both the textbooks, most of the chapters are implicitly based on a particular mathematical domain and include a collection of tasks addressing different aspects of the topic (see Table 5.5). Further, there are chapters built around a contextual theme and which address different mathematical domain

areas that the authors refer to as "special thematic chapters"[68] (Rampal & Subramanian, 2012, p. 69). This includes Chapters 1, 3 and 6 in Book 4 and Chapter 1 in Book 5 (Highlighted in Table 5.5).

Table 5.5: *Math-Magic* Book 4 (top) and Book 5 (bottom) contents page mapped with mathematical topic

Chapter number	Chapter name	Implicit mathematical topic	Number of pages
		Book 4	
1	Building with bricks	*Thematic*: Geometrical patterns based on symmetry	12
2	Long and short	Measurement of length	10
3	Bhopal trip	*Thematic*: Four operations, measurement, number estimation	12
4	Tick tick tick	Time	17
5	The way the world looks	Space	8
6	The junk seller	*Thematic:* multiplication, division, loan	9
7	Jugs and mugs	Measurement of volume	12
		Book 5	
1	The fish tale	*Thematic chapter*: Measurement, shapes, speed and time, big numbers (lakhs/crores)	15
2	Shapes and angles	Shapes & spatial understanding	18
3	How many squares?	Area and perimeter	16
4	Parts and wholes	Fractional numbers	21
5	Does it look the same?	Symmetry of shapes	16
6	Be my multiple, I'll be your factor	Factors and multiples	12
7	Can you see the pattern?	Patterns	13

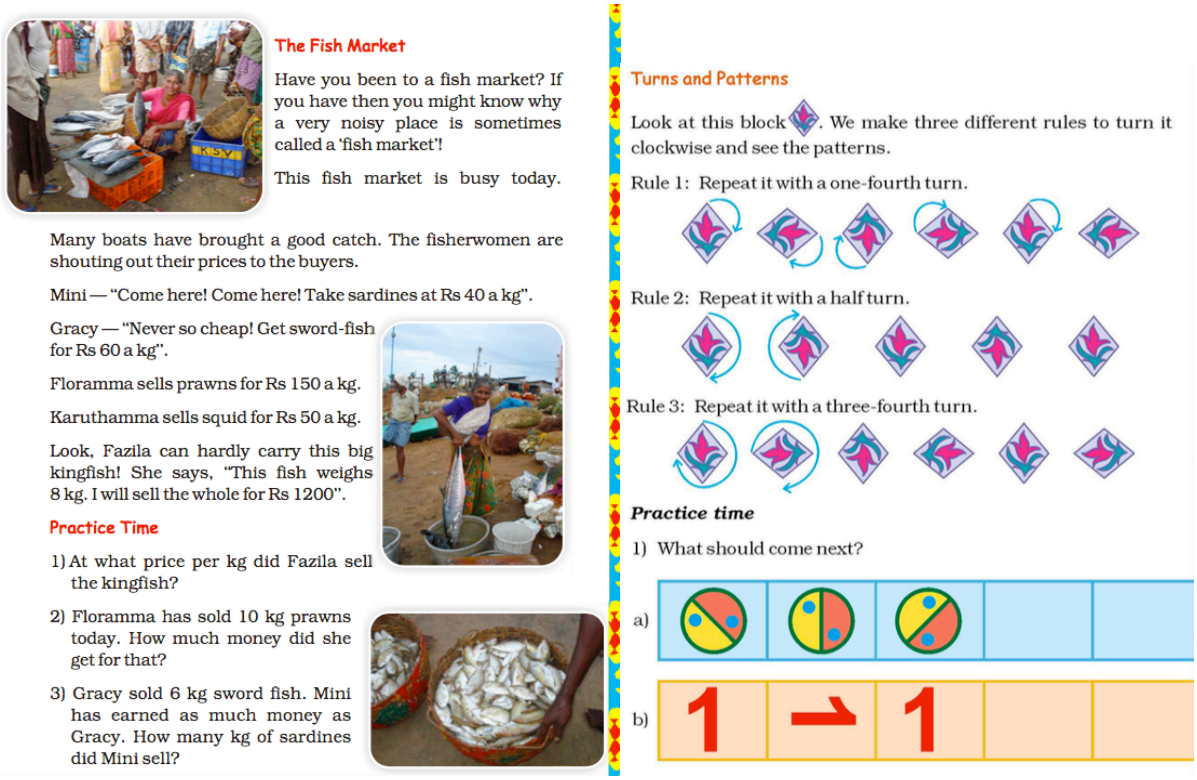
Even within the tasks, there is no explicit labelling to indicate pedagogical features such as: instruction, solved examples, activities, puzzles, exercise etc. No fixed sequenced pattern from 'introduction, explanation, examples and practice', is followed within the chapters. There are a few repetitive names for tasks, such as practice time, activity or find out (see Table 5.6) and these too have no consistent pedagogical similarities.

[68] Note that that only one chapter (Book 5, Chapter 1, Fish tale) include a footnote for teachers explaining its 'thematic' nature. "This is a thematic chapter which presents to children the world of fish and fish workers through an integrated approach. Mathematical concepts such as shapes, estimation, sense of large numbers, simple operations, speed, loans, etc. are woven into real-life contexts to allow a creative revision of some ideas learnt earlier." (Book 5, p. 3). None of the other chapters explain the integrated nature of the thematic chapters. In fact, Chapter 1, Book 4 has no teacher notes at all despite being a special thematic chapter. I further discuss the role of teacher notes in Subsection 5.3.2 that follows.

Table 5.6: Names and headers of textbook tasks

Task names	Book 4	Book 5
Non-standardised names	60	90
Practice time	3	17
Find out	9	4
Activity time[69]	1	6
Try it out/try this	2	0
Total number of tasks	75	117

Two examples of 'practice time' can be seen below. In Figure 5.11 (left), the practice tasks are questions based on the story in the previous task, 'The Fish Market', with no established method for a solution being indicated. On the other hand, in the Figure 5.12 (right), it can be seen that the task before practice time, 'Turns and Patterns', provides a solved example that can be used to solve 'practice time' questions. Thus, there seems to be no consistency in the pedagogical implications for these standardised task names.



The Fish Market

Have you been to a fish market? If you have then you might know why a very noisy place is sometimes called a 'fish market'!

This fish market is busy today.

Many boats have brought a good catch. The fisherwomen are shouting out their prices to the buyers.

Mini — "Come here! Come here! Take sardines at Rs 40 a kg".

Gracy — "Never so cheap! Get sword-fish for Rs 60 a kg".

Floramma sells prawns for Rs 150 a kg.

Karuthamma sells squid for Rs 50 a kg.

Look, Fazila can hardly carry this big kingfish! She says, "This fish weighs 8 kg. I will sell the whole for Rs 1200".

Practice Time

1) At what price per kg did Fazila sell the kingfish?

2) Floramma has sold 10 kg prawns today. How much money did she get for that?

3) Gracy sold 6 kg sword fish. Mini has earned as much money as Gracy. How many kg of sardines did Mini sell?

Turns and Patterns

Look at this block. We make three different rules to turn it clockwise and see the patterns.

Rule 1: Repeat it with a one-fourth turn.

Rule 2: Repeat it with a half turn.

Rule 3: Repeat it with a three-fourth turn.

Practice time

1) What should come next?

a)

b)

Figure 5.11: Book 5, Chapter 1, Task 5.1.10, page 11 (left); Book 5, Chapter 7, Task 5.7.3, page 100 (right)

[69] Note that these headers often also contained some variation, such as 'activity', 'activity time' and 'activity – angles with body'. Thus, even within the more standardised headers, there are some variations.

While clearly the names of chapters or tasks do not support teachers in understanding either pedagogical or content expectations, I explored whether any 'meta-narrative[70]' is included within the tasks. Meta-narratives help move from one task to the other, making mathematical connections and building a potential learning trajectory. For instance, these could be statements, such as: 'we have done numbers up to 100, and now we now move on to addition...'. However, such a meta-narrative or signposting is also completely missing in these textbooks, which jump from one task to the other, without explicitly building upon the learning (An example is shown in Appendix A). I have already discussed how 'contextual themes' are sometimes used across several tasks to build context, yet no mathematical meta-narrative is used to link one task to the next. Hence, the textbook excludes traditional pedagogical structuring devices that teachers might be familiar with. It is likely that such a structure is intended to encourage teachers to design their own teaching frameworks (moving away from textbook culture). However, essentially, the textbook looks like a collection of 'rag-bag tasks' instead of being sequenced and organised based on some explicit framework of mathematical trajectory (mathematical or pedagogical). The only explicit support element is footnotes, which I have coded as 'teacher's notes'. I discuss these in the next subsection, after which implicit support elements will be covered.

5.3.2 Teachers notes: extending the voice of the task

The *Math-Magic* textbook series does not come with any teacher guidebook, and the only way in which authors directly communicate *to* teachers is via footnotes at the bottom of some pages and it thus becomes important to analyse the nature of these notes. While there are only 14 notes in Book 4, there are 30 in Book 5. Compared to the total number of tasks in the textbooks, this is very little support (18% of tasks in Book 4 and 26% in Book 5 come with notes). Guidance within these notes is provided at multiple levels.

First, most of the notes encourage teachers to use different types of pedagogies within the tasks. For instance, I have already discussed in Section 5.1, how voice was used in tasks to encourage students to formulate their own questions as well as address the solutions in different ways. In the notes, these suggestions are directly articulated for the teachers. In this vein, some recurring guidelines are: extend/repeat the given task (20 times), discuss (13), estimate/guess (7), use own/alternative methods (7), use students' experiences or surroundings (8), make children develop own questions (3), retain excitement or fun (2), and

[70] In TIMSS analysis of textbook structure, the code 'narrative' is used to indicate the flow of the textbook (See Valverde et al., 2002).

sensitising students about social realities (2). Thus, these guidelines seem to complement the voice of the tasks. For example, in the following teacher notes, it can be seen that the authors recommend that the tasks are undertaken in the class with follow-up discussions. This guideline then also gives a rationale for why such a task might be important: for “children’s conceptual understanding about fractions”. However, notes providing a rationale along with these pedagogical suggestions are rare. Only in 5 out of 13 notes in Book 4, and only 3 out of 31 in Book 5 provided teachers with some sense of rationale behind introducing the tasks and their corresponding pedagogies.

> The colouring circle game and many such activities should be done in class. The follow-up discussions for all these activities will play a major role in developing children's conceptual understanding about fractions. (Book 5, Chapter 4, page 61)

Finally, many notes encouraged teachers to develop an ‘idea’, ‘sense’ or ‘intuitive feel’ for the mathematical concepts (7), whilst simultaneously discouraging memorisation, definition, and usage of mathematical terms (5). For example:

> Children are not expected to learn the definition of 'area', but develop a sense of the concept through suitable examples. Give them many opportunities in the classroom to compare things in terms of area and guess which is bigger. Things like stamps, leaves, footprints, walls of classroom etc. can be compared. (Book 5, Chapter 3, page 34)

> Children are not expected to know the words 'manufacturing' and 'expiry' dates, but only to recognise these as symbols that show when the medicine is made and till when it is safe to take. Teachers could encourage children to read and observe more such dates on different products. (Book 4, Chapter 4, page 48)

Overall these notes are aimed at, first, extending the task and appealing directly to teachers to use the implicit pedagogies within the tasks. Second, it rare cases, they do provide some rationale for these. Finally, there is active discouragement of ‘fact’- oriented mathematics and encouragement to develop a mathematical ‘sense/feel’.

5.3.3 Prompts: facts, examples, repetitions

As discussed in the above two subsections, explicit support via meta-narratives, names of tasks and chapters are missing, with there being very limited teacher guidance provided within footnotes. In this subsection, I discuss the more implicit support that is provided within the tasks, which can become prompts for teachers. Three main aspects explored are:

mathematical facts or information, answers or solutions, and repetitions (see Table 5.7). Table 5.8 below shows the percentage of tasks that include these types of support elements.

Table 5.7: Support components within the tasks

Repetition	Repeated eliciting components where the same mathematical skill or process is to be used. Tables to be filled by listing answers (even if generative tasks) are coded as repetition.
Fact/information	Non-eliciting components intended to provide information/fact about the mathematical object or procedure.
Solution/answer	Non-eliciting components providing solved examples, scaffolds, or answers to the eliciting questions.

Table 5.8: Percentage of support components within the tasks

Prompts	Book 4 Total	Book 4 Percentage	Book 5 Total	Book 5 Percentage
Fact/Information	9	12%	13	11%
Solution/answer	15	20%	36	31%
Repetition	20	27%	42	36%

Lack of mathematical facts or information

Least of all, are tasks with supporting factual information relating to either mathematical terms or procedures. As can be seen, only about 11-12% of the tasks have any such information (in both books). This is not surprising since the textbook explicitly is attempting to move away from being a collection of facts and rather, the focus is on stressing processes (see Context Chapter 2, Subsection 2.1.2). In the few cases where terms are introduced, they are written in bold, within the task context. For example, in the following speech bubble, a working definition of perimeter is given and thus, this task has been coded as having some factual information. Additionally, as discussed above, there are some instances when teachers are advised 'not to tell'. In general, there is strong messaging of 'not to tell' (Chazan & Ball, 1999) and very little information about what can be directly told.

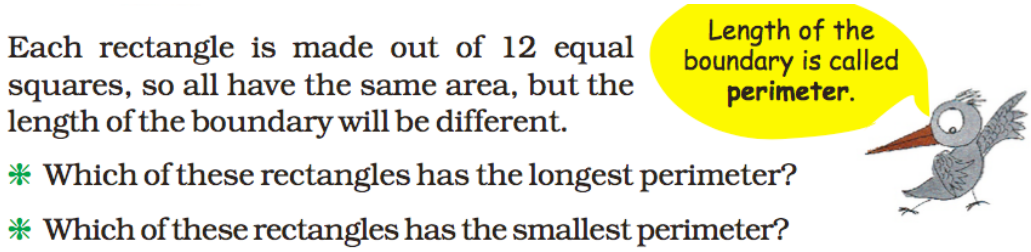


Figure 5.12: Book 5, Chapter 3, Task 5.3.1, page 34

Innovative types of repetitions

Shuard and Rothery (1984) mentioned that one of the unique features of a mathematics textbook is its "repetitive structure", especially exercises (p. 45). On the surface, these textbooks also seem to contain a reasonable proportion of repetition in their tasks, with 27% in Book 4 and around 36% in Book 5. Yet, if the kinds of repetition task are considered more closely, a distinct characteristic emerges. That is, most of the repeated elements are within tasks that ask students to generate their own questions (see Figure 5.13, left, where they are asked to list things you can get in bottles and packets). Overall, in Book 4, 12 out of the 30 repetition tasks are such generative tasks. Such an approach does not provide teachers with any kind of ready-made material that they can deliver to students directly to work individually with.

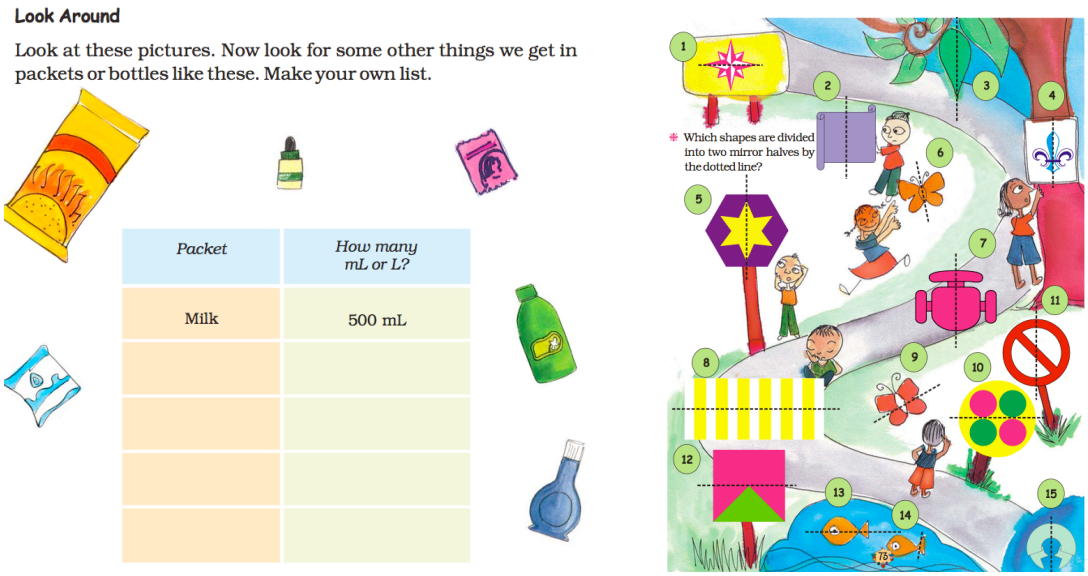


Figure 5.13: Book 4, Chapter 7, Task 4.7.3, page 74 (left); Book 5, Chapter 5, Task 5.5.2, page 73 (right)

Book 5 has many more repetitive tasks, which are not all generative ones. This is especially the case in chapters on patterns and on fractions (Chapters 5 and 7). But here too, not all the tasks are presented in formats that are more commonly found in traditional mathematics textbooks. For example, in Figure 5.13 (right), the format is not conventional, as instead of presenting a list of repeated questions, the tasks are presented innovatively. This is linked to the emphasis on presenting every task in some aesthetically attractive format, rather than those that teachers might be more familiar with.

Solved examples, answers or scaffolding

Apart from questions, typically textbooks contain explanations, and solved examples based on which problems or questions are presented. To capture this aspect, I coded solved examples, scaffolds and answers, if they are included into the tasks. As Table 5.8 shows, only 20% of the tasks in Book 4 have any kind of such prompts provided to help students answer the eliciting questions. Whilst Book 5, which has more support in terms of teachers notes and repetition, also contains more such prompts (31%). These are mostly in the form of speech bubbles (see Figure 5.14, left), or some scaffolded eliciting components (see Figure 5.15, right).

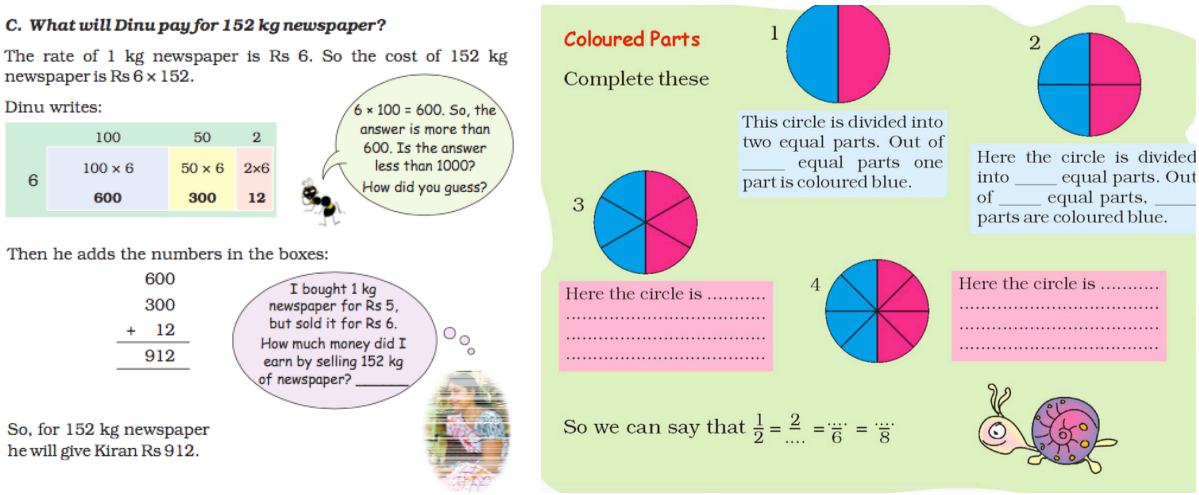


Figure 5.14: Book 4, Chapter 6, Task 4.6.10, page 66 (left); Book 5, Chapter 4, Task 5.4.15, page 62 (right)

5.4 Analytical summary

- In this chapter, the focus has been on the textbooks and three crucial defining affordances of the textbook – its *voice*, the *contexts* used and its *supporting* elements. To begin with, the analysis was on the 'voice' of the eliciting components within the tasks of the textbooks. I found it attempting to shift the ***authoring role*** from the textbook to the reader, by expecting readers (assumed to be students) to partake in textbook formulation and bringing information from their own lives and surroundings. Here, what is critical to highlight is the role of the teacher, who is mediating such tasks. Teachers, thus, have to make choices regarding the ways in which they engage themselves and the students in this 'new' authorial arrangement. Further, the analysis showed that task questions expect students to both engage in 'scribbler' and 'thinker' types of mathematical processes (Rotman, 1988). That is, students they are to both engage in individual exclusive activities, such as answering, checking, estimating and

constructing along with inclusive community-based activities, such as discussing, explaining, expressing and thinking. To demonstrate how these community based mathematical activities might look like, there are several tasks that refer to human characters engaged in mathematical talk as well as activities: highlighting human agency in mathematical processes. Thus, different mathematical processes are included in the textbook, which construct the student as a mathematical thinker along with the producer of mathematical answers.

- While looking at the ***use of context*** in the textbook, I found some interesting patterns. Through the choice of context and mathematics for social justice, the textbook authors have wanted to make ambitious changes to the way in which mathematics can be contextualised. It is, thus, not surprising that almost all the tasks in both the books have included some kind of context. Firstly, using generative and expression tasks, the textbook tasks directly call upon students' own experiences and out-of-school environments into the classroom. This is in alignment with the ideas of integration of 'school' and 'out-of-school' knowledge, as discussed by several mathematics educators. For instance, De'Abreu (2000) wrote about the need to legitimise informal mathematics that students experience in their lives within school mathematics. By using longer detailed extra mathematical information (through contextual stories and themes), the textbook attempts to make contexts meaningful. Equally, there are also short word-problem-like tasks within the chapters. Finally, the textbook has also introduced several illustrations of contextual objects. However, in the attempt to make objects more 'authentic', sometimes its mathematical meaning is lost. Moreover, in some cases the schematised version of the contextual objects provides an 'unrealistic/inauthentic' representation.
- In terms of ***social justice and mathematics***, there are two important aspects to this. First, the textbook broadens the range of contextual themes relating to lives of people from different communities, instead of focusing on economic contexts where mathematics can be 'applied'. Second, it also explicitly talks about marginalised communities and social justice issues, but these examples are very limited in the textbooks. This focus on social justice through mathematics education has been written about by the authors of the textbooks (Rampal, 2015). However, when analysed closely in the books, this is not overtly mentioned in the textbooks. That is, unlike books exclusively designed to address social justice and mathematics

education (see Gutstein & Peterson, 2005; Stocker, 2017), this textbook, whilst containing themes that can be used to address some specific issues of power and social inequality, does not do so exclusively or even explicitly.

- While many alternative ways of presenting tasks, and integration of context have been introduced into the individual tasks, explicit ***support for teachers*** is lacking. The biggest indicator of this is that almost all the tasks in the textbook have eliciting components and almost none are designed solely as non-eliciting tasks for providing 'information' or 'solved examples'. Other structuring devices, such as conventional use of headers and chapter names indicating either pedagogy or content are also missing. Ellsworth's[71] (1997) analysis of curriculum from film studies perspective raised the important aspect of 'multiple entry points', indicating that textbooks are created for an audience just like commercial films. Thus, textbook authors also need to be mindful of how to integrate 'alternative' ideas into the textbook and what could be the possible 'entry points' that might persuade the audience to accept them. As Remillard (2011) discussed in her paper, this notion of 'multiple entry' is especially significant for commercial textbooks in the US, where often traditional formats are merged with innovative ideas so that the teachers will still 'buy' the textbooks. However, in case of Math-Magic, since these are state-produced and mandated textbooks, the idea of what might become an 'entry point' seems to be completely ignored, reflected later in teachers own views of the textbook (see Chapter 7, Section 7.1 on teachers' views). Finally, while there are some explicit teacher notes, these too look more like extensions to the tasks, rather than 'educative' messages for teachers (see Davis et al., 2014).
- Finally, through this unique approach to voice, context and support, we can see that the textbooks lay an (over)emphasis on 'process-oriented' teaching which is participatory and contextualised rather than a 'direct-formulaic' approach where solutions, facts or information are provided straightaway. This is also in line with NCF-2005's objective of shifting the emphasis from mathematical content to mathematical learning environment where 'processes' take precedence. Thus, mathematics learning is viewed as taking part in mathematical processes rather than producing mathematical products (NCERT, 2006d). However, note that this balance between 'process-oriented' and 'direct-formulaic' is often contested. For instance,

[71] See Wagner (2012) and Remillard (2011) using Ellsworth's idea for reform-based textbooks.

Banerjee (2015) who explores the use of *Math-Magic* textbooks, writes how by overemphasising the 'procedural' aspect of mathematical learning, the textbook fails to bring to fore the process-product duality and complementarity. Furthermore, while the choice of such 'overemphasis' is the approach of this particular 'reformed' textbook series, not every 'reformed' textbook chooses such an approach. This is particularly important to keep in mind in view of two aspects: (1) questions around what might be the 'best' pedagogical approach for marginalised children (2) likelihood of textbook reforms after the upcoming revisions to the NCF which might not take such an approach. For the first aspect, as I will discuss further in Discussion chapter (section 8.2.2), there are questions around the appropriateness of these reforms and its implementation for the large section of the society. For the latter issue, as discussed in Context chapter, section 2.1.3, we already see pressures on curriculum developers to produce 'efficient' and reductionist curriculum materials which often emphasise on product-oriented approaches. Overall, while this thesis focuses on the 'process-oriented' approaches, it is important to highlight that these pedagogical choices are contested in India.

CHAPTER 6: TEACHERS' USE OF THE TEXTBOOK – SELECTION AND INTERPRETATION[72]

6.0 Introduction

This chapter addresses my second research question by analysing classroom observation data:

RQ 2: How do teachers use the reform-oriented mathematics textbooks in their lessons?

This question is tackled by investigating two facets of use: selection of tasks and interpretation-in-use of the task affordances (voice, context and support). In Section 6.1, I discuss the ten teachers' task selection decisions in the observed lessons. Section 6.2 considers how the teachers interpreted the 'voice' of the textbook and the extent to which they attempted to engage students in alternative forms of interaction, as intended by the textbook. Finally, in Section 6.3, I explore the notion of 'context', which has been integrated within the textbook and probe the ten teachers' interpretations of this notion during textbook use. In the concluding Section 6.4, a summary of the findings is provided.

6.1 Selection of Textbook Tasks: Direct use, Adapted use and Insertions

A total of 37 mathematics lessons were observed of the ten teachers (3 – 4 observations each), which were categorised into 148 episodes (see Subsection 4.6.3). These episodes were coded based on whether they directly used a textbook task (direct textbook use - DTU), used an adapted version of one (adapted textbook use - ATU) or inserted tasks that bore no resemblance to what was in the textbook (inserted - INS). Overall, 46% of the episodes were coded as insertions, which did not have any resemblance to any of the tasks in the textbook. The other 54% were either direct textbook use (32%) or adapted (22%). This indicates that half of the episodes across the lessons of the ten teachers as a whole were taught through the textbook tasks (direct or adapted), whereas the other half had teachers using alternative ones. This signifies that while the textbook is an important resource, teachers may just as much use other resources.

[72] Part of this chapter has been published as: Nag Chowdhuri, M. (2019). Two primary school teachers' pedagogical design capacity of using mathematics textbooks in Delhi, India. *Proceedings of the Eleventh Congress of the European Society for Research in Mathematics Education*, 4284-4291. Freudenthal Group & Freudenthal Institute, Utrecht University, Netherlands and European Society for Research in Mathematics Education.

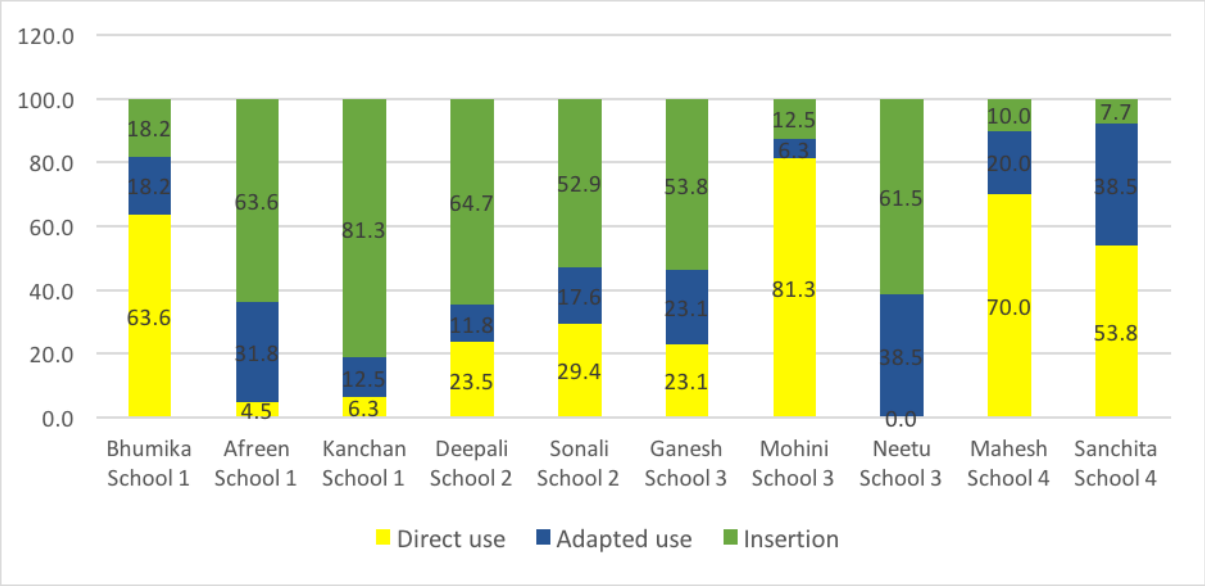


Figure 6.1: Percentage of observed episodes categorised as direct, adapted or inserted textbook use

Whilst the overall percentage indicates that textbook tasks (in some form) were being selected almost as much as insertions, selection choices among the ten teachers differed. Figure 6.1 above shows details of the textbook use of each of the ten teachers. This indicates that four used textbook tasks (direct or adapted) for more than 80% of their lesson episodes: Bhumika, Mohini, Mahesh, and Sanchita. On the other hand, one teacher – Kanchan – used inserted tasks for more than 80% of the episodes, whilst the remaining five teachers did so for between 50% and 65%, that is, Afreen, Deepali, Ganesh, Sonali, Ganesh and Neetu. Thus, while almost half the episodes in my observations were textbook based, this usage was not equally distributed among the teachers. Only four teachers primarily utilised the textbook, while the remaining six relied more on their own insertions unrelated to the textbook.

Instead of labelling these teachers as acceptors or rejecters of the textbook at this stage, it is important to explore the nature of insertions, adaptations and direct textbook episodes as well as how these structured teachers' lessons. In the following subsections, the focus is on this. I first discuss the lesson structures in relation how textbooks define these (Subsection 6.1.1). I show that teachers either rely on the textbook to structure their lessons or they use their own insertions as structuring devices. Next, I consider the different types of adaptations and insertions as well as ways in which they are similar to or distinct from the textbook tasks (Subsection 6.1.2).

6.1.1 Types of lesson structures in relation to the textbook tasks

Figure 6.2 highlights the different ways in which teachers structured their lessons, as they introduced different episodes (direct, adapted, inserted). The yellow boxes indicate direct textbook use; the green indicate insertions; and the blue indicate adapted tasks. At a quick glance, it is clear that there were very few lessons with only direct textbook use (16%) or with only insertions (19%). Out of the 37 observed lessons, only in six lessons did teachers use purely textbook tasks (Bhumika – lesson 2, 4; Mohini – lesson 3, Mahesh – lesson 3, 4; Sanchita – lesson 2). In these rare lessons, they moved from one task in the textbook to the next, following the prescribed sequencing. Similarly, only seven lessons had insertions with no reference to the textbook. In these lessons, teachers attempted to deliver topics that were completely missing from the textbook (Bhumika – lesson 1; Afreen lesson 2, Neetu – lesson 3 and 4) or those from the textbook, but not using any of the task references (Kanchan – lesson 1 and 2; Ganesh – lesson 2). However, the majority of the lessons were a combination of textbook tasks (direct or adapted) and insertions (65%). In essence, the teachers adopted two approaches. The first relied primarily on the textbook and its tasks both to select and sequence the lesson. The second approach was where insertions structured the lesson, while adapted and direct textbook use episodes complemented the insertions. These approaches are discussed below.

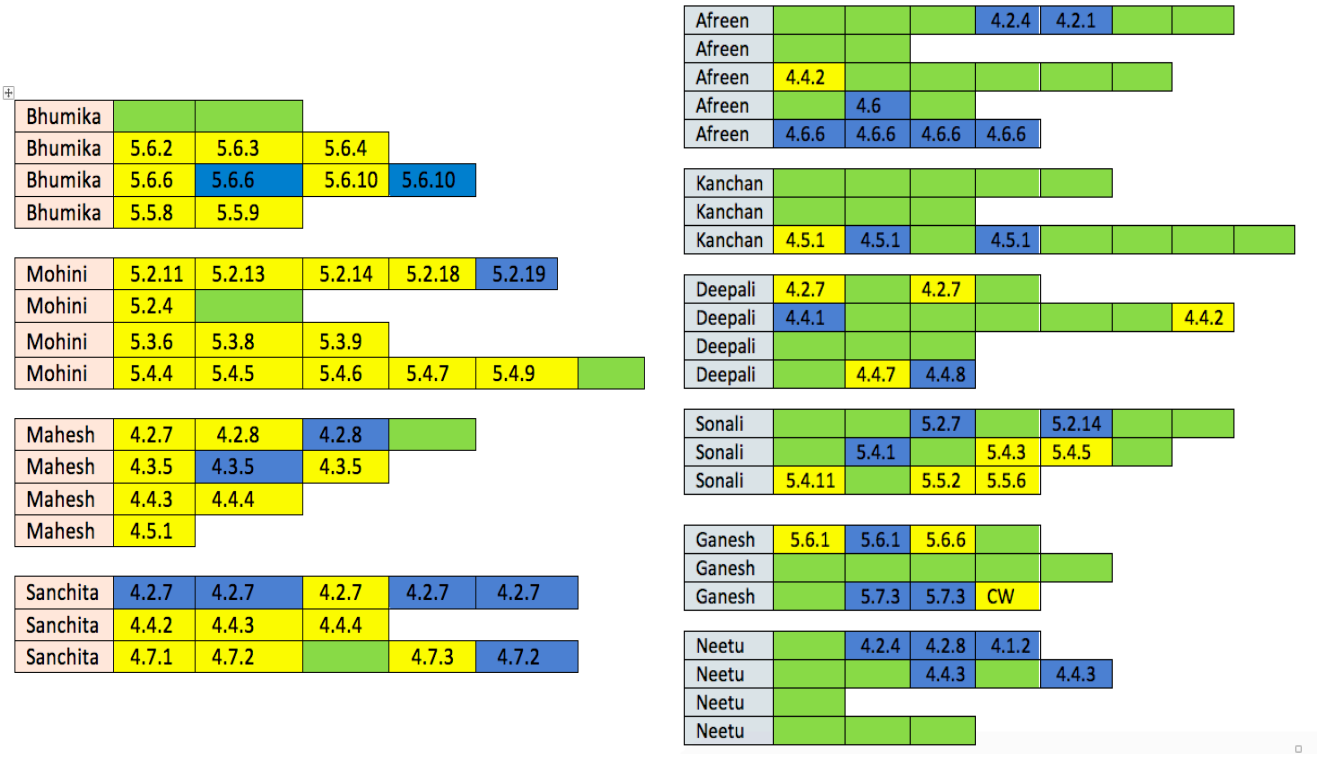


Figure 6.2: Episodes based on textbook use: direct use: DTU (yellow), adapted use: ATU (blue), inserted use: INS (green)

Lessons structured around direct textbook use: with support of adaptations or insertions

As seen in Figure 6.2, in most of the observed lessons of four teachers (Bhumika, Mohini, Mahesh, and Sanchita) there are many more episodes of direct textbook use than of insertion or adaptation. Together, 73% of the episodes in these teachers' lessons involved the direct use of textbook tasks, while the corresponding proportion for the other six teachers was 27%. In all these textbook-dominated lessons, teachers could be observed moving from one task in the textbook to the next; using the prescribed sequence of tasks to structure the lessons. This was often explicated by the teachers, who would ask the students to refer directly to the textbooks. For example, one said:

T: Whoever doesn't have books, look at your partner's.

T: Page number 16 we have already done, [now see] page number 17

Mahesh, lesson 1

Such a format facilitated an environment where the students engaged with the textbook directly too, either by reading out the text loudly (as instructed by the teachers), or reading it on their own. For example, in the following excerpts students are observed suggesting which task to move on to:

S: Ma'am let us do the '*chutki*' (finger snapping) one.

T: Where is the *'chutki'* one? It is after this, so when we reach there, we will do it.

Sanchita, lesson 2

In this way, the textbook was clearly the most important resource for many of the lessons, especially for the four teachers who were relying heavily on it. The textbook set a shared objective (of covering the book) and structured the overall classroom activities, which both the teachers and the students seemed to be participating in. Yet, not all teachers consistently used this mode of choosing their lesson structure. It is important to note here that some of the lessons of the other six teachers also seem to follow a similar pattern. For instance, lesson 4 of Sonali started with her attempting a task from Chapter 4 in Book 5, she then moved on to provide an insertion and then, turned to Chapter 5, with two textbook tasks being set. Even among these four textbook-reliant teachers, Bhumika used only insertions in the first lesson on a topic completely different from the textbook chapters. Thus, it is important to say that other teachers also might choose to make the textbook the primary resource for some lessons,

whilst one who relies mostly on the textbook might also attempt a different approach. In the Discussion chapter, there is a detailed discourse on teachers' selection preferences.

Lessons structured around insertions: with support of adaptations or direct use

For most of the lessons, for the remaining six teachers, textbook tasks came in and out of the classroom in unique ways. First, as discussed in Subsection 6.1.1, some lessons completely circumvented the textbooks and their topics. For example, in Bhumika's first observed lessen, she introduced six-digit numbers and presented questions requiring students to recognise the place values of large numbers. Such an approach to large numbers is missing from the textbooks and the topic cannot be directly mapped to any specific chapter. Similarly, in Afreen's second observed lesson, she asked students to attempt to make a list of questions (written on the black board shown in Figure 6.3, left) to be solved using standard column multiplication and division methods. For these tasks, the book provides no support at all, since it has not introduced standard algorithms anywhere. It is important to note that teachers often attempted these in 'revision' lessons, as was the case in Bhumika's lesson. This was also a strategy utilised when there was low attendance or some disturbance to the schedule, which meant that regular lessons were difficult. This was the case for Afreen's lesson, because the attendance due to rains was particularly low. Teachers calling for inclusion of such questions highlighted how these questions help teachers in times of disrupted lessons and 'covers' topics which they find missing in the textbooks (see Subsections 7.1.2, 7.1.3 and 7.4.1).

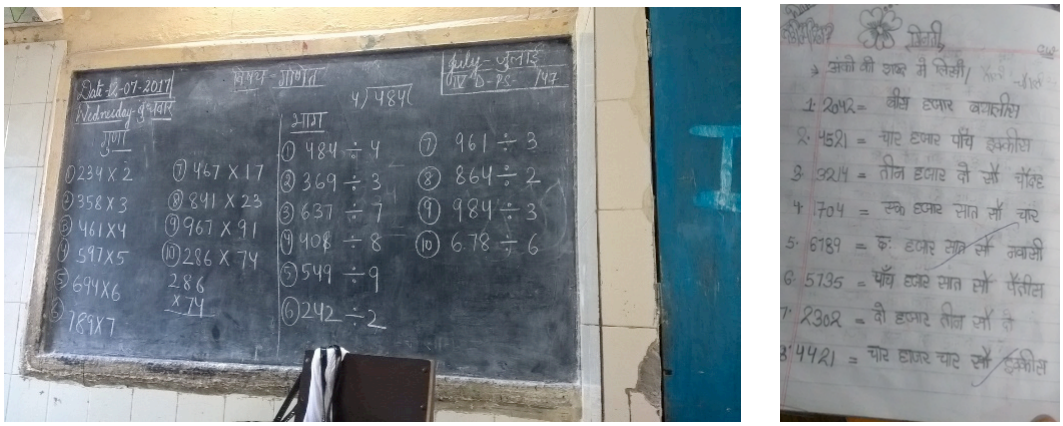


Figure 6.3: Afreen's lesson 2 (left); Sanchita's unobserved lesson's notebook work (right)

Second, in other lessons with only insertions, it was also observed that teachers were attempting to address topics within the books, but used their own tasks (Kanchan – lesson 1 & 2; Ganesh – lesson 2). For instance, in Kanchan's first lesson, she set out to deliver what was in Chapter 2 – Long and Short, but used her own insertions and did not refer to the

textbook or its tasks at any point. In these cases, while teachers were not trying some 'new' topic unavailable in the textbook, they were using their own ways of addressing the textbook content (without directly using textbook tasks).

Third and most commonly, teachers added adaptions and direct textbook tasks to support their insertions in covering a particular chapter of the textbook. In such lessons, only one or two textbook tasks (adapted or directly used) featured in the lessons. For example, Deepa's lesson 2 started with an adapted task, where she used the theme of the textbook task (mistakes in reading time), to provide information on how to read time correctly without making errors. The consequent episodes proceeded with her making the children practice marking the correct time on clocks:

> T: In the book, they have given clocks which you have to mark with the right time. But, let us first practice a little. Now, I will call children, those who come here, will make the time [on the black board].
>
> Deepali, lesson 2, episode 2

She then continued to insert a discussion episode (using the daily routine of a student's life); two information episodes (how to make a clock and how to read time); before finally asking the students to attempt the tasks within the textbook. Thus, she structured the lesson in a way that included information tasks as well as solved example tasks, before asking the students to attempt the questions in the book individually. That is, eventually, a textbook task was attempted directly, but before doing so, she converted a previous task into information and solved examples to be discussed with the whole classroom.

Similarly, in Kanchan's lesson 1, she started with an inserted episode, which pertained to a recap of previously done work, moving on to an inserted task of information, followed by her 'showing' a way of using a measuring tape, followed by providing students with seat-work and finally giving homework. Her lesson was structured around: information, explanation, solved example, student self-work and homework. In case of Deepali and Kanchan they seemed to pick a relevant and needed direct or adapted task, which was integrated within their lessons. Thus, instead of presenting the textbook as the structuring artefact for their lessons, these teachers seem have been using their own narratives to structure the lessons.

6.1.2 Types of adaptations

Up until now, the ways in which teachers structure their lessons have been discussed. Also, it has been documented how while some teachers used one type of structuring device more frequently, there were others who utilised both these approaches approximately equally. In this section, l look deeper into the nature of adaptations and insertions that the teachers made.

Adapted episodes are defined as episodes pursued by the teachers that involved modified versions of the textbook tasks, while inserted episodes did not bear any resemblance to these tasks (even if the mathematical topics were similar). As mentioned above, only 22% (32 episodes) of the episodes were adaptations and 46% (68 episodes) were insertions. In the following subsections, I consider the three ways in which adaptations were included. First, adaptations were included aimed at coverage of textbook tasks, yet these ignored significant aspects of the tasks. In these cases, teachers only used the non-eliciting elements or context to provide information or explanation about the mathematical topic; ignoring the eliciting components. Second, a majority of the adaptations accommodated elements that were lacking in the textbook. These include repeated questions, de-contextualised questions and mathematical information. Finally, while adaptations and insertions mostly seemed to be subverting the textbook affordances in these two cases, two exceptional episodes are discussed where teachers extended the textbook's ideals while adapting and inserting their own tasks.

Table 6.1: Types of adaptations

	Number of adapted episodes	Percentage
To ensure textbook coverage	10	31%
To provide 'missing' elements	20	63%
To extend textbook task affordance	2	6%
Total	32	100%

Ensuring textbook coverage

Even where lessons relied primarily on direct textbook tasks (as discussed above), teachers often made insertions and adaptations. These additional episodes were integrated to ensure that all tasks were being 'touched upon', even if cursorily. For example, Mohini's first lesson moved across tasks 5.2.11, 5.2.13, 5.2.14 and 5.2.18, ending with an adapted version of 5.2.19. Task 5.2.19 is a 'D game', played in pairs, where students make angles, 'guess' their

measurement and then, 'measure' them. Instead of attempting this, Mohini discussed what a 'D' (protractor) is and brought to the fore how this enables measuring both 'acute' and 'obtuse' angles, even though these terms are missing from the textbook. Thus, the adaptation was used to introduce formal mathematical information, instead of attempting the eliciting questions. Such an action of 'touching upon' textbook tasks was also observed in Sonali's lessons. For example, in her first lesson, she introduces 'right angles' and after inserting her own information, she referred to the textbook. Instead of attempting the eliciting components of tasks 5.2.7 (angles in your body) or 5.2.14 (angles on the clock), she used its context as examples of right angles and cursorily discussed them. Overall, among all the ten teachers, there were 10 adaptations (out of 32), where they included them in their lessons to introduce some mathematical information or discuss the context, via the textbook task. This indicates that while teachers used the textbook tasks, they did not engage deeply with their eliciting components, but rather, utilised them either to discuss the topic further or provide mathematical information. While teachers were making attempts to 'touch upon' tasks, there were also tasks that they would 'skip' (see Mohini's lessons discussed above, where 5.2.15, 5.2.16 and 5.2.17 were skipped). As discussed in the next chapter, in Subsection 7.3.3, it can be seen how teachers talked about 'skipping' some parts, especially when they felt that the textbooks were becoming 'too much'. Whilst 31% of the adaptations seem to be aimed at covering the tasks, there were also several instances of omission or skipping, in particular, in lessons delivered by Bhumika and Mohini.

Providing 'missing' elements: repetition, de-contextual questions and information

A common adaptation was when teachers added questions based on the direct textbook task they had just instructed upon (20 out of 32). This was done by changing numbers to provide more opportunities to attempt the same type of specified eliciting tasks as those provided in the textbook. Seven out of the ten teachers included such a modification. For example, Mahesh first put forward a DTU (lesson 2, episode 1, 4.3.5) - 'what is the exact number between 100 and 150' and right after discussing two ways of arriving at the answer, in the next episode he asked – 'what is the number between 100 and 200' (lesson 2, episode 3). Similarly, Sanchita, adapting Task 4.2.7 (see Figure 6.5) in Lesson 1, added several questions using the same task context, such as "How many rounds of 400 m would you need to cover 1 km?" (episode 1); "How many rounds would you cover in 1500 m?" (episode 2). These kinds of episodes clearly were used to provide students with *repeated opportunities* to tackle similar types of questions. As discussed in Chapter 5, Subsection 5.4.2, conventional repeated

tasks are missing from these textbooks, where each pose new questions distinct from the previous one. In two cases, Bhumika (lesson 3, episode 4) and Ganesh (lesson 1, episode 2), a repeated task was followed by formal definitions as well. Thus, the main adaptation used by teachers was to modify the tasks to include more questions (by changing the numbers, or creating their own), to ensure that students received repeated exposure to the same type of question as well as some additional 'mathematical' information.

Extending textbook affordances

In the above sections, I have reported how the majority of adaptations were either used to add elements missing from the textbooks or to engage superficially with the textbook tasks. In this subsection, I discuss the only two instances given by Afreen and Mahesh, to show how these teachers seem to be embracing textbook-like tasks even within their insertions and adaptations.

Adapting a word problem task into a construction task: In Mahesh's lesson 1, episode 2, he explained the task within the textbook on 'Long jump' (Figure 6.4 below (L)) as a word problem. As a follow up task, he added episode 3, where he made the students jump in the class, thereby giving them the opportunity to 'act out' the word problem. He asked the students to volunteer to come out in front of the class and jump, then using a tape measure, he calibrated the distance.

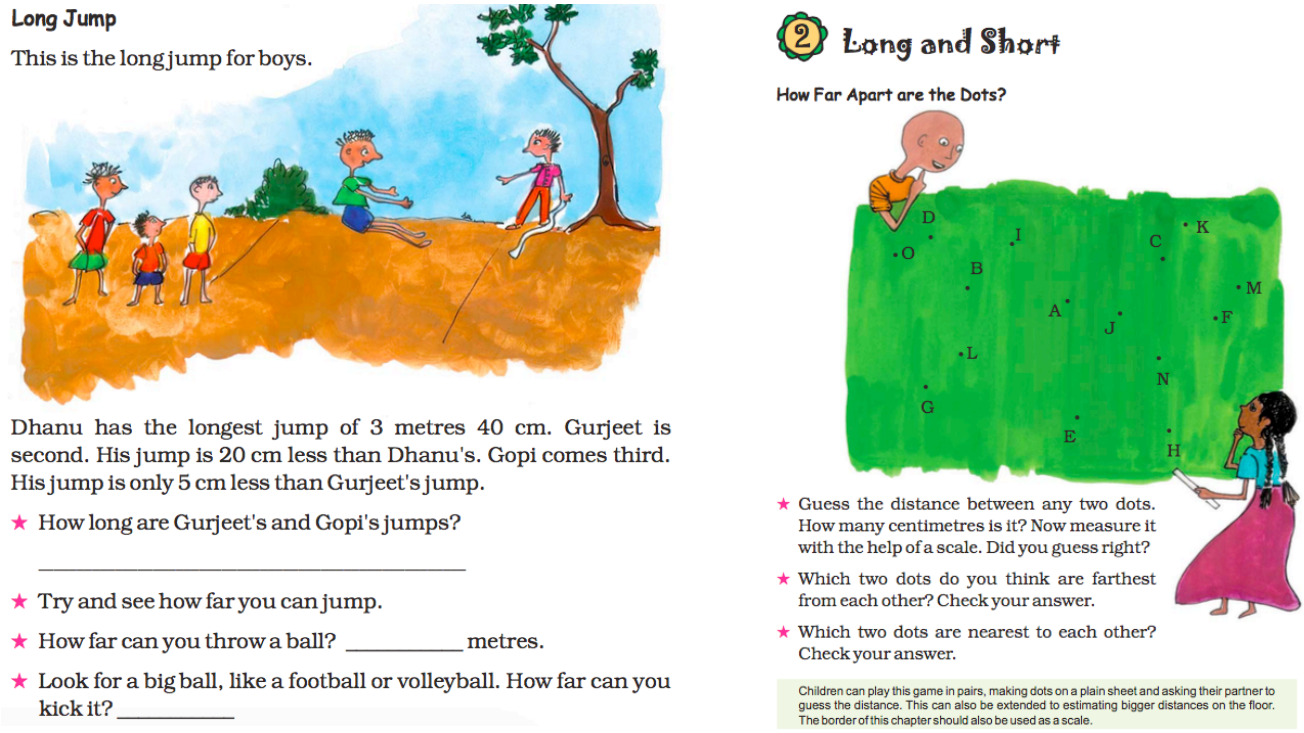


Figure 6.4: Book 4, Chapter 2, Task 4.2.8 (left), page 17; Book 4, Chapter 2, Task 4.2.1, page 13 (right)

Adapting a specified task into a generative task: In the second such type of adapted task episode, Afreen retained the main eliciting components, but turned the task from the specified one to a generative task. Instead of using the illustration provided in the textbook (see Figure 6.5 (right)) and asking students to use that particular illustration to find the longest and shortest distance between two dots, she requested them to make 15 dots on their own in their notebooks and then, to find the distance between them. By changing the location of the task, she made it more open with possibilities of many different solutions. Afreen did not just adapt[73] the nature of the task by making it a generative one, for she also enabled different sets of eliciting questions that were initiated by this change. The kinds of questions addressed through this exercise were also not limited to 'guessing' and 'checking', as recommended by the task in the book. For example, she raised the possibility of getting answers in decimals, and also that the children might make two dots having a distance of more than 15 cm (which is not the case in the specified tasks).

> T: Now look at Nikki's line here. Till this point on her line, we get 15 cm. But the scale is only for 15 cm, then what will we do?
> S: Ma'am, then measure from that point and it will be done.
> T: How?
> S: From zero.
> T: Yes, from zero we measure again. So, from here till here it is 15 cm. Now, this much line is left. We will again place our scale (ruler) here. Okay, Nikki *bete*. Here, your 15 cm is over. Make a point there. Okay. You marked it, so where you marked the point, place the zero of the scale there again. How much did you get? See beta, it will be like this.
> T: How much did you get? 0.6. So, we did not get a complete 1. See *bete*, we get 0.6. So, in total how long is the line, Nikki? Add it. [] That means her line is 15.6 cm long. Okay. Everyone understand?
>
> Afreen, lesson 1, episode 5

By not restricting the activity to the illustration and recommended questions in the task of the textbook, she opened up possibilities of different conceptual discussions around the topic (measuring distance more than the ruler markings, measuring in decimals, adding in decimals). At the same time, since each child made different sets of dots, she had to look at

[73] Note that the teachers' note in this task does encourage students to draw the dots in their notebooks as well as extend the task to larger distances, so Afreen's action seems to have been in line with this suggestion.

every child's work individually to 'check', while also giving feedback to each one about their work. Thus, adaptation into a generative task is in line with the textbook's goal of including students' own ability to create tasks.

6.1.3 Types of insertions

Almost half the episodes attempted by all the teachers were insertions (46%). In other words, in these episodes, they did not refer to the textbook at all. This raises the question what was the nature of the insertions that they used? In line with the categorisation of the textbook tasks (see Table 6.2), I coded the insertion tasks in terms of *de-contextualised eliciting tasks* (numerical problems without any context embedded in the problem) or *contextualised eliciting tasks* (including games that students could directly participate in, whether contextual objects were being referred to or any other word problems embedded in a context). The third categorisation was that of *information*, where teachers provided information to students about the topic being discussed, either in terms of procedures, definitions, or mathematical facts.

Table 6.2: Types of insertion episodes

	Number of insertion episodes	Percentage
De-contextualised eliciting tasks	29	43%
Information	24	35%
Contextualised eliciting tasks	15	22%
Total	68	100%

As shown in the table above, the majority of the insertions seem to be of decontextualized eliciting tasks as well as mathematical information. For example, Afreen and Kanchan both started their lesson on measurement (lesson 1 for both), by providing information about the features of a ruler/ tape measure.

> T: You must all have a scale [ruler]. You can see that either zero is written here, or 'mm'. And after that it reads one, two, three, four, five, six, seven, eight, nine, ten.
>
> Afreen, lesson 1, episode 1

These teachers were inserting information of their own, much more than adapting information through the textbook tasks (only two instances of adapted information was observed). This could be due to the lack of explicit facts, formulas and procedures provided within the textbook, to which the teachers were aiming to add their own (see Subsection 7.1.2). Further, 42% of the insertions were decontextualized eliciting questions. By including

such de-contextualised tasks and information based tasks, teachers might could have been attempting to provide the ‘missing’ elements on their own (see Subsections 7.1.2 and 7.1.3 on teachers views on missing elements in the textbooks). Note that, interestingly, they were including contextualised tasks as well. These were in forms of contextual discussions, word problems and any other forms of reference regarding contextualised tasks. In Subsection 6.3, these types of episodes are discussed in detail.

The nature of the tasks that were being added, as teachers included adaptations and insertions, has been discussed. When they were including these insertions, some were also using additional *resources* for support. Sanchita was using an unofficial privately published guidebook while discussing this chapter, instead of the textbook. Her rationale for doing so was that textbooks had not arrived in the school yet. The guidebook acts like an answer book, providing a solution to each eliciting component of the tasks (as shown below in Figure 6.5). These solutions are all highly formalised (like the multiplication above), rather than process based. Deepali, in lesson 3, was observed using a privately published textbook to insert tasks for the Chapter ‘Tick-tick-tick’ (see Figure 6.5, right). Apart from these two lessons, no other textbooks or resource material were observed being used directly. However, as discussed in Subsection 6.2.2 as well as Subsection 7.2.1, the teachers did see value in ‘hands-on’ activities, where students developed their own resources.

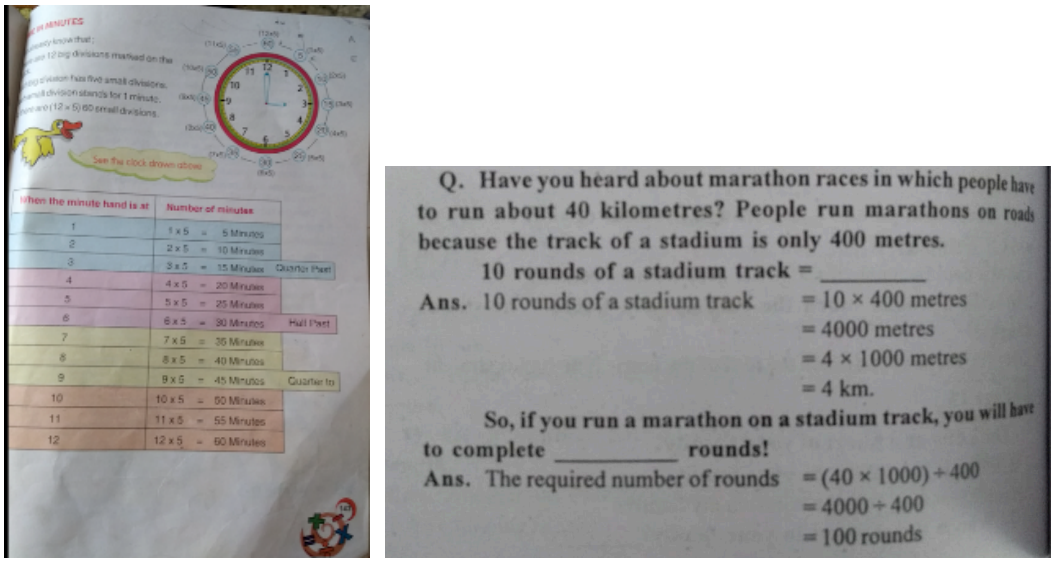


Figure 6.5: Privately published textbook (left); Privately published *Math-Magic* Guidebook (right)

6.2 Interpreting Voice of the Tasks during Textbook Use

In the previous section, the structure of lessons and types of insertions and adaptations were discussed. Briefly I also highlighted how in a few cases teachers 'extended textbook affordances' and inserted 'contextualised tasks', thus reflecting their approach towards the textbook affordances. In this section, I detail the ways and extent to which teachers embraced the textbook intentions as promoted via its affordances (voice, context and structure). I consider the ten teachers' interpretations[74] of the different affordances of the textbook, during its usage. By using excerpts from different lesson episodes (direct, adapted or inserted), I delineate the range of interpretations of the textbook affordances analysed in the previous chapter.

In this section, I focus on the affordance of 'voice'. Subsection 6.2.1 explores the voice through analysing how teachers presented task solutions in varied ways. The textbook also expects students to participate in 'thinking' about mathematics, apart from 'scribbling' it in different formats. Section 6.2.2 investigates the different formats in which students engaged with 'scribbling' mathematics, while Subsection 6.2.3 explores the extent to which students were being encouraged to 'think' and share their mathematical thinking in the lessons. Section 6.3 probes another affordance of the textbook, namely contextualised tasks, in detail.

6.2.1 Interpretations of specified tasks: process-oriented or direct-formulaic?

As pointed in the Chapter 5, section 5.4, the textbook attempts to introduce more flexible mathematics rather than fixed mathematical facts or procedures. For instance, it avoids providing explicit facts, solutions, mathematical information or procedures (see Subsection 5.3.3). It also implicitly points to using a multiplicity of approaches, while discouraging direct instruction. For instance, the teachers' notes at the bottom of the chapters invites students to express their alternative methods of solving the tasks (7), whilst also discouraging the use direct definitions or formulas (5) (see Subsection 5.3.2). Overall, the textbook encourages 'process-oriented' approaches seen in opposition to 'direct formulaic' approaches. Keeping this in mind, this section explores how teachers respond to such an approach. I recognise that while this particular 'reformed' textbook interprets reforms by overemphasising procedural learning over direct formulaic learning, not all reforms do so. I

[74] Note that this chapter focuses on teachers' interpretations based on their textbook use during classroom lessons. That is, it considers their different use patterns as their interpretation of textbook affordance. In the next chapter 7, when analysing teachers' interview data, I will explore their views of the textbooks by bringing forth their voice.

label some interpretations more ‘productive’ than others based on their alignment with these particular reforms.

For instance, in the following sections, I discuss how Mahesh, Mohini, Bhumika and Afreen were able to interpret the affordances within the textbooks ‘productively’, i.e., aligned with these textbook ideals. On the other hand, Sanchita, Deepali, Ganesh and Neetu did not choose to use the affordances within the textbooks in productive ways. In case of Sonali, I also highlight how this ‘overemphasis’ on the processes can often lead to confusion. Kanchan was not observed using any textbook task directly that required any procedure and thus, her case is not discussed[75].

Process-oriented approaches

As aimed for by the textbook authors, some of the teachers seemed to be shifting the pedagogical emphasis towards a more process-oriented and explanation based approach, rather than using a direct formulaic one. This was especially seen in the lessons of Mahesh, Bhumika, Mohini, Afreen, Deepali and Kanchan.

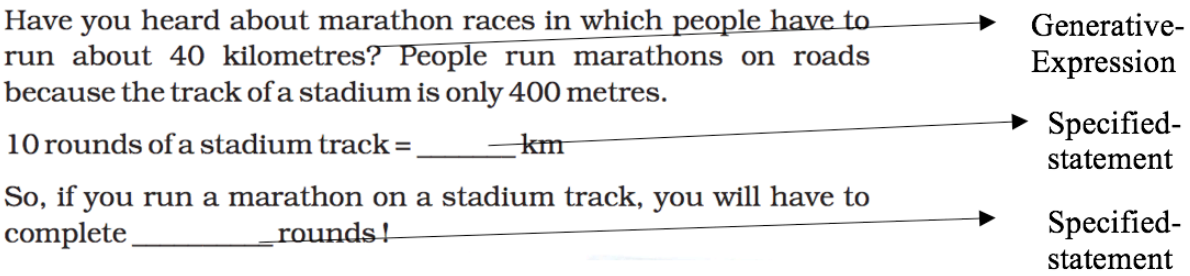


Figure 6.6: Book 4, Chapter 2, Task 4.2.7, page 17

For instance, Mahesh pursued the task shown in Figure 6.6. He began the lesson with a 10 minute discussion on the generative-expression task “Have you heard about marathon races.” (see Subsection 6.3.1). He then used the first specified-statement question as the first step towards the solution of the second question (as possibly intended by the two-part question). He charted a process of first finding the distance travelled in 10 rounds and then discussed how many 10 rounds would be needed for 40 km. He spent 20 minutes on this task and provided a detailed explanation of each step. For example:

T: But how many did we have to run?

[75] Note that while excerpts from a few of the observed lessons are discussed in the following subsection, it is important to note that these are not used to ‘label’ the teachers in any way. While some teachers might have been more inclined to using process-oriented solution in one lesson, the same teacher could have been using a more direct-approach in another. Thus, instead of these episodes being used to ascribe fixed teaching styles to the teachers, they are ilustrated to highlight the range of approaches seen in their interpretations.

T: 40 kilometres. Now in 10 rounds, 4000 metres that is 4 kilometres. In the next 10 rounds how much will it be?

T: In the next 10, if we add more than how much is it adding 4 and 4, 8 km. After that another 10 rounds, if we add?
S: 12 km

Mahesh, lesson 1, episode 1

Thus, Mahesh adopted a process-oriented explanatory approach for the task, using the prompt within the task. Note that whilst he did not present a 'direct' solution, he did not provide the students the chance to come up with their own solutions.

Mohini, another teacher who often structured her lessons around the textbook (Subsection 6.1.1), was observed using multiple methods as a way of explaining specified tasks. For example, while attempting the following task (see Figures 6.7), she provided both a visual and formulaic method.

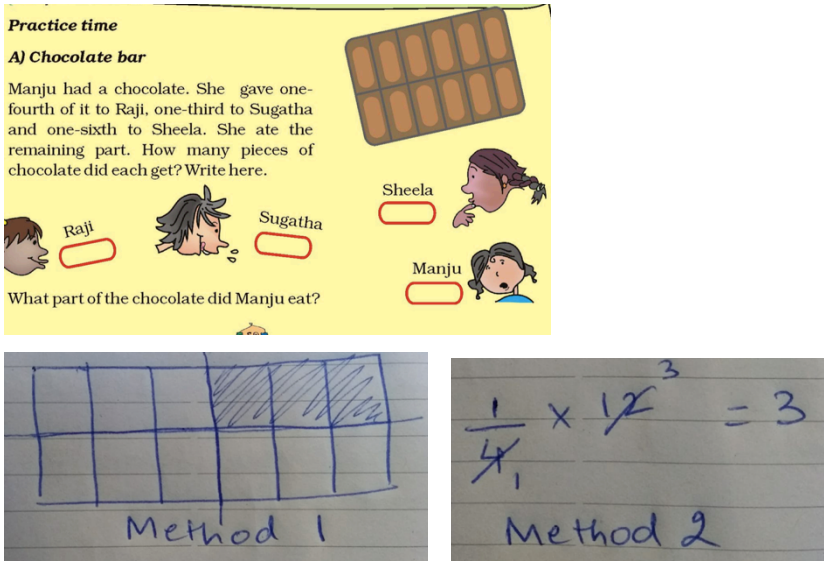


Figure 6.7: Book 5, Chapter 4, Task 5.4.4, page 52 (Top); Blackboard work on method 1 (Bottom left); Blackboard work on method 2 (Bottom right)

T: Yes. You can take it out like this. Either you can look at the picture and take out this or else you can go through the [multiplication] table of four. 4 ones are 4, four twos are 8, four threes are 12. So, 3 it is. And you can do it with the chocolate also. There are 12 parts. So, if we make the one-fourth part of the 12 pieces, that means we will make 4 equal parts of it. How much will it be? 3 will come, right?

Mohini, lesson 4, episode 1

Another teacher using the process-oriented multiple approaches was *Bhumika*. As shown in the following excerpt, she utilised meta-comment to explicate that the method deployed in the textbook (Venn diagram to find common multiples) has only been provided for understanding. Thus, she explained the method to be used in the exam (direct method), as compared to that used in the textbook (visual method). After discussing how a common multiple could be found by writing the multiples in three intersecting circles, she went on to say:

> T: These circle type [Venn diagram] questions will not come [in exams], you will straightaway be asked to write the common factors of 4, 5, and 6. So, what will you do? You will write the [multiplication] tables for it. Like you wrote for 4, for 5 and then, for 6 (she starts writing on the black board to demonstrate the method).
> [] T: In the [exam] paper, you will not have to make the circles and do it. Circles are only in your books to show so that you can understand.
>
> Bhumika, lesson 4, episode 1

Thus, she not only uses the tasks directly from the textbook and articulates their objectives, but also, delineates between the 'textbook' method (for understanding) and the 'exam' method (for attempting similar questions). This meta-narrative is missing in Mahesh and Mohini's approach discussed above. While, Mahesh ensured every element of the textbook was addressed, he did not articulate 'how' this could be done, if a similar question was presented in the exam. Mohini also did not prioritise either of the methods discussed, neither did she comment on the purpose of these methods, as Bhumika had done.

The above examples illustrate how teachers engaged with the process-oriented approaches, yet they seemed to retain their position of authority in deciding which method to introduce or prioritise. Unlike the examples above, a much more inclusive approach was taken by Afreen. She asked the students about the '*tareeka*' (methods) that they might use to solve a particular question. The following excerpt, from an adapted task use episode, shows how she encouraged students to bring in their own solution methods.

> T: 1 kilogram wastepaper (*raddi*) costs five rupees. Then how much will be 30 kilograms of wastepaper cost?
> SS: Ma'am, one hundred and fifty
> T: Okay. How did you do it?

SS: Ma'am I multiplied. Ma'am, if I read the table for 5 ten times, and then read that three times, then

[] T: You need multiplication. Very good. To save our time, we use multiplication. Tell another *'tareeka'* (method). How can we do it differently from Seema's method? Yesterday, you gave me two to three methods of doing a single question, right?

Afreen, lesson 5, episode 3

Looking carefully at Seema's answer, it is clear that she was describing a complex process, which could not be simply viewed as the multiplication of 5 and 30. She described $(5 \times 10) \times 3$. That is, she split 30 as 3×10 and multiplied 5 first with 10, then multiplying that by 3, to get the answer. Further, she also described multiplication as 'reading the table ten times', thus introducing a unique way of referring to multiplication. However, Afreen missed the opportunity to explore the pupil's solution strategy and instead focused a narrower solution of 'multiplication' (viewed simply as 5×30). Despite this, what is important is that she was the only teacher who encouraged students' solutions to enter the classroom discussion. In no other teachers' lessons, was students' (alternative) thinking or methods given such explicit time and space.

Direct-formulaic methods

In the above subsection, I have discussed examples of how teachers introduced process-oriented multiple approaches to the mathematical solutions. Not only were they explaining detailed solutions, for they were also introducing multiple methods to do so. Particularly Afreen enabled students to come up with their own methods. On the other hand, there were still instances when teachers provided singular direct formulaic methods. For instance, Sanchita put forward the same marathon question discussed above (Figure 6.5), but unlike Mahesh who spent 20 minutes on a detailed explanation, Sanchita took a very different approach and only spent 10 minutes in total on the task. She introduced the stadium with a circumference 400 m at the beginning of the lesson and drew it on the blackboard to help model it. She focused only on the first specified question and instead of an elaborate explanation, provided direct procedures.

T: Now, this is given in your book. If you take 10 rounds of this stadium, then what will you get? Take 10 rounds of the stadium and tell me how many metres will it be?

SS: Ma'am, 400.

T: No, if you take one round of this stadium, then how it will be 400? You will multiply 400 with 10 rounds, then we will get how many metres we have run.

Sanchita, lesson 1, episode 3

In the above example, she directly tells the students that 400 needs to be 'multiplied' by 10. She then reminds them how to multiply by writing the standard column algorithm of multiplication. Neetu, much like Sanchita, while attempting a task from the textbook (Task 4.2.7), also directly told what needed to be done in the task and omitted describing alternative methods completely. For example, in the following example, she directly *tells students* that they need to subtract and then, subtracts 20 from 40 to get 20 cm. She also ensures that they write each of the steps in their copies[76], rather than focusing on explaining the process. This kind of approach of 'telling' the answer or procedure and asking students to copy the answers from the board was mirrored in several other lessons (discussed further in Subsection 6.2.2).

T: It is called long jump. Geeta's jump is 3 m and 40 cm. Sita's jump is 20 cm less than her. Then tell, who's jump is longer among these? You have to tell this. So, first you will write how much is Geeta's jump? Write it in your copy. Then, how much less is Sita's jump?
T: Write it. Now, subtract both of them. Because we have to tell the difference between the two, and to tell the difference we have to use the subtraction method. So, subtract that 20 cm and then tell me. Just see, how do you subtract it. This is metre and this is centimetre. Geeta's [jump] was 3 m and 40 cm. Sita's was 20 cm less. So, we will subtract it. I am telling you this again and again. So, how much is it? (she writes the standard column subtraction algorithm method on the blackboard)

Neetu, lesson 1, episode 3

Multiple interpretations of open tasks

While a range of approaches have been discussed (from process-oriented to direct-formulaic approach), there were some episodes where the openness of tasks led to confusion. In the following example, the teacher struggles with interpreting an open task and choosing an appropriate solution for it. In the task shown in Figure 6.8 students were asked to 'colour $\frac{1}{3}$ of the hats red'. The task is accompanied by a substantive-illustration showing drawings of

[76] Copy is colloquially used to refer to student notebooks. As Iyer (2013) explained, copy-keeping and maintaining neat copies are seen as important parts of primary school teaching and learning. Kumar (1991) traced its origins to missionary schools in the nineteenth century India, where students were expected to 'copy' in such notebooks.

different types of hats which are to be used to answer the questions. From one perspective, the solution of the task requires knowledge of the finding fractions of a collection of discrete objects (seen as a whole), such as hats. Thus, colouring '$\frac{1}{3}$ of the hats red' means that out of the 15 hats shown in the illustration, 5 will have to be coloured red. However, from another perspective, the task can also be interpreted as 'colouring $\frac{1}{3}$ of *each of the* hats red'. The latter would mean that all the hats will have some proportion of red colouring on them. The task thus does not clarify which of the solution is to be picked up. Sonali, taking a third approach starts to focus on the different types of hat types. She tries to use the information that the hats can be categorised as different 'types' and use that to somehow arrive at the solution:

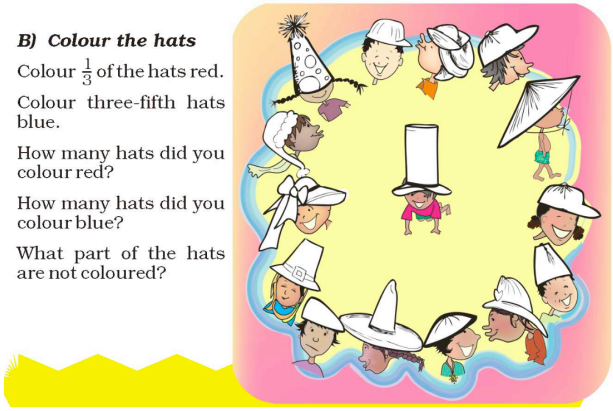


Figure 6.8: Book 5, Chapter 4, Task 5.4.5, page 53

> T: So, children are wearing hats [in the illustration]. This is what you see, right? <u>And there are many different kinds as well. They are not all the same.</u>
>
> SS: yes Ma'am
>
> T: All different kinds. See everyone. From here you have to identify which ones are similar looking. You have to find (*chaantni*)/select how many are of the same kind. Okay? After that, you have to colour *'ek bata teen'* (one-third) of the hats in red. Okay?
>
> Sonali, lesson 2, episode 5

She focuses on the different 'kinds' of hats and assumes that the task is asking the students to find the similar looking hats, followed by colouring some fractions of them. The task is not proceeded by any introduction, information or a similar task to support Sonali and direct her to any particular approach. Thus, the textbook assumes that teachers themselves will be familiar with and adept at drawing from different types of understandings that can be brought in, without much, if any, signposting. In fact, this task can provide an opportunity for investigating different assumptions in such fraction questions (Does the type of hats matter? Does it matter in 'real life'?). No special effort has been made to ensure that crucial

mathematical information is provided along with the tasks, to help teachers who might not have such expertise. Thus, while open-ended process-oriented tasks are being promoted in the textbooks, these can also sometimes become difficult to navigate when the aims of the tasks are not made explicit to the teachers.

6.2.2 Interpretations of scribbling tasks: 'Copy this, answer this and make that'

In the above subsection, I have discussed how teachers interpreted the task solutions, preferring direct or process-oriented solutions. Further, I have also analysed examples when teachers struggled with interpreting the tasks' aims. In this subsection, how the students were made to engage with these tasks is investigated. I have already briefly discussed how Afreen was attempting to encourage them to provide their own solution. I now look further into how the students were being constructed as 'scribbler' (answering/doing) or 'thinker' (showing/explaining) (see Chapter 5 Subsection 5.1.2). I discuss how teachers pursued and interpreted the 'scribbler' tasks, including construction ones that asked the students to use concrete materials and do hands-on activities.

Students 'copying' answers from the black board

One of the ways students engaged in the lessons was by copying answers into their notebooks once the teacher had provided or discussed the answers. In almost all the lessons, teachers would provide some time for them to note down the discussed work in their notebooks. However, in some cases this remained the only way in which students engaged in the classroom, i.e. their role was limited to noting answers in their books (or copies). This was particularly incongruous in cases when teachers were attempting textbook tasks, which were designed to ensure students engaged either by expressing or generating their own solutions. For example, in the following expression-generative task, Sanchita provides one answer and focuses on students filling their textbooks with the 'correct answer'.

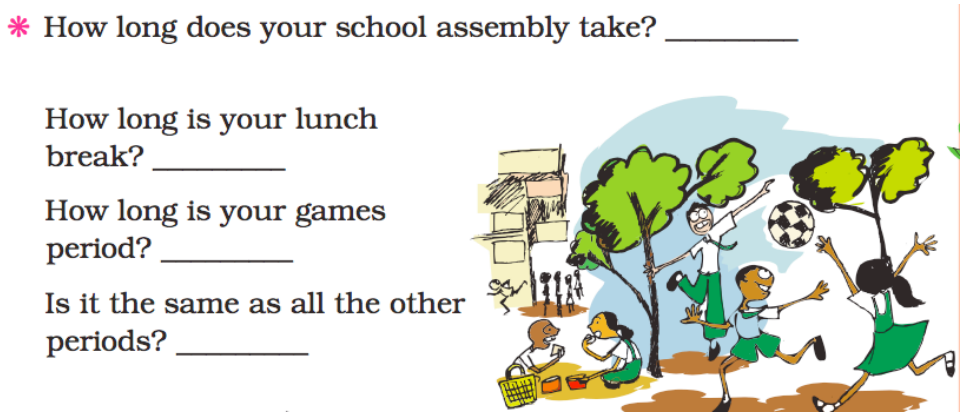


Figure 6.9: Book 4, Chapter 4, Task 4.4.3, page 39

T: You have to write it at the place [given in the book]. After that, look down, it is asked, how long is your lunch break?

S: 30 minutes.

T: Who said it is 30 minutes? It is only 20 minutes. Write down 20 minutes.

Sanchita, lesson 2, episode 2

In Sanchita's approach to the expression-generative tasks, neither openness was accommodated for nor were the students asked to express their own answers. Instead she rendered the answer '30 minutes' given by a student as wrong and went on to give the 'correct' answer to the class. Thus, despite the question being open (depending on the student's perspective), she closed down any alternative answers being put forward by the children. Hence, the students' role was limited to copying the answer in their notebooks. In Neetu (see Subsection 6.2.1 above), Sonali (lesson 1, episode 4) and Ganesh's (lesson 1, episode 3) lessons I found a similar approach of providing answers and only engaging students in noting the answers in their notebooks or textbooks.

Beyond 'copying' answers

In the above example, I discussed how students' role in some of the lessons remained confined to noting down the answers that were sanctioned by the teachers. Thus, they were not 'scribbling' to devise their own answers, but simply 'copying' those of the teacher. However, other teachers aimed to to engage students in more genuine forms of 'scribbling', so they would get opportunities to attempt the tasks (textbook or not) on their own. Here, I highlight three different ways used by teachers to ensure that children became engaged in the lessons.

The first way was asking students directed sub-questions that were more likely to be accessible, within a larger teacher-led explanation of a solution. These were beyond rhetorical questions (or cued elicitations), where teachers provide answers and students repeat them (see Pontefract & Hardman, 2005) (another form of 'copying'). For instance, in the marathon question discussed above (Figure 6.6), important information needed was the conversion of kilometres into metres. Here, by explicitly naming students, and asking them to state this mathematical information, Mahesh draws the attention of his students to the explanation he is giving and also, seeks to provide genuine points of entry to students to engage with the lesson. During the discussion, he asks the students to answer the directed simpler questions, as shown below:

T: How many metres are there in 1 kilometre, Suneeta tell? I am not asking you (referring to another student), let her tell. You get up Prachi – in 1 km how many metres are there? Stand up. I am not asking you (referring to another student), you have already said it. How many metres are there in 1 km? From there Kalpana? You tell.

Mahesh, lesson 1, episode 1

Second, Bhumika explicitly attempted to engage individual students, by inviting them to come up to the blackboard and present their answers. Instead of just copying or pursuing the tasks through individual seat-work, students were asked to present their answers to the whole class. Bhumika also seemed intentioned about this method as she believed it helped with individual understanding (Chapter 7, Subsection 7.2.3). For example, when one student attempts to find a solution to a question, she instructs her to not copy from a previously solved question, but rather, to try on her own.

T: Don't just copy it from above (*nakal utar kar nahi likhna hai*). Look at the question. [supports the student in the solution]
T: *Safeena*, *Sohini*, your chance is also going to come.

Bhumika, lesson 1, episode 2

T: Is it correct? Look at her [answer on the board]. Everyone look carefully, if you can see any mistake im this.

Bhumika, lesson 1, episode 1

Further in the excerpt above, while she encourages students to answer on the board in front of everyone, she also seeks to share the role of judging the solution (right or wrong) with the students. Thus, this does two things. It enables the students genuinely to attempt the task, instead of only copying the solutions and secondly, the teacher starts to share the role of authority and judgement of 'right/wrong' with them. A similar way of engaging with student answers was also seen in Mahesh's lesson, where he asked the students if they 'agree' (*sehmat*) with the answers. While students were hardly heard articulating or engaging with 'why' the answers were correct (or not) (see Subsection 6.2.3), some teachers attempted to bring this discourse of sharing their authority into the lessons. This demonstrates the emergence of how some teachers were making the effort to promote mathematics as a participatory activity.

Finally, a third way of engaging students and focusing on individual learning was observed in Afreen's lessons. In three of her lessons, she asked them explicitly whether they

had 'understood' what she was teaching. Unlike the other teachers, who also asked this rhetorically in their lessons, Afreen would spend time either individually or in groups to address student doubts. For example:

> T: Everyone understands? Who is such a girl who is not understanding? Who did NOT [emphasis on not] understand?
> SS: Ma'am I understood
> T: One second, whoever did not understand come here. Anyone else? Come here, form a line. (Almost half the class volunteers and joins the line)
>
> Afreen, lesson 3, episode 5

The above excerpt shows that instead of her choosing the 'weak' students, who were not understanding, she asked the children to self-identify as to whether they had understood or not. What is noteworthy is that students did not seem to fear that they might be judged harshly for not understanding. Instead, a large number of girls volunteered, and were made to sit separately, where Afreen explained the topic to them again. In this way, she was aiming not only to address individual difficulty, but also, make them take responsibility for their own learning. This is a further reflection of the non-threatening environment that she created (see Chapter 7, Subsection 7.2.3). I have discussed three distinct ways in which teachers engaged students in the lessons: by asking individual students smaller and achievable questions, by asking students to come up to the blackboard and write their answers (which are then negotiated with the larger class), and finally, separating groups or individuals and providing focused explanations.

Attempting hands-on activities

Furthermore, teachers also seemed to be engaging students in other alternative forms of activities. These included hands-on activities, games, experiments etc. Some examples of how the teachers attempted these tasks are discussed below. While a few of these activities were adapted from the textbook tasks, especially construction tasks[77], some were initiated by the teachers themselves. In the following subsection, a few of these examples are reported upon.

[77] Note that construction tasks are defined as: Eliciting questions (specified or generative), where students engage with a task in a format other than answering questions, thinking, expressing experiences or justifying their product or process (in the textbook or notebook). These require students either to use or (and) create additional materials and artefacts, play games, or conduct experiments (See Appendix B.1).

During the first observed lesson, Mohini asked all students to bring matchsticks to make shapes using them as asked in the task below in the book under the header ‘Matchstick puzzle’ (Figure 6.10). Students were then asked to make these shapes using the matchsticks and paste them into their notebooks (not observed). They did so and put them up on the bulletin boards.

Matchstick Puzzles

1) Make 8 triangles using 6 matchsticks. Try!

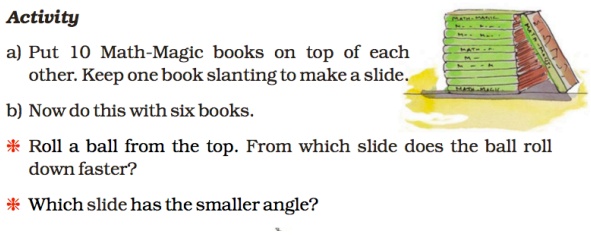
2) Take 8 matchsticks and make a fish like this. Now pick up any 3 matchsticks and put them in such a way that the fish now starts swimming in the opposite direction. Did it?

3) Using 10 matchsticks make this shape. Pick up 5 matchsticks and put them in such a way that you get the shape of a house.

If you have not been able to solve these then look for the answers on page 29.

Figure 6.10: Book 5, Chapter 2, Task 5.2.3, page 19 (top); Matchstick task done in a notebook (bottom, left); Matchstick task on a chart displayed in the classroom (bottom, right)

Mohini, who was committed to attempting most tasks in the textbook, did not hesitate to try out such construction tasks. Another example below, shows how through the medium of a construction task students’ spontaneous ‘thinking’ entered the lesson, which Mohini encouraged. In the task below (Figure 6.11), the instruction was aimed at discovering that a ball will slide down faster or slower based on the number of books stacked up to create the slope. As Mohini set about creating the slope using books (as suggested by the textbook task), it became apparent that this was not clearly being demonstrated. Hence, the students suggested using geometry boxes instead, which got them enthused.



Activity

a) Put 10 Math-Magic books on top of each other. Keep one book slanting to make a slide.

b) Now do this with six books.

* Roll a ball from the top. From which slide does the ball roll down faster?

* Which slide has the smaller angle?

Figure 6.11: Book 5, Chapter 2, Task 5.2.11, page 25

T: Right now, it is not coming out that nicely (*ache se pata nahi chal raha hai*), because we don't have any [right] things.

S: Ma'am should we collect geometry boxes? (*maam* geometry *ikaddi kar le*?)

T: What? (*hain*?)

S1: Put geometry [boxes]

S2: It won't work. (*aise kaise lag jaayegi*?)

S3: It will work (*lag jaayegi*). Ma'am let us try and see. (*maam karke dekhte hai*)

T: Do it and see. Put less on one [pile] and put more on the other. Put three on one and put more on the other.

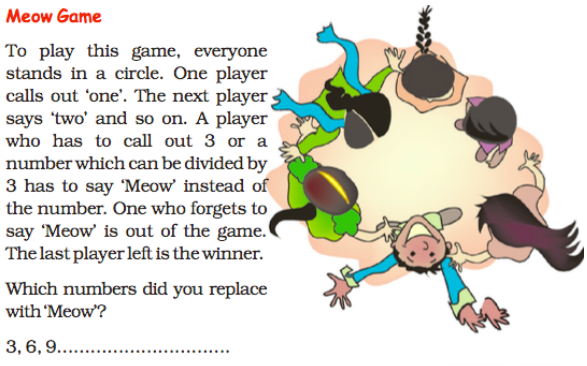
Mohini, lesson 1, episode 1

Similarly, other teachers such as Kanchan and Afreen also introduced episodes (insertion episodes) where the students were instructed to make their own clocks as a part of the Chapter - *Tick tick tick* (Figure 6.12, left). As shown in the photograph below, they made clocks in groups. Another interesting construction task initiated by Kanchan was measuring different objects in her class using a tape measure (Figure 6.12, right).

Figure 6.12: Children making clocks in Kanchan's class (left); Kanchan and students measuring the height of the classroom door (right)

Bhumika, despite being 'exam' oriented and often skipping textbook tasks (see Subsection 6.1.1), still attempted some of the construction tasks. For instance, she played the 'Meow game', where all the children in the classroom participate and have to count from 1 onwards and say 'meow' every time they arrive at a multiple of 3. It is interesting that the teacher also did reinforce the purpose of playing this puzzle (to learn tables). At the end of the episode,

she reinforced that the main objective was to learn the tables, and these kinds of ‘long questions’ would not come up in the exams.



Meow Game

To play this game, everyone stands in a circle. One player calls out ‘one’. The next player says ‘two’ and so on. A player who has to call out 3 or a number which can be divided by 3 has to say ‘Meow’ instead of the number. One who forgets to say ‘Meow’ is out of the game. The last player left is the winner.

Which numbers did you replace with ‘Meow’?

3, 6, 9.....

Figure 6.13: Book 5, Chapter 6, Task 5.6.4, page 89

> T: This is also to learn tables, so what was she supposed to say after 6?
>
> SS: We not only learn tables but also have fun (*ek toh we are learning tables, and uppar se maza bhi aa raha hai*).
>
> T: So, this is the riddle. In this exercise [task], you should know how to count tables. This is just for you to learn – that there is a mouse and a cat or that they jump this much and jump that much. In the [exam] paper, they will not give such long questions. In the paper, you will be asked to find their factors (*gunankhand*). That is, what is the factor - or what number comes in what table. That is why you have to memorise the tables for sure. Okay? Just learning tables of 2 or 3 will not do, at least till 15 you must all memorise the tables by tomorrow.
>
> Bhumika, lesson 2, episode 3

Thus, this relationship of ‘crafts’ (making clocks, making match-stick shapes), and ‘fun’ (playing games) with mathematics activities seems to have been encouraged by these teachers. These were both used by teachers via the textbook activities, as well as on their own. A further discussion on this is provided in Chapter 7, Subsection 7.2.1, where teachers, especially Bhumika, express how they believe that these types of tasks help in student understanding.

6.2.3 Interpretations of thinking tasks: ‘...but can you tell why?’

As discussed above, some teachers were starting to engage students beyond passive ‘copying’ or ‘repeating’ the answers already shared by them. Students were both explicitly asked sub-questions and asked to share their solutions with their peers. There was also an emphasis

placed by many of these teachers on 'understanding'. In this section, I zoom in on five episodes where students were given opportunities to engage with 'thinking' tasks, and discuss the range of approaches taken. Unlike other sections where emerging themes of usage are discussed, in this section individual teachers' episodes will be highlighted to showcase how different teachers interpreted tasks which required deeper student engagement (beyond telling, copying and repeating). These reflect the range of styles and approaches that these individual teachers seem to take.

Mahesh: stressing the importance of reasoning but failing to hear students

Mahesh, who was trying to orient his teaching towards 'process' based solutions, also placed importance on explanations. For example, in a lesson that had already been covered by Sanchita (while he was on leave for seminar work, Sanchita took some of his lessons), students knew the answers to the textbook questions. Here, Mahesh makes it clear that 'copying' answers is not enough and there is a need for understanding 'how'.

> T: What is the number right in the middle [of 100 and 150]?
> SS: one hundred twenty-five
> T: Stand up Makepeace. Only by [Sanchita] Ma'am making you write the answer and giving you the answer will not do. Come here, tell <u>how</u> you got one hundred twenty-five. You have to <u>tell how you got it</u>.
>
> Mahesh, lesson 2, episode 1

As the discussion proceeds; however, despite the fact that the question is posed to Makepeace, Mahesh does not wait for her to attempt it on her own. He moves quickly to presenting the answer himself. He first explains one approach to the solution: using the rows in which the children are sitting, he discusses how by reducing from both sides one by one, the middle most child can be identified. After explaining this method, he moves to a second way of approaching the same task. By comparing the time taken between the two methods, he also points to the efficiency of the second method over the first. The discussion, thus, covers explanation of the two types of methods and designating one method as being more efficient. Yet, it fails to include students' reasoning and explanations even though he set out to do so. Interestingly, with his meta-comment on the need to understand 'how', there is also subtle innuendo about Sanchita's teaching approach. Despite the fact that he sent his students to her classroom, he chose to redo everything that she had covered. He did not ask 'how' Sanchita

Ma'am had explained it, but rather, assumes that it was done without focusing on the process of obtaining the answer.

Mohini: pursuing student responses

Mohini also similarly encouraged students to respond and also used the rationale of 'efficient' methods in legitimising them (or not). For example, in the following excerpt she attempts the explanation question initiated in the textbook: *Can you show that these parts are equal? Think 'how'* (Figure 6.14).

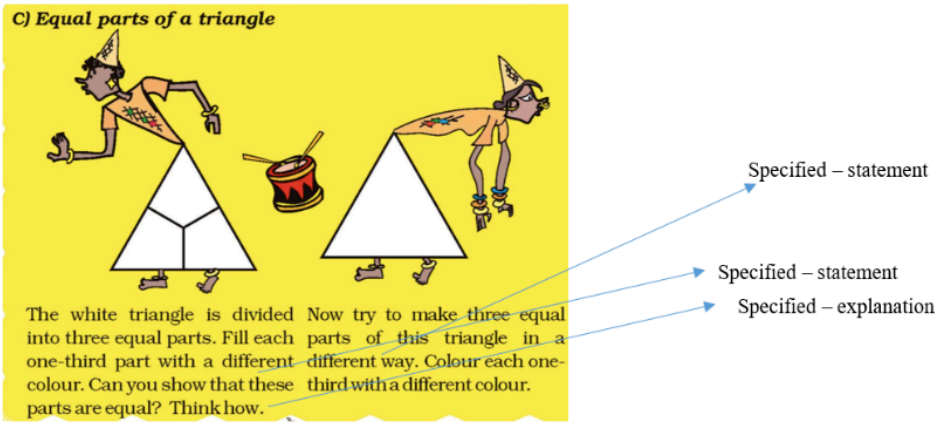


Figure 6.14: Book 5, Chapter 4, Task 5.4.6, page 53

> T: Ok, listen. Let us assume that you have coloured it with three different colours. Now they [textbook] are saying that these three parts are equal, <u>how can you say</u> that these parts are equal?
>
> <u>S: Ma'am, by measuring it with scale.</u>
>
> T: By measuring it with scale?
>
> [] T: Ok fine, measure it, measure it. And <u>think whether there is any other way also</u>?
>
> Mohini, lesson 4, episode 3

When a student attempts an explanation, she accepts the explanation. She doesn't explicitly label it wrong, but rather, encourages the child to think of other ways. To steer the discussion away from the 'measurement' method proposed by the student, she 'reasons' that one could make a mistake while measuring, so there might be another 'better' way, which she then proceeds to present.

T: Maybe there is a mistake in measuring. You think about it, what if you don't have scale and all? You have filled all three with different colours. How can you tell that they all are equal parts? Tell me fast.

S: Ma'am, by multiplying.

T: What will you multiply? What will you multiply? Can't you do like this, that if cut them, what will we do after cutting them? Let's assume that we cut this part. Ok. We have cut this part and if we keep this part on this part, what should happen? If it will be equal, it will cover that part perfectly, right?

Mohini, lesson 4, episode 3

Thus, Mohini engages student explanation only to a limited point, while she encourages students to pursue measurement, she rejects the idea of 'multiplication' completely. She also does not probe the student on what kind of measurement might be needed to give us any idea of congruency between the triangles. The textbook also does not provide any additional support on 'how' to check for congruency or (the even more complex question) how to draw equal parts of a triangle. While Mohini seems open to student responses, she steers the discussion by presenting reasonable feedback (students might make mistakes in measurement) to present a more robust method of checking whether the triangles are equal.

Kanchan: asking the questions, but what are the answers?

Unlike in the above examples, where instead of listening and pursuing what students said Mahesh provided his own explanation and Mohini directed students towards particular solutions, Kanchan had a different approach. In an episode where she was discussing a tape measure that she had brought to the class, she brought forth engaging 'thinking' based question about why it had two different set of measures. In this case, even though the students responded to it with their own thinking, Kanchan was not able to carry forward the discussion or provide any concluding 'solutions' (neither the students' nor her own). She did not give any explanation and moved on to the next episode of discussing how the tape measure could be used to measure lengths.

T: Now, tell me, the same measuring tape has measurements from 1 to 60 [on one side] and 1 to 150 [on the other]. How can this happen? Both 1 to 60 and 1 to 150 are there on the same length tape.

S: Ma'am one is big and one is small.

T: Why is it like that? What was the need?

S: Ma'am, you had told about the kilometre, centimetre and millimetre. So, on this also it is like this.

T: What? Why did they give like this? Inch tape is same, on one side it is from 1 to 60 and on the other side it is from 1 to 150. So why is it like that? Tell me. Why is it like that? Think about it for some time and then I will tell you. And now how will the measurements be done, think that also. Let's assume that I have to measure this as to how long is it. So, what will I do?

Kanchan, lesson 1, episode 2

This is a very insightful episode, since the students do engage and give explanations, yet Kanchan is unable to carry forward their thinking by giving reasonable feedback or encouraging further articulation of their ideas. Secondly, she herself does not provide any further explanation for why this is happening. There is of course one big difference in Mahesh and Kanchan's examples. In case of Mahesh, he was aimed at exploring a fairly routine method (finding average or midpoint of two numbers), whereas Kanchan was investigating a less routine question on how the same length can have two different measures based on the units that are used. This could be a possible reason for her not being able to address it, along with her own limited understanding of this aspect.

Afreen: critically asking and addressing mathematical reasoning

On the other hand, Afreen was much more confident in pursuing initiated 'thinking' questions. While discussing how to read the time using a wall clock, she starts by asking why they were using the table of 5 to do so.

T: Jyoti come out. Tell them how you got it. Why did you read the [multiplication] table for 5? Why only 5 table, why not tables for 3 or 2?

T: Why 5? I want to know this. What you are saying is totally correct. But why 5? You reading the 5 [multiplication] tables is also correct, but why 5? (She gives time to the student to answer)

T: Why did you only take the table for 5? Five fives are 25, that's right. But why did you take the table for 5?

S: (unclear)

T: How? How?

Afreen, lesson 3, episode 4

Unlike Kanchan, who after initiating the explanation question did not come back to it, Afreen, at a later point in the same episode, addresses the question again. Afreen provides time for students to engage and think about the explanation. On revisiting the question, she moves to Preeti and through engaging with her responses brings out the explanation.

T: I asked a question to Jyoti, that of why do we only use the tables for 5 here? Why didn't we take 3, or 4, if we are reading tables only? Okay, the *'tareeka'* (method) is absolutely correct. But why did we take the 5 table? Yes, Preeti

S: Ma'am because after every *'ank'* (number), there are five-five lines.

T: 5-5 lines are what?

P: Ma'am minutes

T: yes, every line is one minute. So, between every number how many minutes are there?

SS: 5

Afreen, lesson 3, episode 4

Ganesh: asking the right questions, but creating a sense of fear

Unlike the examples discussed above, where the classroom environment was such that teachers encouraged some level of student reasoning, Ganesh's lessons had a very different classroom environment. As shown in the following example, he asks the students for explanations and one even answers, but as he continues to ask the same question repeatedly, students fall silent, perhaps because they feel intimidated.

T: Now see this (writes a number pattern on the black board)

SS: (students reading the board as the teacher writes) 2, 4, 6, 8,

T: Now?

SS: *Sir ji* 10

<u>T: Why, why will it be 10?</u>

SS: Pattern

T: What? Pattern? How did you find out that after 8 it will be 10?

<u>SS: Sir the table for 2</u>

<u>T: Speak loudly</u>

SS: You are writing the table for two

T: This is the table for two?

<u>SS: (Silence)</u>

T: This is the table for two? Tell?

S: (Silence)

T: Why are you scared? Tell. This is the table for two? *Arrey* tell na (irritatingly), this is the table for two? Now?

Ganesh, lesson 3, episode 2

Despite him verbalising that the students could speak without fear, the atmosphere of the classroom contradicts this. Such a response from the students was typical in Ganesh's lessons, where it was common to see him scold or even hit students whenever he disapproved of any behaviour in the classroom. In another instance, below we see him mocking and then hitting a student who is attempting to provide an answer to a question:

T: This means that is the common multiple of all three. Then write it down. Besides this, is there anything else that you can see?

S: Yes sir

T: Which one is it? 'Yes sir?' (Mockingly) Tell. What else is there? Tell, tell (mockingly). You don't understand anything, and just say yes sir yes sir (hits him). (Silence in the classroom)

Ganesh, lesson 3, episode 2

As shown in the above examples, the question of 'why' and the initiation of some mathematical reasoning discourse was starting in the classrooms, but they were at different stages. First, the kind of interaction that Afreen undertook, insisting students unpack and articulate clearly the mathematical reasoning behind something they were doing was very rare (out of the 37 lessons, only in two of Afreen's was such an approach was observed). However, teachers like Kanchan, Mahesh and Mohini were starting to tread in that direction and bringing into their classrooms questions of 'why' and 'how'. A similar discourse was found in Ganesh's class at face level, where he articulated the need for students to try and answer fearlessly, but he created a classroom environment that contradicted his talk. He reprimands and even hit students in some instances. Thus, it is clear that encouraging a mathematical learning environment is not just about asking 'why' and pursuing students answers, but also, about creating a non-threatening environment (see Yackel & Cobb, 1996). It is also important to note that regarding teachers, such as Sonali, Sanchita and Neetu, there was no emphasis on explanations being provided by them nor any attempt to engage students in mathematical thinking.

6.3 Interpreting Context of the Tasks during Textbook Use

Apart from looking at the format of the tasks and the consequent student engagement facilitated by them, the other affordance identified within the textbook is: 'context'. I use this term in its broadest sense, drawing Borasi's (1986) definition as "the situation in which a problem is embedded" (p. 128), being seen in opposition to decontextualised numbers (or other mathematical objects). Within this broad notion, I identified several sub-categories within the textbook - *story based, students' everyday lives, contextual objects (illustrated/schematised) and social justice* [78] (see Chapter 5 Subsection 5.2). Clearly the textbook seemed to valorise contextualised knowledge over decontextualised knowledge; evident by the fact that almost all tasks in both Book 4 and 5 contained some 'context'. This section explores how teachers treated this dichotomy ingrained in the textbook.

Consequently, the episodes within the lessons of all the ten teachers which contained some tasks with the notion of context were coded. It was found that in 76 episodes out of the 148, context was referred to. It is not surprising that three quarters of these tasks (55) were either direct textbook ones or adapted from them. That is, considering that the books put so much emphasis on context (almost all the tasks have some context in them), it was likely that the tasks that teachers derived from them would also contain some notion of context in them. However, it is also interesting that one quarter of the context-based tasks were insertions (In Subsection 6.1.2 I have already noted that teachers were also using contextualised tasks in inserted episodes). In the following subsections, I illustrate thematically how teachers used these context-based tasks.

The most common way of using context was discussing examples of how some of the mathematical ideas featured in students' lives (Subsection 6.3.1). The second most common use of contextual tasks was short story based problems, which resembled traditional word problems (Subsection 6.3.2). A less frequent use of context comes up when there are illustrations in the textbooks that either acted as a hindrance or teachers adapted them for alternative representations (Subsection 6.3.4). Moreover, it was observed that teachers hardly discussed social justice issues in their lessons. However, some in their everyday dealings with the students were more sensitive about students' life conditions than others (Subsection 6.3.4). Finally, even though the teaching mostly happened in the Hindi medium, one big issue that seemed to be overarching was the use of language in the lessons (Subsection 6.3.5).

[78] Note that often the students' everyday lives category came in the forms of 'expression tasks' and 'generation tasks', where students had to bring ideas and experiences from their lives into the classroom.

Since the textbook overtly encourages 'everyday' use of language than more formal mathematical language, this becomes an important theme to explore.

6.3.1 Context as students' everyday life

The most common way of using context was by bringing in ideas from 'students everyday lives' (43 of the episodes). The contexts from these featured in tasks either taken directly or adapted from the textbook (25 episodes) or inserted by the teacher (18 episodes). On looking closely at the ways in which students' lives were called upon in the classrooms, it was found that teachers often asked for 'examples' from students' own experience. Thus, teachers posed questions such as:

> T: What does your mother measure with this [tape measure]? Tell me one by one.
>
> Kanchan, lesson 1, episode 2
>
> T: [In your surroundings] where can you all see a 'ninety degree' angle?
>
> Sonali, lesson 1, episode 2

Such listing of examples provided space for students to contribute their own knowledge as well. To give an example, Afreen starts an open discussion on measurement in a shopping context. As she gives a number of possible scenarios that the students might have encountered in shops, they start contributing by discussing measurement of *saaris* (a traditional garment). Afreen encourages this and a short discussion follows.

> T: Have you been to the bazaar with your mother to buy clothes? Have you ever got any cloth measured? They have these steel like rods? Then your mother must be saying that – give me 1 m cloth or 2 m cloth. Does she?
>
> <u>S: Ma'am some people even get their saaris measured. A saari is about 7 meters [long].</u>
>
> <u>T: Yes, you get saaris measured too.</u>
>
> <u>T: How long should saaris be?</u>
>
> SS: Seven, six
>
> [discussion on saaris and its length continues]
>
> Afreen, lesson 1, episode 4

Another example is from Kanchan's lessons, where students brought their knowledge of measurement. She asked a particular question on what their mothers measured and different types of notions of measurements emerged. In particular, a student explains here how her father uses a thread to measure bricks. Even though the teacher does not carry forward the

conversation, such experiences of students' lives seem to be entering the classroom discourse.

T: What does your mother measure with this? Tell me one by one.
S: My mother measures 'kamar' (waist).
T: She measures salwar-suit. And what else can we measure? Tell one by one.
S: To measure the land.
T: What?
S: To measure the land.
T: Very good, clap loudly for her. A different type of measuring tape is used for that. Its round, we pull it out and when we leave it, it goes inside on its own. It has a spring in it. So, to measure the land. Very good. Tell me more. What else have you seen being measured with this?
S: Ma'am, when you are constructing houses then they use thread to measure.
T: You have seen it?
SS: Yes Ma'am (more children). My father ties the thread around a 'latthu' (roll) and then uses it there. My father ties thread on the bricks and does the measurement with this.
T: You saw it?
T: You have given very good examples of what we can all measure. When I will tell you more, you will be able to understand it better. Now, look here, I will tell you how to measure.

Kanchan, lesson 1, episode 2

There were also several cases where teachers used the context provided within the textbook. For example, expression questions such as "have you heard of a marathon?" (Figure 6.6, Subsection 6.2.1). In the excerpt below, Mahesh spends 10 minutes discussing different aspects of the context – What is a marathon? What does a stadium look like? What sports can be played in a stadium? What kind of sports children in their school play?

T: Many times in school there are competitions. Students go from school every year. There are tournaments, and games every year and many school children participate. Okay?
T: Last year a girl from my class went and she came second. It was an inter-school competition, where schools compete against each other. After which, if they win, they compete at district level. In every district, there are more competitions. And at last those who win then they..

S: They receive a gold medal!

T: They receive appreciation prizes (*Prashansa puruskar*) to celebrate that the participant has played very well. And apart from that they get something as a prize, either in form of money or a medal.

Mahesh, lesson 1, episode 1

When teachers were not inviting students to list examples or using the contexts from the textbook, they sometimes brought their own contextual examples and connected them to the mathematical topic. For example, Kanchan determined which objects were to be measured, closing any scope for students suggesting and discussing their own ideas or experiences about these everyday objects.

T: So, what you have to do for now is that you have to measure your maths notebook, your geometry box, your bag and your bottle.

S: We have to do it at home?

T: No, you have to measure it right now with your scale and write it. Those who do not have the scale, they can share and do it.

S: Ma'am we have to measure and write it in the notebook, right?

Kanchan, lesson 1, episode 3

Unlike the above examples (where context was purposefully included in the lessons), one idiosyncratic instance in Ganesh's lesson shows how 'open' questions can unintentionally lead to students bringing their own notions into the lesson. Ganesh asked an open introductory question on 'patterns' and the children answered it based on their own association (smart phones) with the term. Ganesh then attempted to link the colloquial understanding to the mathematical notion, but became impatient when the children were unable to connect the two ideas. He, thus, resorted to moving onto the more mathematical/textbook understanding of patterns as repetitions based on a rule (which is very different from how phone locking patterns work).

T: What is a pattern? Say something, say right or wrong. What is it?

S: Sir, lock

T: lock? Meaning? What does that mean?

T: Vishal, what is a pattern?

SS: Sir-ji, that is there in the phone.

<u>T: In the phone? Go ahead.</u>

S: There is the pattern there.

T: The pattern for the lock? Pattern lock? Okay. What does that mean? So, in that there is something like this (He makes a phone lock pattern on the black board)

S: Yes sir.

T: So, what is the meaning of pattern then?

S: Sir, lock (only a few speaking)

T: Arrey (annoyingly). What did I say? These are dots. By joining these, you get a new thing?

SS: pattern.

T: Now, if the same thing is repeated, like this, then? Now see, here, the line is straight, then it becomes slanted, and then straight again. So then again this is straight, slant, straight, so again what will happen it will be slant again. Then again straight and slant. So, what is this?

S: Pattern

Ganesh, lesson 3, episode 1

Hence, the inclusion of students' experiences comes into the discussion in several ways first, the teacher asks students to *list examples* from their own experience; secondly, the *teacher chooses* what aspect of students' lives will be brought into the task; and third, the teachers bring in *textbooks' suggested contexts*. Finally, teachers provide *open questions*, which also might unexpectedly mean that students bring ideas from their own lives. Inclusion of students' voice also opens up an important contradiction between their everyday understanding of terms used in mathematics classrooms, and what teachers are aiming for them to understand. Both in Kanchan's case (of neglecting students' knowledge of measurement) and Ganesh's case (of trying to steer the discussion around patterns towards what was defined in the textbooks), while the teachers encouraged student examples, they found it difficult to link it to the 'mathematics' they wanted to teach.

6.3.2 Context as story-based word problems

In many of the episodes (28 out of 76) the teachers used short story based problems, which can be viewed as traditional word problems (Verschaffel et al., 2000). In section 6.2, I have already discussed how teachers either directly provided answers to such word problems or gave elaborate explanations. Thus, contexts in the form of traditional word problems, were included on many occasions. Interestingly, even in some longer thematic chapters, teachers, such as Afreen and Sanchita, adapted tasks into word-problem like questions. For instance, in

Afreen's lesson 5, while working on the chapter – *The Junk seller* (a thematic story based narrative about a junk seller and her life: see Subsection 5.2.2), she used the context of a 'ratelist' provided in the textbook, but she adapted it into three episodes. (1) She first discussed what a ratelist is; (2) then explained how two ratelists can be compared (the ratelists were taken from the book); (3) and finally, focused on just one ratelist, creating multiple questions about finding the cost of different items on the list. She adapted the textbook task contexts to make different types of eliciting questions. Thus, even the longer story-based contexts are converted into shorter word problem-like questions.

6.3.3 Contextual objects: moving to a decontextualised representation

As discussed during the textbook analysis, the contextual objects in the textbooks are represented *illustratively* (more authentically real life) or *schematically* (using symbols or simplified) (Subsection 5.3.1). The reason for this distinction is to explore the 'authenticity' in the representation of the contextual objects within the textbooks. During the classroom observations, I found instances when these contextual objects were used. In the following section, I will discuss few of these instances especially highlighting how teachers treated these elements of the textbook.

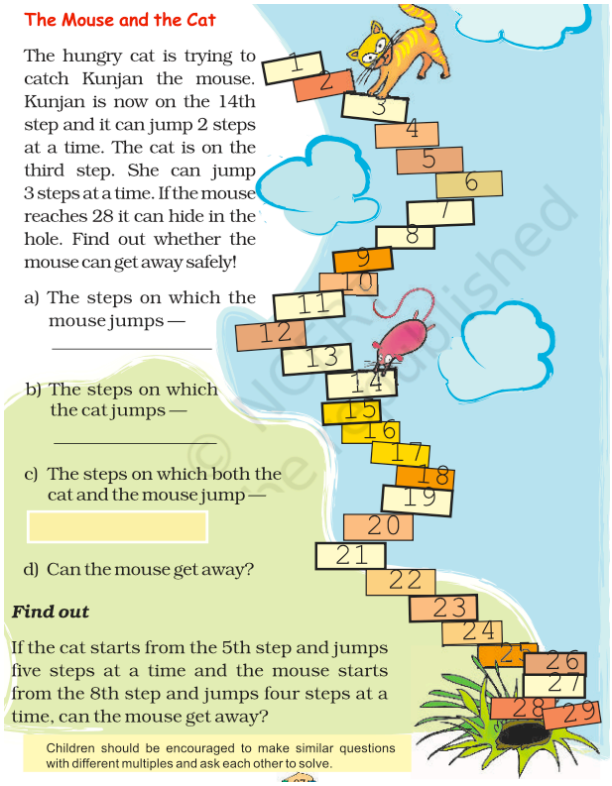


Figure 6.15: Book 5, Chapter 6, Task 5.6.2, page 87

For example, task 5.6.2 (Figure 6.15), coded as having a short contextual story with a contextual object drawn schematically, was used directly in Bhumika's third observed lesson. The contextual object (illustration given alongside the task) was coded as schematic since the 'steps' drawn where the cat and mouse are jumping are not 'authentic' illustrations of real-life ones. These is a 'mathematical adaptation' of them, represented as numbered blocks. Thus, the space where the cat is chasing the mouse is a mathematical one[79], which the reader must imagine. However, unlike a typical number line, which is commonly drawn horizontally, the textbook uses a vertical representation of a whole number one. In terms of its use, Bhumika moved the task into a much more decontextualised/schematic domain. While explaining the task, she used the representation on the blackboard below (Figure 6.16). The steps were represented as a series of numbers and the jumps indicated symbolically. Hence, the teacher reformulated the solution, by converting the contextual object into a more decontextualised form and then discussed it. In other words, she used the blackboard to reformulate some of the contextual illustrations in a more schematised way to cover the task. This is similar to her approach of distinguishing between the 'textbook' and the 'exam' ways of solving the (see Subsection 6.2.1). While the textbook might have a more contextualised schematised representation of a number line, she provided the students with a more 'mathematical' representation of it.

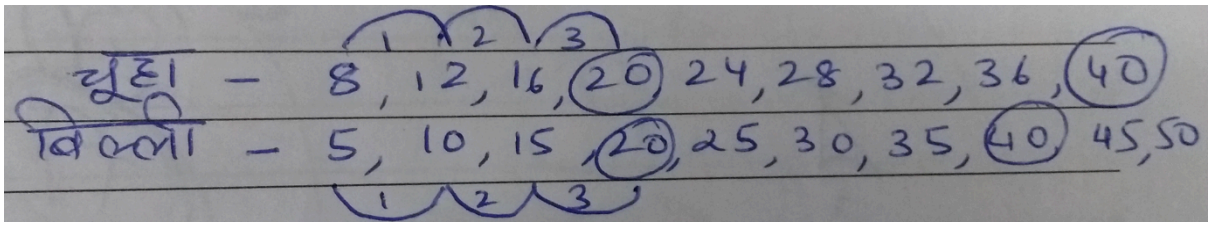


Figure 6.16: Bhumika's blackboard work from observation notes (lesson 3, episode 1)

An example of an adaptation where the teacher attempted to retain the 'illustrative aspect' of the contextual object is the following. The textbook task asks students to increase the length of certain contextual objects and then draw them (Figure 6.17, right). Sanchita showed me how she pursued a similar (adapted) task, where the students were asked to decrease the length of an object and redraw it. In this adapted version, the length of the tree was measured by drawing a line segment next to it and its length was reduced from 6 cm to 4 cm (Figure

[79] Note that the distinction I am drawing here between mathematical and real-life as opposites is highly simplistic. Dowling (1999), more accurately perhaps, has called these esoteric versus public spaces. However, for the particular understanding of the objects represented in terms of imagery, I have used ideas of schematic versus illustrations.

6.17, left). The line segments acted as a mathematical proxy for the tree. From the perspective of ‘authenticity’, these tasks are hardly meaningful as these measurements can never exist in ‘reality’ (see Subsection 5.3.1). This ‘unreal’ context was replicated by the teacher, who did not question the task’s inauthenticity. This suggests that teachers (like certain textbook tasks) adapt contextualised objects into a mathematical form (in this case the line segment), irrespective of how ‘authentic’ that adaptation may or may not be.

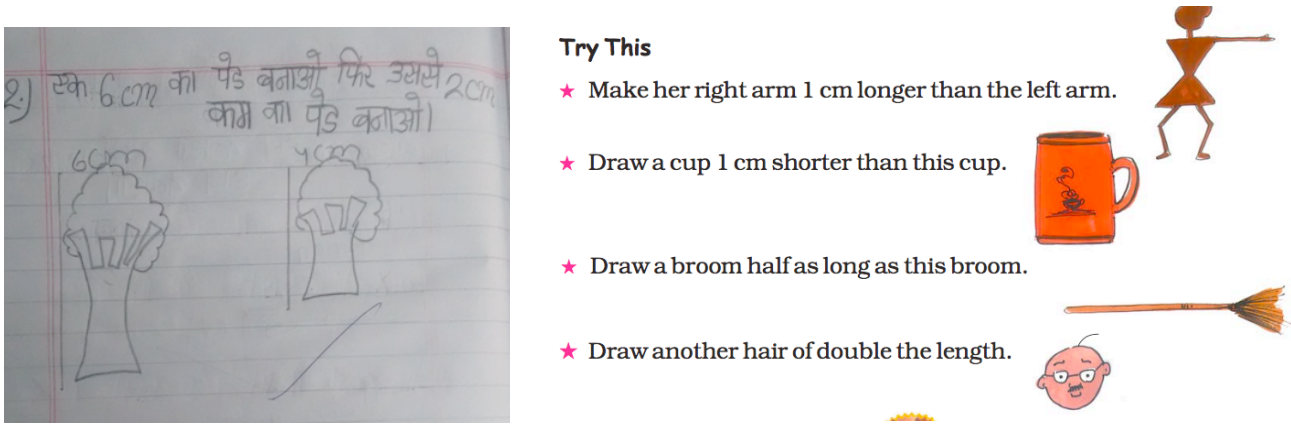


Figure 6.17: Classwork in Sanchita’s lesson (left); Book 4, Chapter 2, Task 4.2.3, page 14 (right)

In some instances, the illustrations given in the textbooks also cause confusion. For instance, in the following task (Figure 6.18), many students started counting the bangles in the illustration and when they did not add up to 18 this brought up a contradiction. The teacher then made an important clarification proclaiming the superiority of the ‘text’ over the ‘image’ and thus, directing the students to focus on the words.

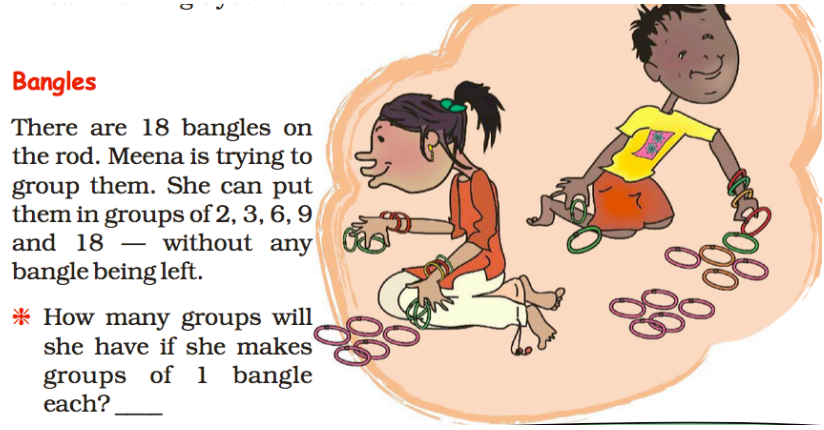


Figure 6.18: Book 5, Chapter 6, Task 5.6.10, page 94

T: See again, are there 18?

SS: There are 18, there are 13 (mixed responses)

T: Don't look at the book. That is [just] a picture. In the picture, all the bangles are not there. In the picture, all are not given.

T: The picture can show whatever, in the book it is written there are 18 bangles. So, we have to work with 18 bangles.

Bhumika, lesson 4, episode 3

In another example of a mismatch, the authenticity of the imagery used in the textbooks comes up again. In task 5.5.9 (Figure 6.19), a fan has been drawn 'schematically' and not illustrated. During the use of this task, when the teacher asked the students to look at the 'fan', they argued that this could not be a fan since it has just four blades. Students repeatedly point to this, indicating their difficulty with the image.

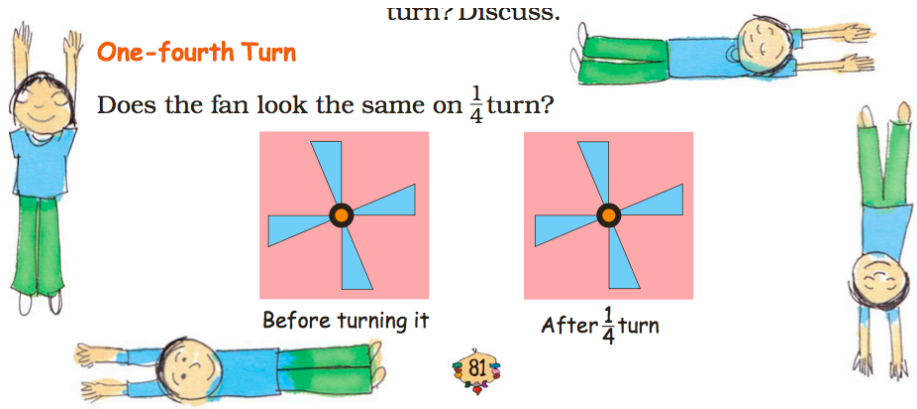


Figure 6.19: Book 5, Chapter 5, Task 5.5.9, page 81

1.16: See now we will come to this page, page number 81. One-fourth turn. Okay?

T: There is one fan, which has four blades (*pankhudiya*), and those are at equal distances.

SS: (one girl says) Ma'am there are only three 'blades' (*pankhudiyan*)

T: No, here there are four

[after some discussion on the task, students again say]

SS: Ma'am but there are only three [blades]

T: No, this one has four.

SS: There are three.

T: Yes, there are but some fans [can have] four blades too.

Bhumika, lesson 5, episode 1

Overall, we can see that there is a tension between the representation of real-life objects when shown more authentically and when shown more schematically. The teachers had to deal with children 'getting stuck' (Lubienski, 2000b) regarding these issues, for instance,

when they started counting the bangles or did not believe that the representation could be a fan. In such cases, the teachers redirected the attention to what they believed more important, i.e. the 'written' text or the assumption behind the representation. In the other cases, the teachers used some kind of *simplified schematic representations* (number line, or line segment next to the image), thus shedding its real-life authenticity and moving the focus to a more decontextualised mathematical domain. In these cases, the objective seemed to be to discuss the esoteric mathematical property and the context simply acted as a "veneer" (Maier, 1991, p. 62), which needed to be shed (see Subsection 8.3.2).

6.3.4 Contexts linked with morality or social justice?

One of the features used in the textbooks is the notion of social justice issues. Some of the tasks within the books (especially the thematic chapters in Books 4 and 5) aim to bring to the fore socially relevant themes. For instance, in Chapter 6 (Junkseller), which has an overarching story of a woman Junkseller, touches upon issues of gender and caste (Rampal, 2015). During neither of the two observed lessons given by Afreen, when she this covered this chapter, did she explicitly mention any of these social justice issues. She instead focused on the notion of multiplication and the unitary method, which she saw as the core of the chapter. As seen below, she mentioned how the story in the chapter was 'inspirational', however emphasised that the lesson is primarily tackling 'mathematical' ideas of multiplication and unitary method.

> ME: So, you had already started the *kabadiwali* (Junkseller) chapter.
> T: Yes, I started yesterday. And in this, only her story has been told. Her <u>life story [which is] inspirational</u>. Even for the children it's good.
> ME: So, you told the story yesterday.
> T: Yes. I just told the story yesterday and discussed a few 'sums' (questions) of that type. <u>Basically, the concept is of multiplication, and unitary method</u>. That, if one thing is this, then for many things what will it be? So, to take them to unitary method I thought doing this was important.
>
> Afreen, lesson 4*, interview*

Further, while teaching this chapter, Afreen explicitly linked the name of the chapter with the concept – so that children could remember that it was about multiplication, and presumably not get distracted by the story.

T: *Bete* (children) we are doing multiplication, multiplication! Remember *(yeh dhyan rakhna*), that *kabadiwali* (Junkseller) means multiplication

T: *Kabadiwali* means?

SS: Multiplication (children repeat after her)

T: In the entire chapter, we will be multiplying.

Afreen, lesson 4, episode 4

No other teacher explicitly or implicitly attempted to raise any of the social justice issues embedded within the book. Instead, they spoke about students' lives and society in a much more normative fashion. For instance, in Kanchan's lesson, she started the lesson on time (Tick-tick-tick) by narrating a story (insertion) about a boy not being punctual and then, ending up missing his own exams. Such stories of lessons of ideal behaviour, '*samay ka palan*' (virtue of being punctual), are common in primary schools in India (see Manjrekar, 2007 for an analysis of the notion of the ideal child promoted through classroom pedagogical practices).

T: He started playing with them. And he thought that he will play only for 5 minutes and after that go to my school. But he got so busy in playing that he forgot to keep track of time. When the bell rang, when the [exam] paper started, he kept playing over there. So, when he remembered that he had a paper in school, he ran. But what had happened till that time? The paper had already started. He said that Ma'am, I got late, please let me come inside. Teacher took him inside also. But would he be able to able to finish his paper?

S: No, Ma'am.

T: He was late by half an hour because of which he would not be able to finish his paper. Then, what did he think he would do?

S: See the time.

T: He will always be punctual (*samay ka paalan karoonga*). Whatever work has to be done at a particular time, I will only do that work.

Kanchan, lesson 2, episode 1

Thus, when socially relevant stories did find their space in the classroom (outside of being used as word problems, as discussed above), they were used for inspiring or moralising the children about ideal behaviour. Interestingly, in both these examples the teachers used an example of a boy, despite the fact that Kanchan taught an all-girls class. Thus, the

construction of this 'ideal' child was a boy. In Neetu's episode below further stereotypes about a girl's ideal behaviour come out.

> T: How many children see the clock before leaving their house? Only half of the children? And the other half, you don't see the clock before leaving?
> T: What time do you get up in the morning?
> S: 6 'o' clock.
> T: You get up at 6 'o' clock. What do you do after that? Do you help your mother with something? Do you help your mother? Children who get up at 6 am, must be helping at home with something. How many girls help their mothers in the morning? What do you do in the morning?
> S: Ma'am, I brush and mop.
> T: You come after brushing and mopping the house. That means there are quite a few girls here, who help their mothers and then come to school. And this is a good thing. It's good to help them a little bit. Very good.
>
> Neetu, lesson 2, episode 3

Thus, it is not just that none of the teachers seemed to pick up the social issues that the book talks about, for they also continued uncritically to reaffirm normative notions of the virtue of an 'ideal' child. Thus, there is a need for teachers to themselves become aware of how to bring in critical issues into the classrooms. The next stage is to be able to connect the issues meaningfully with the mathematics being discussed. Whilst in the use of textbook teachers were not discussing 'social issues', there were some who seemed sensitive towards to the life situations of the students and even talked about them critically. Teachers' own perspectives on students' lives, are discussed in Chapter 7, Subsection 7.4.4.

6.3.5 Contextual language and vocabulary usage

One of the significant ways in which 'context' interacted with mathematics was in the choice of language used in the textbook and that employed by the teachers. Here, I take language to include both the medium of instruction, as well as the vocabulary/terminology introduced. When analysing the textbook, I did not identify 'contextual words' that are used within the tasks, but it is clear that the authors have attempted to prioritise contextual terms over more 'mathematical terms' (several teachers' notes suggested not using the formal terms). However, in the context of these schools this becomes complicated due to language choice. As discussed in the Methodology chapter, while these schools use the Hindi medium, a few

of them have English medium sections and many students often transfer from private schools, where they learnt in English. This complicates the distinction between 'mathematical terms' and 'contextual terms'. One of the teachers (Deepali) had explicitly to tackle this issue since she had a mixed group of students – some who were studying in the Hindi medium and the rest in the English one (thus, some used Hindi medium books and other English). So, she taught both in English and Hindi. For example, in the following excerpt she taught the three ways of reading time: formal Hindi, English and colloquial Hindi.

T: Now, the time is three fifteen. What is it?
S: Three fifteen
T: We will call it *Sawa teen* in Hindi. What will we say?
S: *Sawa teen*.
T: And, how do we say it English, Afsha? Quarter past three.
S: Quarter past three.
T: Fifteen minutes past three. (*teen bajkar pandrah minute*) (H)

Deepali, lesson 2, episode 6

Afreen also struggled with this issue and termed the Hindi version of the talk as 'local language' (even though she taught a Hindi medium class). There were many instances, where the teachers tacitly moved between the different languages and it seemed like even though these were primarily Hindi medium spaces, there was an assumption that there was some knowledge of English as well.

T: Lakshmi, how will you show three hours fifteen minutes (*teen bajkar pandrah minute*) on the clock? Show on the clock.
T: *Sawa teen*, as we say in the 'local language' (E)

Afreen, lesson 3, episode 3

Thus, the decision of using Hindi or English (when and where) had to be confronted by teachers in 'purely' Hindi medium classes too. As articulated by Bhumika, this is because children often change schools. They attend private English medium school where they learn numbers and operations in English before moving to a Hindi medium government schools. Mohini too discussed this issue, claiming that students were becoming weak in number names since they learnt in both Hindi and English; not gaining fluency in either (Interview 1). Teachers often had to take this into consideration when interacting with students. For example:

T: This is right. Aniketa will you write in Hindi? You can write in English. Should I write in English (asking the whole group)?

S: Yes Ma'am

T: Okay, she will write in English. I will tell you in Hindi after that.

T (to me): this girl has come from a public[80] school so she knows it in English. Now, she's just come into 5th grade.

SS: Ma'am we also know it in English, yes Ma'am me too (some girls talking)

Bhumika, lesson 1, episode 1

The issue of using 'contextual language' and terms thus opened up a unique struggle, which the teachers consciously or unconsciously grappled with. The textbook brings with it the question of using 'mathematical' or 'contextual' terminology. In terms of the 'contextual terminology', what is further complicated is that students often have knowledge of a few English as well as Hindi terms. Thus, when context is allowed to enter mathematics classrooms, these complex issues of language also seem to come up. This is especially problematic for these textbooks, since the authors have avoided giving explicit 'mathematical terms' in many cases and instead, have encouraged students to use their own everyday terms to talk about mathematical constructs.

6.4 Analytical summary of the findings

In this chapter, I have discussed three important aspects of teachers use of the textbooks: selection of the textbook tasks and how they structure their lessons (Section 6.1); interpretations of the voice of the textbook (Section 6.2); and interpretations of the notion of context (Section 6.3). In this section, I summarise the key findings.

- Overall, in 54% of the observed episodes for the ten teachers' direct textbook tasks or adapted textbook tasks were utilised, with the remainder being insertions. Thus, important as the textbook tasks are, teachers were also including content of their own. While overall it was evident that all the teachers were using both the textbook and their own insertions, on a closer look, it was found that they did not have similar preferences regarding the textbook tasks. While four teachers primarily used direct textbook tasks (for more than 50% of their episodes), the other six used their own insertions for most of the episodes. Thus, it was important to take a closer look at the ways the textbook featured in the lesson structures.

[80] Private schools are known as public schools colloquially.

- Two types of lesson structures were found to be used by teachers. First, lessons that followed the textbook script and thus, the teachers attempted to move from one task to the other. Second, lessons that primarily used insertions and textbook direct use or adapted usage was supplementary to these insertions. While a few teachers chose to use one type of structuring over the other (such as Mohini, Mahesh and Sanchita, who almost always relied on textbook scripting), other teachers switched between these types.
- Further, depending on the type of lesson (structured around the textbook or insertions), adaptations and insertions were also observed to have different roles in their teaching. In some cases, especially in lessons structured around the textbook script, adaptations were to ensure that all the textbook tasks were being 'covered'. In these cases, instead of engaging deeply with all the components of the tasks (eliciting and non-eliciting), teachers only cursorily discussed the theme or the mathematical topic within the task. In other cases, insertions and adaptations were mostly to provide students with some opportunity of repeating a particular type of task by adding eliciting tasks similar to those in the textbook or providing explicit mathematical information and procedures. This was possibly done to complement the lessons and provide support that was deemed as 'missing' from the textbook tasks. Finally, there were a very small number of cases of adaptations where teachers seem to develop and extend the textbook task in alternative ways – embracing some of its features. For instance, Afreen was observed adapting a specified task into a generation one, which opened it up in different ways that enabled discussion on several mathematical concepts.
- In section 6.2, my focus turned to the observed episodes, where I explored the ways in which teachers seemed to interpret the notion of 'voice' within the textbook. As discussed in the previous chapter (Section 5.1), the textbook authors, by using different features, have attempted to shift the way students are to interact with the book as well as mathematics. Three elements of this shift were explored in terms of the way teachers presented the textbook tasks (and other insertion or adapted tasks) to the students. First, the textbook discourages mathematical facts and procedures being presented explicitly before students have a chance to engage with the processes. Thus, via tasks which require students to 'scribble' or 'think', a more process-oriented approach is embedded. The evidence has shown that not all teachers had abandoned 'telling' the answers or solutions directly to the students. On the one hand, teachers,

such as Mohini and Mahesh seemed to be incorporating process-oriented multiple solutions to tasks presented to the students. On the other, those, such as Sanchita and Neetu directly gave more formulaic solutions without engaging with an explanation of the procedures. Also noteworthy is the possibility of misinterpreting some of the task solutions. Sonali's misunderstanding of a task and what it required, shows that there is room for more support to teachers in enabling these process-oriented pedagogies, rather than just removing direct solutions/procedures/information.

- In terms of the opportunities teachers provided for student voice to enter the lessons, two aspects were explored. First, different forms of student engagement, i.e. how they were 'scribbling' and 'doing' mathematics (Subsection 6.2.2) and second, how they were 'thinking' and reasoning (Subsection 6.2.3) were investigated. In terms of 'doing', there were still some cases where teachers were using the 'chalk and talk' method (Ramachandran, Bhattacharjea, & Sheshagiri, 2008; Seshadri, 2000), whereby they wrote the solutions on the blackboard and the students simply had to 'copy' them in their notebooks. Yet, there was strong evidence that several were moving away from such simplistic pedagogies. In lessons delivered by Bhumika, Mahesh, Afreen, Kanchan, Mohini and Deepali, these teachers were making efforts to ensure that all students could access what was being covered. This was done by asking them to answer the questions on the blackboard (Bhumika), asking individual students sub-questions (Mahesh) or grouping students to address their doubts (Afreen). Another important way in which students were given something 'to do' was to engage them in hands-on activities, which might involve them creating something (matchstick shapes, clocks), attempting experiments or measuring everyday objects. These types of tasks were coded as 'construction task' in the textbook analysis (Subsection 5.1.2).
- The initiation of a mathematical thinking and reasoning discourse was also observed in the classrooms in different forms. Afreen was a rare teacher, who persisted with students and encouraged them to articulate their mathematical reasoning. It was much more common that teachers started asking 'why' and 'how', but failed to pursue their inquiry further for several reasons. In Mahesh, Kanchan and Mohini's lessons, the teachers steered the discussion towards their own explanations. In Ganesh's case, a similar discourse on the importance of asking 'why' was initiated, but unlike the other teachers, he did not create a non-threatening environment for students, who seemed to be too fearful to speak. Only Afreen seemed confident in asking students to provide their own explanations and keeping on encouraging them until they did so.

- Section 6.3 discussed how teachers used contextual tasks within the textbooks. The most common way of incorporating *students' experiences* was by asking students to list examples related to a mathematical topic. Teachers used the textbooks' predefined contexts, their own ideas, as well as students' examples. Much like the approach towards students' reasoning, these 'examples' were usually not pursued to develop meaningful understanding of the mathematical notions. The second most common use of context was seen in '*word problem*'- like questions. Teachers tended to adapt longer thematic tasks within the textbooks into shorter word problems as well. In the case of the use of *contextual objects* two crucial issues emerged. First, students at different points during making sense of these objects got 'stuck' regarding the contextual aspects of the tasks and instead of engaging with them, the teachers would more than likely urge them to move beyond them and focus on the 'mathematical' aspects. Second, teachers, much like the textbooks, often ignored the 'authenticity' of the contextual objects and simply used schematised versions, even if these were not realistic. Finally, there were examples where teachers were using transformations between 'illustrated' and 'schematised' versions of the objects – indicating that some were open to using multiple representations. These findings show that while the textbook seems to valorise contextualised knowledge, its use is not as straightforward. Some tasks that might seem to be using contexts might not be very meaningful, for example drawings of 6 cm long trees (Figure 6.17). On the other hand, more severe issues of suitability of contextualised tasks for marginalised children is also raised, for example children getting 'stuck' in details and not accessing the underlying mathematics. This finding resonates with Khan's (2015) critique of the NCF-2005 as well as the *Math-Magic* textbooks. She argues that these textbooks hinder access to 'powerful knowledge' for children who need it the most (See Chapter 2, Section 2.1.3).
- The authors of the textbook had the intention of including critical *social justice* themes and integrating mathematics learning within these. While the teachers were not observed addressing these explicitly in their mathematics lessons, several raised the matter of students' disadvantageous backgrounds, either viewing them through a critical and sensitive lens or as a deficit. This is discussed further in Chapter 7. An unusual yet important finding about context was in terms of the *language* being used. The textbook discourages using 'mathematical' terms and promotes the use of more

contextual understanding of these terms. Here, the conflict of Hindi medium versus English medium becomes pronounced. In India, there is a growing market for English medium schools and their challenging impact at the micro-classroom level in mathematics learning is evident in these lessons.

CHAPTER 7: TEACHERS' VIEWS OF THE REFORM-ORIENTED TEXTBOOKS

7.0 Introduction

In this chapter, I present the findings from teacher interviews, addressing my third research question:

How do teachers *view* the reform-oriented mathematics textbooks?

As explained in Chapter 5, for the textbook analysis, three textbook affordances were explored: textbook support, voice and the use of context (see Figure 5.1). In accordance with this, I discuss teachers' perceptions of these three textbook affordances in this chapter. Section 7.1 probes teachers' perceptions of the support (and its lack) provided within the textbook in structuring their lessons. Section 7.2 discusses teachers' views on the alternative ways of engaging students, as promoted within the textbook. Section 7.3 then covers teachers' views on the contextual tasks of the textbook. Finally, Section 7.4, documents the important issues raised by the teachers about their school's institutional realities as well as their pupils' out-of-school ones, which impact on their work.

7.1 Views on the Structure and Organisation of the Textbook

One of the features that the teachers talked extensively about was the structuring of the pedagogical and content elements within the textbook. Despite the fact that my questions initially did not explicitly ask teachers to discuss this, it came up repeatedly in their views. The following subsections discuss how teachers responded to the structure of the mathematical content in the textbooks (7.1.1); perceived topic 'coverage' (7.1.2); and missing practice questions (7.1.3). Teachers also spoke about the way this might impact 'other' teachers' work (7.1.4). While the views on these matters were common among most of the teachers, two special cases of those wishing to expand upon their view of the textbooks and their structure are discussed in the last subsection (7.1.5).

7.1.1 Structure of the mathematical content: labelling and arrangement of the topics

The structure of the mathematical topics was highly striking to the teachers, many of whom who commented on it. They discussed not just the arbitrariness of the *labels chosen* by the authors for the chapters and headers, but also, *arrangement and sequencing* of the topics and

questions. For instance, teachers, such as Neetu, Ganesh and Sanchita, did not believe that the names of the chapters adequately signified the mathematical topic being introduced.

> The names of the chapters are like that, [for example] this [chapter] is about money transaction. So, the name also should have been like that, but the name that they chose is 'Kabbadiwala' [Junkseller]. Here, 'Tick tick tick', is absolutely right, by the name you can make out that it is about clocks.
>
> Sanchita, interview 1

> What is there in 'Trip to Bhopal'? Like, after reading the lesson, you don't understand what is happening. The names are such, that is why. Here, they could have given questions on distance, like, if you are going to Bhopal, then how long will it take. Things like that. So, it is very difficult to teach; it is very strange (*ajeeb sa hai*).
>
> Neetu, interview 2

With respect to arrangement of the topics, some teachers especially felt that there was a need for clear delineation of the mathematical concept. For instance, Kanchan talked about the need for the demarcation of topics. Similarly, Deepali and Bhumika also discussed how instead of the conflation of different concepts, there should be a focus on clearly indicated specific topics.

> If there was some demarcation given, like we are doing 'time' for some time, and after that we are doing 'distance' and then integrating it with this, then children would have understood it clearly.
>
> Kanchan

> They are [even] giving a question on multiplication within this; they have an integrated approach. Like, if there is a chapter on multiplication, it should concentrate on multiplication sums. I mean you can do 3-digit, 2-digit multiplication and then you can do unit based questions.
>
> Deepali

> Like, this chapter is there. These types of things are there in other chapters also. So, there was no need to put it in this chapter. They have done this with other chapters also. In one chapter, they have included many things but this one is very lengthy.
>
> Bhumika

Interestingly, many teachers seemed to have this concern about the first chapter of both the books (Fish Tale – Book 5; Building with Bricks – Book 4). They were not happy with the way the text was organised in these chapters, which they felt mixed-up too many concepts into one. The first chapter seems to be crucial for Bhumika and Mohini, who felt that it "should be very interesting" (Mohini), but instead was "boring" (Bhumika) and did not work well with the children. These comments about the first chapter are important, especially since authors have explicitly written them as "thematic chapters" (p. 6) integrating several aspects of mathematical content (Rampal, 2015) (see Subsection 5.3.1). Most teachers ranked these chapters as their least favourite (see Appendix E).

> In a single chapter, you are teaching length, shapes and unit sums, actually they should have different chapters for all of these. I would have divided it into two parts. You know, there are two types of questions in it. One is unitary method that: 1 kg fish costs this much, then 2.5 kg will be how much? And then [second], speed and distance are there, which should have been a separate chapter in itself. [] They have related it [both] with fish and all. I could not understand it. They have given it in depth. They have told about the 'Fish bank' and that this much loan was taken for it. I think too much has been given in this. It looks like 2-3 units have been clubbed together in it. If they would have given 'Speed and Distance' separately, maybe children would have understood it properly.
>
> Bhumika

> They have not clearly mentioned here, that what needs to be done. The concept is not very clear and what is 'machli ucchli' (Fish Tale). If they had given good questions, then it would have been better. Yes, actually it is not very clear. That too they have made it into an entire chapter - if it was only one part it would have been okay. There is nothing worth doing in that (*karwane layak*).
>
> Sonali

Furthermore, half the teachers (Kanchan, Sonali, Ganesh, Sanchita, Afreen) commented on the lack of progression of topics within the chapters (and across them), from *simple to difficult*. To give an example, Sanchita talked about how the first chapter in Book 4 contains a high-level multiplication question, whereas the subsequent chapters contain much simpler tasks relating to the topic.

> [In the first chapter] it has a very big question [Rs 12,000 per brick]. Like, if it was Rs 12 or Rs 13, then they would have understood a little bit. So, in the first chapter itself, they

> have asked such a big question. Yes, in [the later chapter on *Junkseller*, the questions] are much smaller. In that they did it easily, but they could not do this big one.
>
> Sanchita

> First an easy chapter, then slowly difficult and more difficult chapters. And in every chapter also, there is an explanation of easy questions, then for the hard questions. And if there are very hard questions, then its explanation should be written at the back of the book.
>
> Ganesh

As can be seen, these teachers did not agree with the choice of labels, integration of topics and progression of tasks within the textbook. Yet, they seemed unable to describe what this new 'structure' exactly was and the authors' intended purpose for this arrangement. Thus, teachers like, Neetu exclaimed that "I don't understand what is happening". In a similar vein, other teachers described this obscure nature of the textbooks by calling them "mixed up" (Neetu), "upside down (*ulta pulta*)" (Deepali), a "mess" (Mohini), "mixed veg/*khichdi*" (Kanchan) etc. This lack of meaningful articulation of textbook's features was reported across the themes (discussed further in Subsections 7.1.5 and 7.4.3). Instead, of describing what the structure was, teachers tended to point to what they felt was missing. These 'missing' structural elements in the textbook are further discussed in the next subsections.

7.1.2 Missing coverage

As discussed above, a few teachers explicitly disliked the integration of multiple topics within the same chapter. On the other hand, even for the chapters with the same mathematical content (see Appendix C), some felt that the book did not necessarily 'cover' the topic adequately. For instance, in the quote below it can be seen that Deepali talks about a lack of depth regarding the notion of perimeter. She felt that, if this 'concept[81]' is dealt with, then it should be covered for all shapes and not just limited to the shapes of rectangles, as covered in the chapter. She also highlighted the significance of the absence of mathematical definitions and terms, contending that their lack disadvantages children who are expected to have this knowledge in higher grades.

[81] The notion of 'concept' is very complex in mathematics education literature – here, I am not using any specific definition, but use it to loosely to mean different school mathematical domain areas – and specific sub-domains that have become part of the mainstream school mathematics syllabus.

> In the chapter 'long and short', first you come upon centimetres, then metres, then area and then perimeter. Now, if you are doing perimeter, then do it for all [shapes] - like circles [and other shapes]. Here they have only done for a square field. There needs to be a rhythm for the course. That when you start something then you make sure that you have touched every aspect of it.
>
> Deepali

> How will you do the concept building, if you do not give definition and the terms. The child will go to sixth grade and then learn these terms?
>
> Deepali

Similarly, Kanchan and Afreen talked about missing concepts, such as 'counting' and 'conversions'. It is important to note that Afreen's grievance was not with the genre within which the concept is presented (she suggested that the topic could be added in any format including a story), but the absence of the concept itself. In Chapter 6, Subsection 6.1.1, it was shown how teachers, such as Afreen and Bhumika, introduced topics on their own, which were not included in the textbook.

> Nowhere in this book have they given the concept (E) that how can counting be taught. They have directly arrived at the number itself. This is a really big issue in the book. The 'basic concept' (E) has been left out.
>
> Kanchan

> So, when children had been introduced to centimetre and metre in the 3rd grade, then conversion could have been done in this chapter. There are no activities related to conversion in this. There should have been some of them here too. Like, we have introduced the shapes, so we could have left all this. We could have put the conversion activities over here. Like, if we have to convert from centimetres to metres or from metres to centimetres, so what activities are there or there would have been some story in which conversion could have been involved. So, the children could have understood that.
>
> Afreen

The importance given to coverage was further evidenced by the fact that, when asked which chapter they felt was the best among the ones they attempted - most teachers in Grade 4 chose 'Tick-Tick-Tick' (see Appendix E). They attributed this to the coverage, expressing how the chapter adequately dealt with all the topics of that content. This signifies that these

teachers were still able to find chapters within the textbook that they believed worked better than others. They appreciated those chapters, which from their perspective, were clearer and covered all aspects of the needed topics comprehensively.

> ‘Tick-tick-tick’ was a good chapter. It covered all the aspects. So, according to time, all aspects were given; timeline was there, and then 12 and 24-hour clock, [etc].
>
> Deepali

7.1.3 Missing practice questions

Another important element emphasised as missing in the textbooks by many of the teachers was *practice questions*. This was clearly a contentious issue among them and even one who did not think of it as crucial (Mahesh), commented about it as being something important for many of the other teachers.

> Yes, many teachers say that, let the chapters be like this, but there should be exercises given at the end of the chapters. There should be exercises based on it. Like, if we take *Bhopal ki sair* (Trip to Bhopal), it is practically related to addition and subtraction. But, after that give like 5-10 questions after this, readymade [based] on that. I guess, they can make their own exercises. But then, their work is increased. It is not 'readymade' (E).
>
> Mahesh

This concern that Mahesh expresses above, was echoed by several of the teachers in my sample (Bhumika, Kanchan, Sanchita, Afreen, Deepali, Mohini). The most common reason for the need for practice questions was ascribed to its role in mathematical learning. Specifically, repeated work was viewed as a way of gaining procedural fluency as well as understanding.

> [If] there is a repetition, they get into the habit so that they can answer it verbally and instantly. The child would not have to think about it. We do these kinds of exercises in the classroom also, but if they are given in the book, then there is no harm in it, right?
>
> Afreen

> There are lesser practice questions, which we have to give [additionally]. There is very little scope for practice with these children, because children don’t understand with one thing [example]. Till they apply in 2-3 places, till then they would not have ‘concept

clarity' (E). It is not just children, but even us [adults]. Till we 'apply' (E) in two-three places, we are unable to do it. This we have to do on our own.

Kanchan

Similarly, for two teachers (Neetu, Sanchita) practice questions were also essential for another aspect of their teaching – homework. They discussed how it has now become harder to give it using these textbooks.

Ok. After that, in the end of the chapter, they should give [questions] for practice. There should be 3-4 pages for practice, which they do at home by themselves.

Sanchita

There should be like a proper exercise that you can keep doing. That is missing here. The questions that are given here are not that great. If I have to look for homework exercises, that becomes very hard. We then have to make our own questions. Like, you cannot just say do these page questions; instead you have to write the questions on the black board yourself. In private schools, teachers just mark in the book and say do these questions.

Neetu

Mohini raised a more functional purpose of these kinds of tasks, which enable teachers' work to become easier, especially in a context where they often need to leave the classrooms for other administrative work (see Subsection 7.4.1). In Subsection, 6.1.1, it was seen how teachers use more 'traditional' practice questions in days when there is a disrupted class.

In this [book] I feel, that [even though] there are many activities to do here, the thing is that the teacher effort needed is too much. And like sometimes, in MCD schools this happens that we have to do a lot of work sometimes. That [principal] sir has called us, and if we tell the children to sit and do this lesson, then they cannot do it on their own. Exercise work is very little here. So, either you give it on the board separately, then it is okay. But if you tell the children to do it on your own from this - that one number is given and you do after that, then that is the problem here.

Mohini

What comes out strongly is that 'practice questions' was an integral part of their typical mathematics teaching used not just for mathematics learning, but also for providing students

with classwork and homework to be done on their own. Teachers seem to structure their mathematics lessons in a particular linear fashion: moving from introduction of the concept, explanation using examples and then finally, student practice. This pattern was referred to by several teachers as they attempted to make sense of the textbook and particularly, the absence of practice questions within them. As can be seen below, Afreen talked about first understanding and then practising. Similarly, Mohini and Sonali also talked about the teacher's role in explanation and then, the students' role in terms of practice. While Kanchan discussed how the sequencing needs to be 'examples' to 'concept' (inductive), rather than the other way around (deductive); she still had a linear model of teaching in mind. In such a model, practice questions which are done by students a part of "self-study" (Mohini) is crucial. Thus, in an activity-oriented textbook such as these, the teachers felt that the latter 'student practice' aspect of their teaching was not being included.

> Like, we will make them understand the method and they can sit down and practise that on those exercises. In this, children can be kept busy. But in activities, if I am not there, children cannot do it on their own.
>
> Afreen

> Sometimes, these details are not important. We have taught them and children do it on their own, then the work of the teacher becomes easy. You have explained, given them examples, then [children] do the examples on their own. For that the teacher has to prepare 10 questions, which increases the work of teacher. So, I think that the work of the teacher should be reduced.
>
> Mohini

> If our book is like this [privately published book], as you can see there are so many practice problems given here, numbers etc, they are given in such a proper way and the children can get so much practice. These are [questions] which the children are supposed to do by themselves, if we explain the concepts, then they can practise by themselves.
>
> Sonali

> The book's approach is 'inductive-deductive' (E). It goes from examples to concepts, but that approach gets lost somewhere. For the sake of adding activities, the basic things are lost. So, we have to study that first, and find out what the chapter is trying to do.
>
> Kanchan

> My point of view is that, [first] they give all shapes of 2D and 3D, then it's questions, like this is cylinder and its examples, its role and its importance. These descriptions or it's examples would be more beneficial, than these patterns.
>
> Deepali

Having discussed how many of the teachers believed that practice was important in their teaching, and find it missing in the textbook, the question arises as to who is responsible for providing practice – is it the responsibility of the textbook authors or the teacher? In this respect, Afreen's changing stance in her two interviews is particularly revealing. In both the interviews, she articulated that practice is important for mathematics learning, but when asked if the textbook should include it she expressed opposing views on the two occasions. In the first interview, she talked about how the textbook had already given so much and that it was really not its job to provide more practice, which teachers could easily provide on their own problems. In contrast, during the second interview, it can be seen below that she discussed how the absence of practice questions in the textbooks was an important issue that needed to be addressed by the textbook authors.

> The book is giving so much. So many activities are given that it's difficult to even do all of these. These activities are fantastic, and we are unable to even give these. We can always take out practice questions from these. This depends on us. It's not like they should provide everything in writing [in the book]. If it is all readymade, then what did you [as a teacher] do with the children on your own?
>
> Afreen, interview 1

> There are lots of activities. There is no dearth of activities. Even if they are reduced a little bit, it won't affect much, because they are telling the same concept again and again. Ok, it is important for the practice of the child, but the exercises which are important for practising are not many. So, like I am doing extra as per my wish, I will be able to do them, because I feel that children need to do more on this. But there are teachers who will not do anything extra and they might feel burdened while doing so many activities also.
>
> Afreen, interview 2

It is also important to note that the first interview was undertaken at the beginning of the term, when the Afreen was just beginning to teach. On the other hand, the second was at the end of the half-term, when she had covered almost half the textbook. This helps in contextualising the feeling of "burden" that she talked about, starting off with having greater

expectations from her teaching, but slowly being weighed down by several constraints. Afreen's contradictory response brings an essential dilemma to the fore (as also articulated by Mahesh, Mohini, Neetu). Teachers found certain important elements to be missing from the new textbooks, thus placing the responsibility on them to provide their own practice questions (and other missing elements). At the same time, they suggested that many teachers find doing so too burdensome. In such a situation, how many teachers would make that effort and see it as a part of their teaching job is questionable (this is discussed further in Subsection 7.4.1). This is articulated by Afreen below:

> They [NGO for teacher training] said that you can also add practice yourself. Only one or two teachers can do it. For example, if there is a group of 30 teachers and they are teaching maths every day, only four will include it, 26 will not do it. But if you will give practice in 'readymade' form, then there will be compulsion on us to do that.
>
> Afreen, interview 2

7.1.4 Teachers' view of other teachers' textbook use

This dilemma of additional effort needed by teachers (and whether they would make it or not) was addressed by several teachers who spoke about 'other' teachers (as Mahesh and Afreen were seen doing in the above subsections). For instance, Kanchan talked about how teachers often rubbished the book and ended up using it tokenistically when they did not have the expertise. Sonali added that teachers did not have the expertise needed for these textbooks, as their training was for a generalist teacher (as opposed to a specialist mathematics teacher). Finally, Afreen mentioned how some teachers ended up not using these books at all, because of the effort needed. Thus, whether the teachers added their own practice questions (or made other adaptations) seemed to depend on their time availability (Mohini), motivation (Afreen) and/or expertise (Sonali and Kanchan).

> If you ask other MCD teachers, they will all say these books are rubbish (*bakwas*). In all our seminars, it always comes up that these books are not good. Also, to be very frank, the <u>level of the teachers [expertise] is not that high</u>. <u>Every teacher has a different forte.</u> Some are good in Hindi, some in maths, and some in English. So, for someone who has a Hindi background, for them this becomes very difficult. There are teachers in our school, who themselves are not clear of the concepts – so what will they teach? So, they end up using the guidebooks (privately produced answer books) and then just do it on the blackboard.
>
> Kanchan

> Yes, the teacher has to do it, and how many types of questions will the teacher give? She will be able to explain one or two questions. She won't be able to do all of them - she also needs something straightforward, which she can give them for practice as much as we can (*zyada se zyada practice karwa payein*). How much can we frame problems on our own; we can bring some but not a lot. Those that we can bring we will be doing here [in class], but students will still not be able to do it on their own. This is the issue. Not all the teachers are experts, who can churn out examples and explain to the students, isn't it? As much as the teachers can do individually, they do it. It is not also compulsory that we have to know maths very well, nothing of that sort [is required].
>
> Sonali

> Some of them [teachers] are not even doing this. Some of the teachers teach only a few things when it comes to maths. Like, addition, subtraction, multiplication and division. They think that the child is completing primary so at least he should learn this much. You should take the opinion of other teachers as well. They will tell you everything frankly. They will tell you that, if we are teaching them this much, that is enough as children are not able to understand anything from the book. Firstly, they are not able to understand how to carry out these activities and secondly, this has become outdated also. Since nothing new is coming up, teachers are also not getting motivated.
>
> Afreen

7.1.5 Special teachers: making sense of and learning from the textbook

In the sections above, I have discussed issues about the structure of the textbook that were raised by the teachers. There were; however, two teachers who had either attempted to make sense of the format's uniqueness (Afreen) or appreciated it (Mahesh). Afreen, while seeking to understand the structure of the textbook, exclaimed that these chapters are more like "units", which need their own time and space using multiple approaches.

> And this is so vast. I won't call it a chapter; this is an entire unit. One unit in maths can take up to 2 to 3 weeks, if you want that child to able to understand it properly. If the child is not able to understand with one method, we will make her understand by the second method. And if she is not able to understand with that also, then we will apply the third method. Sometimes, one unit in maths can get extended up to one month. I have done like that, when children were not able to understand, some of my units have gone up to one

> month. So, in these circumstances, if there is pressure to complete the course, how will the children cope?
>
> Afreen

This is an interesting notion, which suggests that Afreen was trying to understand and also articulate how the text perhaps conceptualises these topics differently. Her association of covering 'units' seems to include an in-depth longer engagement with the topic, rather than covering the chapters page-by-page, as presented in the textbook. Here too Afreen pointed out that such a "unit" becomes difficult to get finished under "pressure". In particular, she reported the pressure of finishing the syllabus, since the state level scholarship exam (*Medhavi*) was going to be held in four months, before the end of the academic year, which meant finishing the syllabus faster. Afreen, with this approach to 'units', seemed comfortable 'combining' them. In the following excerpt, we can see her talk about how she combined the chapters 'World as it looks' (concepts of different views of 3D objects) and 'Fields and fences' (area and perimeter), because she felt the former was too 'theoretical' and the latter would help students see the application of those concepts. While these two topics are traditionally seen as separate, she felt that space and measurement could be interlinked and discussed together. While other teachers reported feeling hindered in their teaching by the integration of too many concepts (as discussed in Subsection 7.1.2) and preferred traditional barriers between 'concepts', her approach celebrated the idea of interconnections and integration across topics in mathematics.

> Yes, this one, *Khet aur Bhaad* (Fields and fences) and *Duniya kuch aisi dikhti hai* (The way the world looks), I am going to teach these chapters together. Because in this there are a few hypothetical things, I mean, a child cannot understand the things that are there in this [The way the world looks]. I am finding this lesson a little theoretical. So, it can be related to this chapter [Fields and Fences]. They can be related together.
>
> Afreen

Similarly, Mahesh also sought to make sense of the textbook structure. In fact, he is the only teacher who mentioned the National curriculum framework (NCF 2005), signifying that he was aware that these textbooks were based on its ideals. As seen below, he viewed this as the rationale behind 'activities' used as the themes of lessons.

> So, actually these books have been based on the NCF, so they are made as 'activity based' (E) books. So, you have to give activities - like the bus one, or the picnic one. So, the entire lesson is based on that single activity (*ek paath hi bana diya hai, poora activity lekar*). So, it is supposed to be activity based. Almost all chapters have the same thing.
>
> Mahesh

Mahesh, accepting this, considered the 'pattern' given in the textbook is actually useful for teachers since they do not have to think about their own and can rely on it instead. He did not suggest combining or adapting these 'units', as indicated by Afreen, but unlike other teachers, he viewed this as a stable and reliable structure. On the other hand, Afreen who was also more accepting of the textbook did not see the need for it to be 'followed', but rather, saw the chapters as fluid 'units', which could take their own course depending on how students responded. These reports on textbook understanding and its structure are important, since it brings out how the focal teachers view the 'changed' textbooks.

> The benefit is that you get content and a content pattern that you go along with. So, we don't have to make the pattern, <u>the content is ready made</u>. This is the benefit, that the topic list that is given, that is taken along *(lekar chalte hai*). The second thing is that it has a limit which we have to tell the kids <u>all this and it has to be covered, it becomes a limit</u>.
>
> Mahesh

The same two teachers also explicitly talked about *teacher learning* from the textbook. Afreen commented how having dealt with this book once (from grade 1 through 5) in the first round, she had now learnt how to approach it. Mahesh even added how he had learnt with the help of the teachers' notes given below, which indicate what needs to be done and what the tasks' objectives are. No other teacher talked about the textbook as being a part of their learning process.

> After seeing it [the textbook], and after doing it, I got to know that this is an activity which can be done. And now we have understood that if any topic has to be taught, then these activities can be done there. Without seeing [the book] also, suppose we have to do it without a book in the class, [even] then I can do it. In a way, this is a benefit that since I taught the book one year, then later you can use it.
>
> Mahesh

> I have done this book with one batch [from grades 1 to 5], and in those years, I only learnt. I even made mistakes in that batch. Then, I used to think that maybe I could do it this way or that way. But now I have a better understanding of how to do it. So, I can easily do this [book] now.
>
> Afreen

These views are important, especially in the context where many of the other teachers could not understand why certain elements had been included or felt burdened by the textbook expecting teachers to do the activities and also add their own practice questions. Thus, the examples above provide evidence for the possibility that the textbook could have some potential 'educative' value for the teachers themselves.

7.2 Views on the Voice of the Tasks

As pointed out, a lack of clear articulation when talking about the 'changed' textbook was evident and continued when the teachers spoke about textbook tasks[82] as well. However, as discussed above, many did comment how these textbooks included different forms of questions (different from practice questions). In this section, I unpack how teachers described these tasks included in the textbook. They used several terms, such as 'activities/ or exercises/ or questions' to signify them. This itself is important, since this new form of presenting content in the form of distinct 'tasks', was not necessarily explicitly articulated. In the rest of this section, I explore aspects of the textbooks that the teachers described and their ways of viewing them.

7.2.1 Construction tasks: students doing mathematics

When the teachers were asked to identify and describe the ways in which the textbook introduced 'activities', they mostly related this to using physical manipulatives to 'do' mathematics. This was closest to the notion of 'construction tasks', which the textbook introduces (see Subsection 5.1.2). In such tasks, the students had to engage with the textbook by creating their own materials or playing games or doing experiments. Seven of the ten teachers discussed this particular feature of the tasks.

[82] Note that in my textbook analysis, I used the term 'task' to include all the components of the textbook (eliciting and non-eliciting). Moreover, within that I categorised different ways that students are expected to engage with the tasks. This was used to help capture the structure of the textbook as well, instead of identifying text for 'introduction', 'example' and 'practice questions', since such linearity (as also pointed by the teachers) is not followed by the textbook.

For fractions, I made them cut circles, which they pasted in their copies. They understood fractions well that way, what is one a fourth or half. So, the children could understand it easily. If you do activities, then the children definitely understand better. They remember that way what they did, that I cut that much, which was one-fourth.

Bhumika

It has been given so nicely. Shapes are to be made with the match sticks. Children take a lot of interest in this. Each and every child will make it.

Sanchita

One thing was that, they had a lot of activities to do in that. In both these chapters, *Akriti aur cone* (Shapes and Angles) and the other, children had a lot to do. They made things from match sticks. In this also, like we have a maths kit, fractions are given in that also. So, that was also shown to the children. So, children got to do it on their own. Children also take an interest in making pictures, so that's why children like it very much. Other than this, you should be able to do the activities on the particular topic, because when children do it on their own, they learn more from it.

Mohini

So, I want that all the activities should be such that wherein there is a lot of things that can be done by the children.

Kanchan

As we can see above, some of the teachers expressed the view that by children working with actual materials and 'doing' (for example paper cutting), they become interested and understand better. Thus, these kinds of activities gained support from most of the teachers. Yet, there were three teachers, who brought out the constraints of these activities in the contexts of their schools, where there was not enough material resources.

Look, there is benefit, but if there are no materials in the school to do it like that, then how can there be benefit? We have not been provided with any learning materials. Then, how can there be benefit? Now suppose we make them sit in groups, where will we get the materials from? Firstly, I am on contract, we do not have so many learning materials, we don't even get the money. I think the permanent teachers get about Rs 1500 per month to buy materials for the children, but we don't get that. So, where will we provide this from?

Ganesh

In Ganesh's view, the lack of materials was linked to his status as a 'contract' teacher. Contract teachers, who do not have a permanent status, are not provided with similar privileges to the permanent ones, which is a source of continued conflict[83] in Delhi. Ganesh, being the only contract teacher in my sample, brought out this difference while discussing the constraints that he believed he particularly faced. Much like Ganesh, Sanchita also talked about the unavailability of resources (despite being a permanent teacher) and she encouraged the students to do these activities at home, instead of attempting them in school.

> Like, in the bricks chapter, they show the patterns and tell about the length and the width of the brick, but as there are not bricks in the school, we cannot get it in the class and measure them. I have asked them to do it at home. But they don't do anything at home. If you ask them to do anything at home, like measure the brick and all, they would not do it.
>
> Sanchita

On the other hand, Bhumika's approach to this problem was totally different from Ganesh and Sanchita's. While they did not attempt these activities at all in class, she (re)sourced the material from a friend despite feeling materially constrained. It is important here to point that Bhumika took a *collective approach* in finding a solution for the constraint.

> But when these chapters are there and teachers get all these things [materials] here [in school], then it will be really good and then they can explain it to the children in a better way. If we are provided these things related to the chapter, then children would be able to understand them properly. Although I did arrange it from my friend, but some people may not share. So, we should have our personal kit. That is what I am saying.
>
> Bhumika

Mahesh and Afreen took a third approach to materials. Mahesh talked about making his own resources and applying them in his lessons. Afreen, was awarded an NGO teachers' award and consequently received many materials as a reward, thus, not using the language of 'constraint' at all. She exclaimed that while these materials could also be made by teachers, having readymade materials made it easier.

[83] Contract or guest teachers often strike in Delhi, asking for similar pay and benefits as permanent employees. Their contracts are also annually revised which makes their job much more precarious than their permanent counterparts (Kumari, 2018).

> Last year I had made these cards [as given in the book]. I cut white sheets to make cards. They couldn't be sturdy, they were thin sheets. If I had cut them out of cardboard, they would have been sturdier.
>
> Mahesh

> We got one kit from NGO Y [teacher awardee], so, we use that. In that half and the one fourth concept is explained very nicely. [] Yes, it turns out to be quite helpful. [But] sometimes, it happens that we don't have the kit. That doesn't mean that we will not do it. So, I helped the children to make it themselves. Like, you get any paper and show me how to make half of it. But I had already explained to them through this [material]. So, it helped them in understanding it fast. In a way, it reduces the time you take in explaining the concept, if you have something readymade like this.
>
> Afreen

Moreover, Afreen seemed to take a much broader view of resources, which was unique in this context. She reported having access to many resources (online, other books, library, other teachers), which supported her teaching (not just construction tasks) and thus, her focus was not restricted to the textbook. In the following excerpt, we can see Afreen mentioning other teachers, such as Bhumika, who she shared resources with. She also indicated that these teachers in her "group" shared similar values and perceptions towards the activities in the textbooks, unlike other teachers who might not attempt them. This *collective approach* is discussed further in Subsection 7.4.2.

> There are so many activities that can be done. You have to look for other activities [apart from the textbook]. These days there are so many 'resources' (E). I have other books as well from NGO X. There are books in the library as well. Yes, I refer to the library books as well. Whatever I find that might be useful for Hindi, English or Mathematics, and if I find something useful, I take it out. Sometimes, when there is nothing there, I search the internet.
>
> Afreen

> These kits [maths kit from the teacher awardee] are very nice. We share them among ourselves. A few teachers are interested [in sharing]; not all of them. Like in our group Teacher V does it nicely; Bhumika Ma'am does it nicely. We only have one geometry box, so we share it among ourselves, but not everyone does it.
>
> Afreen

7.2.2 Other task features: multiple methods and openness of tasks

Unlike construction tasks, which were essentially viewed as beneficial for students (with some systemic constraints), other kinds of task that are introduced in the textbook were more contentious. For instance, Sanchita, Kanchan and Bhumika, did not value the openness of generation tasks, which required readers to bring their own information in order to complete the task. Bhumika commented how "pre-made" questions are better, instead of teachers or students creating them. Sanchita similarly discussed how "direct" questions come in examinations, which should be given here instead of these open-ended activities. Kanchan also appealed for tasks that provided a "specific situation" instead of requiring students or teachers[84] to come up with these on their own.

> See, if a child gets a pre-made question (*kara karaya*) and the pictures, then he is able to do it properly. If <u>we are creating</u> it, that's a different thing.
>
> Bhumika

> This is the main problem that here there are a lot of activities, but when they get direct questions (*seedhe sawal*) in the exam paper, then how will they [children] do it? Suppose we do these [activities]. <u>We attempt them</u> and <u>children learn</u> as well, but when the direct questions come in exam, they fail there.
>
> Sanchita

> OK, so there are few activities which children have to fill out on their own. For example, let's assume, we ask them, that if you are going somewhere, how long did it take and how did you go? <u>Not every child is able to do it</u>. So, there should be some specific activities like, when you started at this time from here and when you reached there, how much time did you take. Instead of having open ended questions, if they are situation specific [questions], then it would be good.
>
> Kanchan

For the tasks that incorporate *multiple methods,* two teachers, Sanchita and Mahesh, seemed to take two different approaches. While the latter expressed the belief in providing all methods (while privileging the book one), Sanchita declared that there was a 'normal' (algorithmic) method that needed to be focused on. Thus, Mahesh seemed to follow the

[84] It is important to note that, while Bhumika and Sanchita talked about task creation as something that teachers have to do, Kanchan commented on how making students bring in their own information is difficult.

textbook recommendations when it comes to multiple approaches, while being aware that the more algorithmic methods also had to be discussed. This is also reflected in their textbook use approach, as discussed in Subsection 6.2.1.

> The aim is that all the methods are told, like the division method, but more stress is given on what is given in the book. But the other method is also told. Because some children have been taught that way in their tuition. So, then they understand faster with that method.
>
> Mahesh

> Like, in this they have been given different types of method to multiply, [but] I have told them these superficially. And I told them that method by which we normally do the multiplication. Otherwise they will get confused. I told them that you can do it like this also, but you have to do it with the normal method only
>
> Sanchita

7.2.3 Encouraging individual student participation and discussion

Apart from describing the openness and multiplicity of methods provided within the text, only two teachers spoke about how this enabled involvement of students with different learning needs. Mohini discussed how the activities in the book might encourage those students who typically get ignored, thus making access to mathematics more inclusive. Mahesh commented how different methods work with different types of students based on their learning styles (furthering his rationale for addressing all methods). Mahesh was particularly happy with the 'success' of the alternative approach to division in the textbook, when he found the students using it in their examinations. This crucial aspect of 'alternative' forms of the textbook in attempt to access different students and their ways of thinking about mathematics was not directly addressed by any other teachers.

> Yes, to engage everyone in it. But, sometimes, it happens that the child who lacks behind in writing, here she will speak and answer. Sometimes, this happens, that if they are lazy, does not want to do, when sitting with other children [in groups], they sometimes tell [engage].
>
> Mohini

> For [different] children, they have different abilities to grasp things using diverse ways (*alag alag tareeke se grahan karne ki kshamta*). There are some children who grasp from

> those [earlier] books, and there are also some who grasp through this [new book] way. There are some children who when taught like this understand better, some are there who prefer to be directly told the method. Let me give you an example from my class. The division method that is given here [in the book], where you have to do 28 divided by 7, [visually] if you make seven shirts, where you have to put buttons, there are 28 buttons; so, 4 buttons would be put on each. Some kids understand like that and I am giving this example because I gave this question in their examination. So, most children, what they did was that they didn't do 28 divided by 7 [algorithmically], what they did was they made 7 shirts and then put 4 buttons each. But two-four children were also such that they did it this way that 28 ÷ 7 (long division method). So, some children understand better in that way, and some understand like this. So, the old books that were there were better for some children in that way, and for some this is better.
>
> Mahesh

At the same time both the teachers also talked about the difficulty that these activities pose, since students get "distracted" (*vichalit*). Mahesh also added that this is possibly because students are not used to activity based teaching and expect more direct pedagogies. This shows that these teachers saw the possibility of using these textbooks to engage students in their lessons in alternative ways.

> I thought with cards the children are becoming distracted (*vichalit*), because maybe in earlier grade they were taught in that [direct] way for addition (*waisa tareeka karaya ho*). They felt that now this is a different way.
>
> Mahesh

> It [activities] can be done, but if someone cannot understand, [they] will be engaged in some other activity.
>
> Mohini

Other teachers, too, discussed ways in which they attempted to engage *all* the children in their lessons (Bhumika, Kanchan and Afreen). For example, Bhumika ensured that all children got the opportunity to attempt tasks on the blackboard, instead of their notebooks, where there was a greater chance of just 'copying' answers, rather than genuinely attempting them. This method was observed in several of her lessons and has been discussed in detail in Subsection 6.2.2.

> Actually, instead of children doing them it in their exercise books, I make them come to the blackboard and ask them to do it here, then it is better. Sometimes doing it in their own exercise books they cheat from others, or they copy everything from the board. But once I make them do it on the board, their hesitation also goes away, even if they do it wrong or right, they attempt to do something.
>
> Bhumika

Afreen and Kanchan talked about several attempts so as to ensure that every child became involved and "moulding" and "simplifying" the activities, if required for those of different levels of understanding. Afreen expressed frustration when these attempts were not fully successful.

> So, if they are not understanding and finding it hard, then I will find a simpler activity. But my aim is that in a week at least every child gets to do it. This is my aim. Yet, it is not always satisfactory – only about 65% of the children can do it. You can say it is a time constraint, because if I do maths for 45 minutes, then all children cannot be reached in that time. On top of that, we have to finish the syllabus.
>
> Afreen

> I understand that they have to learn through activities, but it depends on the nature of the activity. If it matches with the level of the child [then its fine]. But there are many activities which are a very high level, such that children are not able to understand what to do. In that case, we have to mould it and simplify it to use it to teach children. Then, they are able to do it.
>
> Kanchan

Both Afreen and Bhumika also talked about creating a non-threatening classroom environment. They mentioned how they were happy that, in their classrooms, children spoke their minds and did not fear them. Afreen, for instance, encouraged student interaction, especially in the light that these children often struggled with several difficult issues and found this to be a meaningful way of gaining trust. This meant that the children could interact "openly" (Afreen) without fear or "control" (Bhumika). Afreen further urged 'discussions' in her lessons. In the following quotation, we see her using materials as an instigator for

discussion. Here too, Afreen points to the time constraints that she experiences in achieving her goals.

> They often have different kinds of problems. So, I feel that there should also be interaction with the children in class. In my class, these children say anything they like. I like that they are open with me. So, even if I scold them, they understand that I am saying something right.
>
> Afreen

> My class is actually very talkative. They think that they should come and tell everything to madam. They want to share everything. That controlling thing is actually less in my class. You must have seen this. But I feel that its ok, when they will think something, they will come and tell me, otherwise where will they go? That is what I think.
>
> Bhumika

> I leave the children alone with these [materials] and ask them to tell me whatever they are able to understand from this and I ask them to discuss among themselves. Because when they discuss among themselves, they learn fast. So, this should be done. But we are not given enough time, so that children can do these discussions among themselves. We have to impose a new thing on them even before completing the first one. I feel we are imposing, because we have to complete the course. So, maths is still going on and we ask them to take out science and even before the science finishes, we ask them to take out Hindi. Children are not even getting to have discussions among themselves.
>
> Afreen

It is also important to note the silence of teachers, such as Neetu, Sonali, Sanchita, Deepali and Ganesh in either describing the textbooks' or their own attempts of engaging students in their alternative ways. While this silence does not necessarily mean that these teachers were not engaging the students in alternative ways, it does indicate that, despite the textbook including tasks that explicitly encourage student engagement, they did not appear to interpret these as key features of it.

7.3 Views on the Context of the Tasks

In this section, I discuss teachers' responses when they were probed about the 'context' within the textbooks. They mentioned advantages of the contextual tasks in mathematics learning (Subsection 7.3.1) but also criticised the usefulness of such tasks (Subsection 7.3.2). Moreover, a few teachers discussed the problems with the kinds of contexts used in the textbooks (Subsection 7.3.3).

7.3.1 Context as affordance: interest and application to the real world

When asked how the teachers viewed the incorporation of contextual tasks in the mathematics textbooks, there was agreement among some of some, that it makes mathematics "interesting". These teachers seemed to essentially endorse the idea of using context to teach students mathematics.

> Yes, this is the most interesting way. How will the child take interest in class, if we don't link it to their homes, bazaars, their food habits? Only then will they take an interest.
>
> Afreen, interview 1)

> Yes, it is like a story, maths is not done like maths, it is attached to daily life. Like, if going out somewhere, like *'Bhimbhetka caves*', having gone to see them and there are so many children have been, and so on. It is attached to daily life and made into a story. It becomes interesting and the rest depends upon the teacher.
>
> Mohini

Another reported role of context was its importance in students' ability to *apply* school mathematics in their everyday lives. Four teachers (Mohini, Deepali, Mahesh and Afreen) held that students' ability to use mathematics learnt in their school in their daily life activities was an essential goal of primary mathematics.

> We also give such questions to the children, where we ask that, if you were doing this at home, then how would you do it? This is very important. For example, if you are going to buy sugar or oil or anything else, do you ever ask him, how much did he charges for 1 kg of sugar? So, if you have bought 2 kg, then how will you 'apply' (E) that, [to know if] shopkeeper has not charged you more? So, blending that into this real environment *(class wali cheeze ko parivesh mein daalna*), I think is very important. Because if we have given

them the knowledge theoretically and the child is not able to use it practically, then there is no point in teaching them.

Afreen

They should also know what we call 'unit sums', like, we bought it for this much and sold it for this much. If the child has gone to buy the stuff from the shop, so the child can understand, how much balance there is. They should know how to give and take of money (*len-den*) and basic bookkeeping (hissaab kitaab).

Deepali, interview 1

7.3.2 Context too idealistic and not doable

In contrast, there were two teachers (Neetu and Ganesh), who felt that contexts were not useful at all. While these teachers could see why the authors might think that these are important (either for interest building or other reasons), they did not feel they were necessary. Neetu, for instance commented on how the writers might have felt that "slum children" would understand better through these ways, but felt these are just ideals to talk about ("*kehne ki baat"*), but hard to achieve in reality. Ganesh took an even more severe stance, claiming that this was not mathematics at all and that the approach infantilised the serious mathematics that should be taught in grades 4 and 5. Furthermore, he claimed that the 'mathematics' that they did in their everyday lives was not at all compatible with school mathematics, by pointing to common misuses of its terms in everyday language. He was the only teacher who talked about this possible dissonance between school and outside mathematics.

These are just things to talk about (*kehne ki baatein hai*), but when you practically try and do it, then it is very difficult.

Neetu

There are absolutely no [questions], these books are like for kindergarten or nursery, like their primers, it has been done like that. There is nothing to teach from the books. Like they have given patterns, now for class 5 we won't teach them patterns. That, match the patterns, or match the lines, and then tell what is the next pattern. The focus should be on 3-4 things, like multiplication, division, area, etc.

Ganesh

Now, let me tell you about things linked to the lives. Like, if you go to any shop, like the mother dairy [local milk shop]. What do they say? They say, 'give 1 kilo milk', but liquid

> is not measured in kilos. We measure it in litres. So, to differentiate between things related to the lives and to move from one type of thinking (*bhavna*) to the other becomes difficult.
>
> Ganesh, interview 1

7.3.3 Context use within limits

Apart from talking about use of context as 'advantageous' or 'disadvantageous' (as discussed above), teachers moved beyond these normative descriptions. While accepting the 'usefulness' of contextual tasks, they also felt like there were limits to it, in particular, regarding the kinds introduced in the textbook. That is, there were different kinds of limitations expressed by teachers relating to the *choice* and *length of the contexts* within the books.

Choice of contexts in the textbook

While teachers recognised the need for 'typical' contexts, such as shopping or family related contexts, they claimed that beyond these there needs to a "cut-off" point (Kanchan) and that they can only be used a certain "extent" (Bhumika).

> See, in some places the 'concepts' (E) are good. Like family related, or that you are going to market and buying things. For those, contexts are very helpful. But when it is too high level, then we also skip it, because children will not be able to do it. This is a good thing in these books, but <u>they have overdone</u> it sometimes. So, we have to find the <u>cut-off point</u> that only up to here is it OK.
>
> Kanchan

> We can do it [context tasks] <u>to some extent</u>. We can measure their heights, they identify the short height children and also the children who are taller, who is taller than whom, so to some extent these can be explained.
>
> Bhumika

Teachers further problematised this choice (or extent) of context by bringing up their *relatability*, as used in the textbooks (Mohini, Kanchan, Afreen, Sanchita). For instance, in the following quote we see Afreen talking about brick kilns and how they were not found in Delhi, so students were not commonly familiar with them. While Afreen discussed ways of navigating this (by showing images or videos), Sanchita talked about how students' lack of exposure to these contexts, debilitated their learning. The relatability of the contextual themes thus appears to have been an impediment (to be crossed).

In this I feel that the pattern of our book is a little generalised. I mean, it is not only for the Delhi children, but it is for all the children, all over India. For example, there is a '*Innto se bani Imarat'* (Building with Bricks chapter). They have provided the concept, after which, they are talking about the brick kilns and where these bricks are made. So, we cannot take the children to that place where these are made, but they have shown the children, how it is done. So, we can make the children understand. Or maybe we can show them [images] in the mobile [phone]; that this is a brick kiln. Mostly you will be able to see, brick kilns in Uttar Pradesh or Haryana [not in Delhi]. Then there is Bhopal, which is in Madhya Pradesh. There are the caves of Bhimbhetka. So, I feel that our book doesn't only cover the Delhi region, for it covers the entire country.

Afreen

So, where can we show them the patterns? Like, here we can show them a little bit from the corridor outside or maybe from downstairs. But if we tell them that you see in this, they never go themselves to see it. They have never gone out of this neighbourhood. They have not even seen the metro. If I ask now, only two or three children would have seen the metro, others would not have seen it. They don't go on holiday also (*kabhi ghumne hi nahi gaye hai bahar*). So, these patterns cannot be shown to them. I told them that if you go somewhere, then you pay attention to these patterns. But if they don't go, how will they see them? In this lot [chapter] there are a lot of complicated patterns. They are really nice, but they won't be able to see them anywhere. And now, they are not even made. Earlier, people used to make such patterns in their houses also.

Sanchita

[This chapter] was difficult for all the children. Maybe the children who live near the sea shore, they found it interesting.

Mohini

In this, we could not create it visually. And nor do we go on such excursions with the children, so that they can feel it and understand it. No matter how much we tell them that while going home, you have to notice it, but at the end of the day they are children, they don't know that much. So, we cannot do such things. Now, there is this petrol pump scene. At that time, I asked the children about it. Hardly more than three or four children have seen a petrol pump. So, how will they understand anything about the petrol pump. So, it will be much better, if it is simplified a little bit.

Kanchan

This perspective of relatability was voiced by two other teachers (Mohini and Nidhi), who felt that the textbook often made assumptions about children's background, such as it being 'rural'. They argued that since most children in their schools have been raised in urban spaces (even though their families might be from villages in different states) these assumptions might well not hold.

> It is related to their day-to-day lives (E). And sometimes there are such things that are so 'local' (E) that even we don't know it. So, some words are such that many children don't relate as well, because not many children are from villages. They are all from here [Delhi]. They are local [from Delhi], and their parents have been living for a very long time here. So, they don't know much about villages. Parents are from villages and they do go there in holidays, but there also they don't know much. Yes, so some things they also don't understand.
>
> Mohini

> There are many things here which are not okay. Yes, they relate to practical life, but not like this. Now, even their living styles have changed.
>
> Neetu

This reveals that the teachers were struggling with the 'kinds' of context presented in the textbooks, especially whether these were relatable to the students' lives or not. This suggests that they were also questioning the purpose of these contexts in the textbooks: did they need to be immediately relevant, if not for what purpose were they to be used? Are they too parochial and hold wrong perceptions of children's lived realities? Or are the students too deprived to experience some of the contexts? While attempting to understand the contexts used in the textbooks, some teachers also spoke about how they had adapted some of these contexts. For instance, Mohini talked about using a different example rather than stamps, which the children might not have been familiar with. Similarly, Afreen and Mahesh encouraged students to go out and explore the kinds of contexts mentioned.

> Now, when I asked children about stamps, very few children could say that, yes, we receive letters and we have seen these stamps on them. So, [instead I use] tattoo stickers, which are used in today's time, I relate it to that also. Main thing is that only if it is a small object, how will you measure it using squares. Because for a lot of students, these stamps were quite a new thing. Nowadays nobody receives letters, so they had not seen it.
>
> Mohini

> I asked them if they go to the petrol pump with their father. They said that yes, we go with him. So, I asked, have you ever noticed how much does 1litre of petrol cost. They had not seen it. So, I told them that next time, you will check the machine to find out the cost of 1litre petrol. Then, you will go after one week to find out whether there was any change in the cost of petrol. So, with this child will get aware about his surroundings. Like, earlier petrol was this much and now it has become this much. And now we will pay this much. So, children do this. It is not like they don't do it. they actually do it.
>
> Afreen

> Like for metre units, I ask them that to look for objects that are shorter than a metre or longer than a metre. I tell them that they will have to tell me the next day. And like, for measurement, what are all the pots at home where you can have less than 1 litre of water. Like that, I ask how many bowls of water will fill this bucket or fill with a spoon. Such work is given.
>
> Mahesh

As discussed in the textbook analysis chapter, the books introduce stories of lives of marginalised communities and their everyday struggles (fishermen communities, and a lower-caste woman social entrepreneur), but these were not directly commented upon by any teacher as opportunities to discuss *social injustice* through mathematics. Yet, when they gauged what their students 'can' do or understand through the varied contexts within the textbooks, some brought up the issue of culturally relevant mathematics teaching. Specifically, by beginning to explore the relationship between students' social reality and the textbook, critical questions were raised about situated and socio-culturally relevant mathematics teaching. Some teachers tried to engage with more relevant examples, instead of just assuming what may or may not work. This is an important starting point, yet teachers' attempts to mobilise relevant examples and use them meaningfully were not discussed. Bose's (2014) work in slum settlements in Mumbai looking at commercial contexts of tailoring, provides a good example of how localised contextual out-of-school practices can become a means of discovering powerful mathematical ideas. Even though the textbook authors, by introducing rich and unique themes of different contexts (including that of a fisherman's community) might have attempted this, the teachers were not sure how to make sense of them at a deeper situated level.

Length of contextual themes

Teachers also felt that the (over)use of context acted as an impediment to the other important features of mathematics learning. For instance, Sanchita believed that with all these contexts the "main things" (presumably her idea of important mathematical notions) that need teaching got lost, which led to confusion.

> If there is one question on something, children can do it and move ahead, but here, there are many questions on the same thing, so children are getting confused. Like, in this they have made a story about fishes and in this they have kept taking it forward on the same thing.
>
> Mohini

> They have explained a lot of things by relating them from day to day life, but they get preoccupied only in that. The main thing which is being taught to them, I mean, once they have read it and understood it, the main thing which we are trying to tell them, they are not able to understand that.
>
> Sanchita, interview 2

As a way of overcoming this, teachers suggested 'shorter' questions, explicitly delineating the "type" of task. For instance, Bhumika talked about how the prolonged contexts in longer themes were often not helpful and instead, that shorter tasks (word problem like) needed to be provided. Thus, here again we do not see a complete rejection of context, but limitations on the extent of its use.

> The book is good in terms of pictures, but if you start reading the story, then, in any one question there is such a long story, and if you start going by that, it will become very lengthy. To explain the questions in short stories, will be better, for if these long stories are considered, then it takes lot of time, and also, it is not possible to complete in one day. It becomes very lengthy and then the children are not able to understand anything from this. They are able to understand with shorter activities.
>
> Bhumika

> We make the questions short and write them in our language and then give them to them.
>
> Deepali

Here it is important to talk about Mahesh, who explicitly appreciated this particular genre used in the text. Mahesh preferred chapters that introduced concepts relating to 'practical life'

(*vyavaharik*). For instance, he rated "Bhopal ki sair" (Trip to Bhopal) as the best chapter, despite the fact that it has a long theme (stretched throughout of the chapter), which Kanchan especially disliked.

> It [trip to Bhopal chapter] has been given elaborately and it has been given based on *'vyavaharikata'* (practical life). Children are going on a trip, they are going to the petrol station. Even though it is only on 'addition and subtraction', it is done in practical ways, using the 'vyavaharitkta' method.
>
> Mahesh

In the textbooks, there are several integrated chapters (especially the thematic chapters) as well as 'longer' contextual task sequences (spread over several tasks), which look different from the short 'word problems' that were more familiar to teachers. This feature of adding much longer deeper contextual information, caused difficulty for teachers, who felt that it distracted them from the 'main mathematics' to be taught. Thus, the presence of more 'extra-mathematical' aspects, which perhaps are important parts of making contextual tasks more 'authentic/situated' (Verschaffel, 2009), becomes too challenging for some teachers.

7.4 Views on Institutional and Social Realities

In this section, I discuss other recurring themes, which, while not directly related to the textbooks or their features, came up while teachers described their teaching. This was especially the case when they spoke about the relationships between their teaching and the larger system within which they were working. In this section, I discuss the notion of 'time' and its relationship with other *administrative work* that they had to manage (section 7.4.1). Secondly, I discuss the support networks for teachers and other school resources they access (section 7.4.2). Teachers often compare these textbooks with other *parallel private school textbooks* (or older textbooks) which is further discussed (section 7.4.3). And finally, their perception of students and their *home environments* and how these influenced their work is covered (section 7.4.4). This is important, because how teachers use textbooks is not just related to their 'individual' thinking, but also constrained or afforded by their larger setting. To access these aspects, I asked what support they had received when these textbooks were introduced and what other help did they get in their teaching role.

7.4.1 Non-teaching tasks and teachers' 'other' work

Some of the systemic issues that teachers faced while attempting construction tasks, which required their use of learning materials have already been discussed (Subsection 7.2.1). Relatedly, teachers brought up several other issues that they felt hindered their work. One of these that almost all teachers discussed was the burden of 'non-teaching tasks', which were essentially additional administrative work that they had to do apart from their teaching. Afreen succinctly exclaimed that: instead of being a teacher first, her job had become that of a clerk, wherein she had to find time to teach. It is interesting that the conflict between being a 'clerk' and 'teacher' was repeatedly reported by other teachers as well.

> We come here to teach, we are basically teachers, but here [infact] we are clerks (*kaam mazdoori*) doing paperwork, out of which we are to find time for teaching. This is the biggest drawback. If this is removed, then [it will be good]. We are also filling in bank forms for children, we are opening their accounts, we are preparing their data. There should be some help for that in the schools. They should keep a clerk for that. So, that we could give the clerk hard copy and then can make it into soft copy. But no, we have to do everything. Even if you are making us to it, give separate time for that. They should give extra time for it. Basically, I think, there is no time here for teaching, but there is time for everything else.
>
> Afreen

> The department focuses on many things, like upload this data, or do some other kind of [admin] work, but when it comes to 'innovations', there is nothing. This is the reality, reality check. So, if there are teachers who want to do more, they don't get any channel.
>
> Kanchan

> If the government gives us some facility and reduces our <u>burden,</u> then our attention will go onto the children. They shouldn't make us do 'useless' (E) work like for elections and census. If the paperwork that we have to send, that was reduced, then the focus will come onto the children. Then, the six hours we get will be given to the children. Otherwise, we cannot do it. <u>We are more like clerks here than teachers.</u>
>
> Ganesh

> So, there can be other '<u>burdens'</u> also, like I have the midday meal work. The food comes at 9.30, but then I go in the middle of teaching for that. Then I have to check it, then to distribute it. So, whoever has extra work, then they get less time for teaching. Children are

then given some work in the meanwhile. In that time they are either given drawing work or in maths they are given work on addition and subtraction or something like that.

Mahesh

Yes, because the principal was not there, that's why a lot of my time got consumed in [work] for the bank and other things. This affected the studies also.

Mohini

In MCD here, there is a lot of work. Every other day they will give us some work. Now, there will be duties allotted when the election comes. All teachers will be called in for election duty, which you cannot refuse.

Deepali

Teachers argued that this impacted on their teaching plans for the day, complaining that it both disrupted teaching as well as reducing teaching time. Thus, when asked what kind of support they desired: they urged the removal of this non-teaching work and for having more time in their classrooms.

I think if there was more time, [because] it takes time to explain. It is mostly about time, if we are to do all the exercises. If we can do everything, then [more time] would be better. But then time gets lost, for midday meals etc.

Mahesh

I feel like the school should run till 1.30 pm; 12.30 is too little time. And within that time, we have to also to check their notebooks, but because we don't have time, I have to take their notebooks home.

Afreen

It was clear that non-teaching work overwhelmingly occupied the teachers. They would often have to disrupt their teaching for some other work (in almost all my lesson observations there was some disruption). This included parents walking into the classroom for some work (bank related or wanting to pick up their children early), some announcement from the principal, other teachers walking in to discuss administrative work, and so on. Thus, the classroom space did not seem to be an exclusive and bounded space for teaching and learning, but rather, it was freely accessed by the larger school system and parents. In the next two subsections, I discuss to what extent teachers felt supported (or not) in their schools.

7.4.2 Support for teachers: teacher collectives and other school resources

Teachers as collective support

Teachers supporting each other was a strong idea that came out in three of the teachers' views, namely, Bhumika, Afreen (both in the same school) and Mahesh. This is significant, in a context where there are no official means of creating collectives. In section 7.2.1, Afreen and Bhumika's collaborative efforts to use and share resource materials were reported upon. They further went on to comment how 'problems' were often solved by discussing them with other teachers. Similarly, Mahesh also mentioned how he would approach a senior teacher, if he had any problems with his teaching.

> Wherever you have a problem, you should talk to colleagues. I always discuss with my colleagues. Kanchan is my best friend. So, those who have similar thinking (like-minded), we interact with them. Like there is teacher V, who I go to. [we shouldn't have] the attitude that why should I ask and assume that I know everything. That mentality should change. There are some teachers in our school who think that they know everything. So, they stay 'reserved' (E). We will also discuss things during lunch. So, this I think it is very useful. So, in our 'group' (E) we discuss. If there are children who have some emotional or other kind home related problems, then we discuss that as well.
>
> Afreen

> For the usage of the textbooks, if there are any such difficulties then I ask sir or the help of other teachers. Mostly, I ask Adeel sir. His class is in front, and he's there only. He takes the third grade.
>
> Mahesh

For Afreen, it was important to have a 'like-minded' group, where teachers thought alike. She pointed out that this is not the case for many of the teachers in her school, who refused to collaborate or discuss their problems with others. Mahesh on the other hand seemed to be often discussing his teaching with a senior teacher, who in his case was more like a mentor. In his school, this particular senior teacher (who was also my contact with the school), is a respected older teacher who seems to influence others. These look like different models of collectives that teachers build in their schools. What is also important to note is that in the other two schools, the teachers do not mention this kind of discussion with their colleagues. This is significant, as it indicates that many teachers often continue to work in isolation.

School structures and other support

What comes out strongly is that the school system itself does not enable teachers either to collaborate or facilitate the use of the textbook. None of the teachers I interviewed had received any formal training about the textbooks. The seminars they had attended, they claimed, were not helpful and only there for the bureaucracy (*khanapurti*). Afreen raised an important point about how the seminars had treated teachers like students, being 'taught' the mathematical concepts, rather than being taught 'how to teach'. This is really important since it demonstrates how the notion of pedagogical content knowledge (PCK) (Shulman, 1986) is still missing from in-service training (Kumar, Dewan, & Subramaniam, 2012).

> The last good seminar that was done was in 2012 on integrated learning. After that no relevant seminar has happened. There was one seminar, which was useless.
>
> Kanchan

> Most of the trainings are also not that motivating. Now, like they are calling for a seminar just to use up their funds.
>
> Mohini

> OK, you conduct the seminars, those seminars are badly conducted. I can't even explain you. We go and take the class for Teaching of Mathematics. <u>They are teaching us. They are not telling, how it has to be taught to the children. They are explaining the concepts to us.</u> Like, if we are teaching them about Aayat (rectangle), then how will we teach a rectangle to children? Why are you teaching us? <u>You should tell us how to teach the children</u>. I attended that workshop twice or thrice, but it was an utter waste of time. Then, I stopped going for that. They are teaching English to us. we don't need English. You have to tell us what we can teach the children. You should tell us the activity.
>
> Afreen

Further, Sanchita pointed out, even spatially there were often no ways of maintaining and expanding their resource base. She talked about the unavailability of rooms/staff rooms/lab spaces, where teachers could store additional resources. Since her school now worked in two shifts, she especially found it difficult to use charts in her classrooms or store materials safely.

> Yes, we cannot keep it [resources] here [in school]. We cannot keep it anywhere. There is nothing in the school. There should have been a resource room in the school. When I came

to this school, I thought I will make a resource room but there were no rooms. In fact, in one room, two classes sit.

Sanchita

7.4.3 Comparison with other books: private books and older books

Having discussed teachers views on the systemic hindrances (non-teaching tasks, limited time, limited support within the system), what references teachers used for comparisons or to understand these *Math-Magic* textbooks is reported upon. As I mentioned briefly in Subsection 7.1.5, Mahesh was the only teacher who articulated that these books were developed from the NCF policy. For the rest of the teachers, their main frame of reference of understanding these books were either *older or privately published textbooks*. As can be seen below, some teachers spoke about how 'missing' elements (practice, concept clarity) were present in other privately published books, or in the older NCERT books.

There are no exercises in these books. <u>In public schools, teachers just mark the questions to be done, and students have to do them.</u> If we look at those books, there is a big difference. I think they are better to teach from.

Neetu

Even the questions that are there in the book are not like the way we have read in the private books. In that, there were chapters and at the end of the chapters, there was lots of stuff to practice. There used to be a lot of questions, which are not there in this book.

Sanchita

We need books that are meant for public schools, particularly where the examples are given properly and explained properly. Even if we don't explain to the children, they can practise by themselves. This should be there when you select the books.

Sonali

I think the 8-10 years older books were much better than these. Those that we learnt from, 10 years back. Those books had all the knowledge. So, whether teachers teach, or don't teach, but at least students could understand from those books. It was given clearly what had to be done.

Ganesh

Yes, [these books came] in 2009. And before that the books that were there, were the ones that we studied in school. They were more difficult, but they used to give so much practice to the children, that it would make things clear for the children.

Deepali

Government run schools are only allowed to use the state-prescribed textbooks, in this case the NCERT *Math-Magic* books. So, they cannot officially use 'older NCERT books' or 'private' books that they mentioned. On the other hand, as previously mentioned, private schools are free to choose from a variety of privately published textbooks. Thus, comparison with private textbooks would often also lend itself to a comparison with the private school system itself. For instance, Deepali and Afreen felt that, because of the difference in the textbook styles of privately published textbooks and these NCERT textbooks, their children were "lagging behind" private school children. There was also a sense of injustice and that they were 'purposely' being left behind by being given these 'bad' books, while other private schools got better quality books. While more information and higher-level mathematics is being included in the private books, they believed that these books in comparison were not "advanced" (Afreen), thus disadvantaging the children. Sonali further talked about how the books for private and government schools should be the same, and then any comparison would be possible amongst all children.

> And you know, if you see the books of private schools of the same class, there are so many [more] things. So, then we feel that our children are made to lag behind. They are lagging behind. [So] I feel that it [our textbooks] should be advanced. It should be reviewed a little bit. Some advanced things should be included in this, because our children are no less than the ones in the private school. Their mind is also sharp and they can do it, but the books have become a little outdated.
>
> Afreen

> All the books should be same, both for the private schools and for ours. Then, they should talk about who is better. If you are making good books for them, and for us you are giving like these, we also need those kinds [privately published] of books.
>
> Sonali

> All these things matter, whereas private schools give them [students] all the syllabus in advance, so that children get prepared for board exams [on their own]. For tenth grade students are much more prepared. That is why they [these students] lack behind, because their practice is not like them [private school children].
>
> Deepali

It is important to contextualise these arguments within the wider public perception and discourse about government schools, which views them as inferior, with worse teachers and worse performing students in comparison to private schools. These discourses are navigated

by teachers themselves, as seen above. It is worth noting that some of the teachers expressed how they felt wronged by having been given these books, while private school teachers get could use privately published textbooks. This idea that, if they were also given 'those' books the students would do better is an important grudge to investigate. It brings to the fore important questions of equality in education. The designers developed these textbooks with a view to enabling mathematics becoming more accessible to children from disadvantaged socio-cultural backgrounds. Yet, the same textbooks are being perceived as sites of 'creating' inequality. In such a segregated school context, it becomes crucial to re-think about the role of reformed textbooks, which are only prescribed in government schools, while other schools do not have any such compulsion. In the next subsection, a deeper consideration of teachers' perceptions of their own students, their homes and outside school lives is made.

7.4.4 Attitudes towards children and their home environments

While the textbook authors had the aim of including students' lives in the classroom, viewing them as funds of knowledge, teachers' perceptions on these lives and their interaction with the school manifested itself in several different ways. Firstly, the one issue that several teachers raised was that of absenteeism and how it impacted on their teaching. For instance, Afreen talked about this being the biggest obstacle with teaching, while Neetu gave an example of how absenteeism interrupted the flow of teaching.

> No, the books are good and there is no problem, but, the problem arises when children are not able to understand. There are factors that children are not able to understand, in particular, because here there is so much absenteeism. So, if the child doesn't come one day, they miss it, and then if they come the next day, they will obviously face issues.
>
> Afreen

> Children go to their villages for many days. These days half the children are not coming. I have 36 children enrolled, but only 17 have come today. Less than half are here. So, how can I start a chapter?
>
> Neetu

> Mostly they belong to poor class. And their vacation also become long, sometimes it is for one month and sometimes for two months. If they go for one and a half month holidays in summer, they come back only in the end of July. Because they feel that when we have borne the expenses for coming here, then let's spend some time also.
>
> Afreen

Secondly, some teachers talked about the lack of a supportive home environment for children's learning. As Deepali noted, unlike private schools (as she perceived them), the responsibility of students' learning was not shared between the teacher and the parent. This made their work harder, since they felt solely responsible for the students learning.

> Problem is that when even, if the child wants it, they cannot do it (*chahkar bhi nahi kar paata*). At home, they don't have any support system. Nobody is there who can check what has been done in the school and what should be revised. So, whatever has to be done, it has to be done here only. They will not do anything at home.
>
> Kanchan

> We are never able to achieve 100%, that all children will be able to follow. There is also their personal background. Our attempt is to make sure that all the children are able to follow and for weaker children we make extra effort.
>
> Afreen

> The other thing is that in private schools, children are a headache for parents. If madam does one sum, they will do it, but they give rest as homework, and parents will make sure that the child does it before going to school. This is not the case here. Whatever we have done, the child relies on that.
>
> Deepali

The lack of home support along with the high level of absenteeism also meant that students were at different 'levels' of learning in their classes. Teachers, thus, had constantly to make decisions about who to focus on and to what extent. This conundrum was articulated by Mohini, Afreen and Kanchan, who found themselves making hard choices within the time constraints on which students to focus on, being aware that this meant some would not get equal attention.

> There are also other things, actually, in class, there is a lot of difference in children. Suppose if we have 25-30 children, out of that 10 will be below average, 5 will be average, 5 will be above average and 5-7 children will be such that they will understand at once. So, there is so much disparity that some children lack behind. If you concentrate on them, so then those who can learn more [they are left out], so, the management becomes a little difficult. These are not 'homogenous classes' (E).
>
> Mohini

> Then, [if we focus on weaker students] then there is injustice towards the brighter children. So, instead I give them work separately.
>
> Afreen

> If we place emphasis on some of then, the remaining 40 will suffer. So, even if we want, we are not able to do as much as we would like.
>
> Kanchan

Thus, teachers expressed the difficulty they faced in accomplishing what was seen as 'traditional schooling', which assumes regular attendance, regular classes, homogenous classes and parental support. Other socio-economical diversities (caste, religion, gender) that are prevalent in classrooms (especially governments schools) were not spoken of explicitly (see the class composition in the table in the methodology chapter). However, two teachers, Afreen and Kanchan, seemed to sympathise with the vulnerabilities of the lives that the children had. Both these teachers shared stories of the students and their backgrounds, discussing how complicated traditional school teaching norms and learning becomes in such situations. These were the only two teachers who attempted to place the problem in the larger social structure, instead of blaming parents or students' individual motivations.

> In first grade, two children dropped out from my class. They were very smart children. I don't know why but they went back to their village. We don't know what will happen to them in the village. Those two girls were very brilliant, they would have received *Medhavi* scholarship today. I really tried hard so that they didn't do it, but the parents said that madam, we are not able to cope up here, so we will have to go. And they left. So, this also the condition of children. Most of the children have migrated. Most of them are like that. Only one-fourth would have been from here.
>
> Afreen

> Now, I have a girl in my class. I told you about her. They are five sisters. Both her parents passed away in a year and now, we don't know where those girls are. They are five sisters and in today's date, I don't know their status, where are they. I have contacted two or three NGOs also, but nobody has come forward.
>
> Kanchan

Thus, we can see that while teachers were frustrated with both the lack of support from the system, as well as the students' disadvantaged backgrounds; some of them were aware that the complexity of students' lived realities, which made the traditional expectations of

schooling (and its norms) impossible to achieve. These teachers did not find support within the textbook (or schools) to navigate this unique position that teachers found themselves in.

7.5 Analytical Summary

This chapter has presented the key findings on how teachers viewed the textbooks and a summary is provided in what follows.

- Most of the teachers seemed to have a negative opinion towards the structure of the textbooks. Except for two teachers (Mahesh and Afreen), all articulated their discontentment towards the structure and organisation of the content in the textbook. These teachers found it hard to make sense of the labelling of the chapters and the task headers as well as the integration of the topics within chapters. Furthermore, they highlighted how the textbook both lacked a comprehensive coverage of the mathematical topics and did not have enough practice questions. A few of the teachers, such as Kanchan, Sonali and Afreen, also spoke about the general negative perception of the textbooks among the larger teacher community, who tended to rubbish them. Two specialist teachers (Mahesh and Afreen) attempted to understand and appreciate the format of the textbooks. While Mahesh viewed it as having a stable and reliable collection of activities, Afreen saw it as being more fluid and something that could be modified. These two teachers also spoke about how they learnt from the textbook.

- In terms of affordances within the textbook tasks, when asked how these encouraged students to engage, teachers spoke about different elements. Most importantly, they related 'mathematical activities' with construction tasks, which needed use of concrete materials. While some teachers ignored these tasks altogether due to lack of resources (Ganesh and Sanchita), a few made their own materials (Mahesh) or resourced them from different sources (Afreen). Several other features of the tasks included within the textbook were not mentioned as explicitly. Most of the teachers agreed that construction tasks were beneficial for the students, but other kinds of tasks, such as 'open tasks' or the use of 'multiple methods' were more contentious. Some teachers, such as Bhumika, Kanchan and Sanchita, preferred more direct questions (closed questions) rather than open ones. Mahesh was the only one who explicitly favoured the use of multiple methods. Inclusion of student 'voice' and their

thinking was only spoken about in terms of teachers attempts to engage 'all' students, thus having a larger equity value involved. In particular, making the environment non-threatening or ensuring that an activity's affordance of enabling student engagement were highlighted. Teachers did not, however, talk about how discursive practices are intrinsic to mathematics learning. Yet, it is important that teachers are starting to create classroom environments (non-threatening in some cases and encourages children to speak) which are conducive for discussions.

- Contextual tasks which are an integral part of the textbooks were viewed from different perspectives. Teachers raised its advantages (interest building and application in real life), whilst also discussing their disadvantages (everyday maths not aligned with school maths and too idealistic). Some teachers present a more nuanced perspective and attempted to delineate the 'extent' to which contextual tasks are reasonable and when they become necessary. First, they pointed to the choice of contexts that are in the textbooks – claiming that they not 'relatable' to the children. Second, they discussed how the long contextual themes distracted students from the important mathematics that was being discussed. These both reflect the discomfort that the teachers felt when contextual tasks were expanded beyond the 'word problems' and 'application based problems' that they were more used to.

- To understand the institutional context within which these teachers viewed and used the textbooks that are state-mandated, it was important also capture whether they felt supported in their work and if so, how? Apart from the lack of resources as articulated by a few teachers some other important institutional barriers were raised. The primary issue that all teachers spoke about was the overall lack of emphasis on teaching itself. They saw their own profession as being split up into two parts: one as an administrator; and the second as a teacher. Many of the teachers discussed how the former took up most of their time and the latter was institutionally neglected. Further, while a few teachers discussed how they found support in collectives or mentors, these were informal support systems. The formal in-service support seemed unhelpful and unsupportive. Finally, teachers were also conscious of the wider positioning of government schools in the discourse around schooling of the 'poor'. They felt that by being provided these textbooks (which were 'bad') the children were further being made to lag behind private school children, who received more advanced/effective

privately published textbooks. The barriers seemed to be heightened by the fact that they felt that the children came from disadvantageous backgrounds and thus had high rates of absenteeism, lack of home support, as well as difficult and complex home conditions.

CHAPTER 8: DISCUSSION

8.0 Introduction

In the last three chapters (5, 6, 7), I have presented my analysis of three distinct types of data: textbook, lesson observations and teacher interviews. In this chapter, I elaborate upon these findings by reflecting back on the literature and conceptualisations that were reviewed in Chapter 3. As a result of the review of literature in Chapter 3, I conceptualised the teacher's use of textbook as being participatory (Remillard, 2005). Thus, both the textbooks' own affordances as well as teachers' views influence their textbook use. This participatory relationship has been operationalised by several other scholars (Brown, 2009; Choppin et al., 2018; Pepin, Gueudet, & Trouche, 2017). Within such a participatory approach, Brown's (2009) model of *design capacity for enactment* has been adapted, comprising three components: textbook affordance, textbook use (selection and interpretation) and teachers' views (see Figure 8.1). In terms of the use, Brown (2009) distinguished between 'offloading-adapting-improvising' of the curricular materials, defining them in terms of degree of responsibility teachers share with the textbooks and their own resources. The use component of the adapted framework also comprises: direct use (textbooks content is directly attempted), adapted use (textbook's content is adapted for usage); and inserted use (textbook content is not used at all). While, fundamentally, my proposed framework shares a similar rationale, it differs from Brown's in three significant ways.

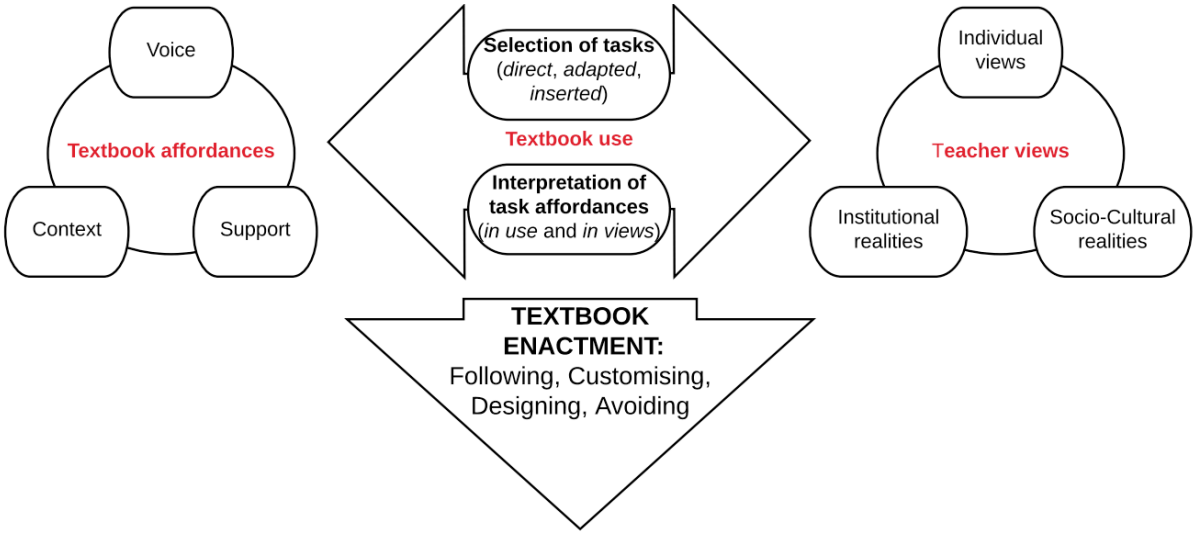


Figure 8.1: Framework of teachers' enactment of the textbook adapted and extended from Brown (2009)

First, unlike Brown, I do not assume that every kind of textbook enactment can be called 'designing'. Following Pepin et al. (2017), I argue that designing has two dimensions: *intention* and the *creation of something new*. Thus, using this framework I have encapsulated different types of enactments; keeping in view intention and creation. This significant difference was made since it was clear that while teachers were willing to use the textbook in different ways, not many saw the textbook as a springboard to design their own teaching. For instance, Mahesh, who agreed with the textbook's changes and also attempted to use them in his class, continued to *follow* the textbook directly using the tasks and hardly made any adaptation (only 22 % of his episodes had any adaptation of the textbook tasks). While on the other hand, it was seen that Afreen was actively thinking of using the tasks and adapting, thereby *designing* her own kind of teaching. Thus, textbook enactment (as a result of the process of participatory relationship) was viewed as: following, customising, designing and avoiding. It was important for the framework to make these distinctions explicitly, while keeping intentionality in mind (this is discussed in detail in Section 8.3).

The notion of 'selection' and 'interpretation' is similar to the Brown's (2009) conceptualisation of 'mobilisation' and 'adaptation' of curricular resources. While, mobilisation is understood as how teachers bring different resources (including the textbook) into their teaching, adaptation is viewed as how teachers modify these resources. Similarly, while 'selection' is a way in which textbook feature in the teachers' lessons, through direct textbook use, adapted use or insertions (see Section 6.1), 'interpretation' helps in understanding how the teachers interpret the textbooks' affordances (see Sections 6.2 and 6.3). Further, interpretation also includes teachers' views of the affordances, thus being both interpretation 'in use' as well as 'in views' (in Section 8.2, I discuss this in more detail).

Second, the components 'textbook affordance' and 'teacher views' are structurally similar to those in Brown's framework, yet they differ significantly in terms of how they are conceptualised. This is both because of the nature of the reforms in India and thus, the textbook as well as the distinctiveness of teaching as a profession in the Indian context. The three important ways in which the authors of these textbooks have adopted the reforms are in terms of the affordances of: voice, the context used, and the support elements incorporated. From the other side, Brown focuses on the notions of teachers' 'beliefs' and 'knowledge' (both subject matter knowledge and pedagogical content knowledge). There are two significant reasons why I did not focus on these two aspects, which are commonly used in mathematics education. First, as discussed in the literature review chapter, there is a lack of

teachers' voices and agency literature in the Indian context (see Subsection 3.4.1). Since 'voice' was an important affordance studied within the textbook analysis, it was also deemed necessary to bring in teachers' voices, as an equally important component. Note that ideas of 'beliefs' and 'knowledge' are not necessarily discounted in such a focus. In fact, in my analysis, important questions around subject matter knowledge were raised, especially when teachers got confused with the openness of some of the textbook tasks (see Subsection 6.2.1). Yet, the aim was to bring these forward by foregrounding teachers' thinking and voice rather than conceptualising these as their individual 'mental' constructs. Thus, the notion of teachers' views was considered holistic enough to capture their ideas around the textbook and its use, which also included their perceived institutional and socio-cultural realities.

It is important to remember that the teachers in the study were not just mathematics teachers, for they were primary school government employees, both responsible for teaching all subjects as well as fulfilling administrative tasks. As discussed in the methodology chapter (see Subsection 4.4.2), during the fieldwork it was clear that teachers often taught in very precarious and 'disruptive' situations. For example, during my fieldwork some teachers were called in for election duty lasting more than a week, one had to go for a 15-day long physical education training exercise and two of the schools were disrupted due to official auditors' visits. This was clearly reflected in their views, as the focal teachers struggled to balance 'non-teaching work' with their teaching time (see Subsection 7.4.1). This is integral to the way they used and viewed the textbooks, as well as how these became positioned in their teaching and learning. Further, the socio-cultural norms around how the teachers viewed children from disadvantageous backgrounds and thus, approached their teaching is also important and gets captured within this framework (see Subsection 7.4.4). In the next section, I will discuss my findings using this adapted framework by considering (a) the uniqueness of the textbook affordances (Section 8.1); (b) teachers' interpretations of these affordances (Section 8.2) and (c) the four types of textbook enactments that emerged out of this analysis characterising the teacher-textbook relationship (Section 8.3).

8.1 Affordances of the textbook: What are they attempting to achieve?

In this section, the findings in relation to Chapter 3 on textbook affordances are discussed in depth. In the conceptualisation, the textbook is viewed as an artefact that provides affordances, i.e, a "range of possibilities that artefacts present to human activity" (Brown,

2009, p. 34). This conceptualisation facilitates analysis of the three affordances of the textbook, namely, voice, context and support, which is the focus of this section.

8.1.1 Opening the text: use of voice to challenge textbook authority

Textbooks have been criticised for being too authoritative and normalising only one particular view of knowledge (Kumar, 1988). This complicity of textbooks in narrowing mathematical interpretations has been critiqued in many contexts. For instance, Fauvel (1991) discussed the tone of mathematics textbooks between 16th-18th century England and ways in which textbook authors used different forms of writing to encourage readers to use their own reasoning, rather than relying on the textbook. More recently, in work by Wagner (2012), he examined his own textbook writing in the Bhutanese context and identified ways in which texts can become more 'open'. The authors of *Math-Magic* NCERT series seem also to have been making an explicit effort to subvert its positioning as an authoritative text.

My findings clearly reveal that the textbook includes tasks that expect students to engage in several kinds of mathematical processes important for mathematical activity. Rotman (1988) discussed how two types of activities - *scribbling* and *thinking* - are crucial for mathematics. While scribbling is an exclusive activity, where the learner is supposed to work on their own to apply and use what they know, thinking is an inclusive one involving working with a larger community, which includes some level of communication. In Subsection 5.1.2, I demonstrated that the textbook has a variety of questions enabling both of these processes. While there are many scribbler questions in the textbook (state/answer, construct, estimate, check), there is also a variety of thinker questions (think, express, discuss, explain). For example, the most common thinker question was 'expression', which asked students to bring forth their interests, thoughts or experiences about the theme or context underlying the task. In Book 4 and Book 5, 19% and 8% of the tasks encourage students to 'express', respectively. Notably, 90% of the tasks include some scribbler element (in both Books 4 and 5) (see Table 5.2). These kinds of questions provide opportunities for the reader (assumed to be the student) to engage with the mathematics in different ways. As Herbel-Eisenmann and Wagner (2007) discussed in their paper, a naïve counting of scribbler and thinker questions does not necessarily indicate how the reader is positioned. A look at the flow of the text (when does the thinker question arrive) is also important. As discussed in the findings chapter, the thinker questions are often posed after some scribbler ones, which constructs the reader as someone who scribbles first and then brings that to the larger community. A second aspect highlighted by Herbel-Eisenmann (2007) is the importance of

the audience with whom the reader is supposed to share their thinking. Most of the tasks do not explicitly specify with whom 'discussing/explaining/thinking/guessing' is to be shared explicitly. However, about 39% of tasks in Book 4 and 21% of tasks in Book 5 include human agents shown to be engaged in some mathematical activity. These types of tasks showing humans talking, experiencing and sharing mathematical ideas implicitly indicate that mathematical activity can be an inclusive 'thinking' activity.

Further, the support element in form of teacher notes provides some context for these 'thinker' questions. Several of these notes directly ask teachers to encourage students to answer the 'thinker' questions (Book 5 – 46%; Book 4 – 64%). These notes, thus, become extensions of the tasks, articulating that thinker tasks need to be encouraged. Yet, the notes do not usually clarify 'why' these are important or 'how' these tasks could be pursued in their lessons[85]. Thus, even when there is the space to give more context about these 'thinker' tasks, the textbooks fail to do so. Further, none of these mentions explicitly what the role of the teacher in these discussions would be. Would they have to choose the correct answer, lead the discussion towards an efficient solution and/or ensure participation of all students? In sum, neither the intention nor the role of the teacher is clarified in these teacher notes, which just seem to repeat the 'thinker' questions.

As Davis & Krajkic (2005) highlighted in their work, curriculum materials seen as 'educative materials', can themselves become a source of teacher development and learning. They proposed five "design heuristics" (p.5), which focus on teacher learning keeping in mind: "how to help teachers understand the rationale behind the recommendations" and "how teachers could use these ideas in their own teaching" (p. 6-7). As discussed above, neither the rationale nor its use in the teaching are explicitly mentioned within the textbooks (in tasks or teachers notes). While these kinds of 'educative materials' might be talking exclusively about materials for teachers (such as teacher guides), I argue that since in the Indian context we do not use multiple resource packages and still depend on a student book, curricular developers need to start thinking about how these 'educative' elements can be integrated into the textbooks, especially in cases such as these, when pedagogical reforms are being introduced within the student textbook. In India, despite scholars starting to point to the

[85] As discussed in chapter 5, 64% of the teachers notes in Book 4 and 90% of them in Book 5 do not have any additional rationale or explanation provided for why and how these thinker questions need to be incorporated into the lessons. Moreover, only about five notes in Book 4, and three in Book 5 gave any rationale for the approach taken in the tasks.

failure of current continuous professional development programmes, such as Subitha[86] (2018), the textbook is still not being spoken of as a potential teacher learning opportunity; unlike in the international context, where scholars, such as Ball and Cohen (1996) have been advocating for the transformative role that textbooks and other curricular materials can play in teacher learning. Clearly, by including the teacher notes within the textbooks, the authors were already hoping that these would become a kind of 'support' to enable teachers to use the tasks. However, 'educative' elements are not clearly articulated within them.

Another attempt to subvert the authoritarian positioning of textbooks in India can be seen in the introduction of several 'generative' tasks. These tasks (Book 4 – 44%; Book 5 – 27%), which require students to bring in their own information to complete the questions in them. Further, several teacher notes (Book 4 – 3; Book 5 – 2) also recommend students making up their own questions. Unlike the previous discussion on the student being constructed as a 'thinker' or 'scribbler' of mathematics, here the intention appears to be to encourage students to become 'authors' of mathematics. The idea appears to be that the authority of 'what' mathematics is to be discussed is being shared with the readers. Here, Wagner's (2012) analysis is very useful. In his work, he pointed out that, even while making an effort to make texts more open, this does not necessarily quell 'seduction'. By seduction, Wagner highlighted how the text might be leading to a construction of "an ideal child" (who engages in a particular type of mathematical activity) (p. 163), despite attempting to make the textbook open. Thus, the openness is an "illusion" (p. 164) as the path has already been determined in the curriculum. Similarly, Herbel-Eisenmann (2007) discussed this paradox by noting that textbooks that want to imbibe the fallibility or flexibility of mathematics, are much more complex to write:

> Representing mathematics as fallible in written materials is difficult for at least two reasons: (1) the authors have to help the readers learn particular mathematical ideas, and (2) the authors need to assume some particular ideas have been learned in order to write the next section of the textbook. Adopting a discovery approach to mathematics may be more difficult for curriculum developers than writing more conventional curriculum materials, because they have particular mathematical ideas in mind that the students need to learn and do not have access to the student reader's actual prior knowledge. (p. 364)

[86] Subitha (2018) comprehensively brought together literature on current continuous professional development in India, and discussed alternative ways in which this needs to be conceptualised.

Wagner (2012) suggested three ways of addressing this issue. The first two ways foregrounded aims of social justice, instead of focusing on mathematical curriculum. He acknowledged that this is difficult for mathematics textbooks[87]. His third recommendation was making the author's voice visible and making it a "critic" (p. 167). As Wagner (2012) pointed out, in Fauvel's (1991) analysis of English textbooks, the author provided examples of how the textbook itself became a critic and questioned appropriateness of mathematical procedures (within itself) explicitly. The *Math-Magic* series does include 'open' elements (both expanding mathematical activity and sharing authorial roles), but there are no instances where there is critique within the text. For example, while the textbook encourages the student to 'think' or generate' tasks, there is no acknowledgment of contestations that might arise during these task enactments or formulations. Thus, a meta-narrative critiquing and clarifying these 'open' elements is unavailable.

8.1.2 Contexts within the text: creating a distinction between 'real-life' and 'mathematics'

To begin the discussion on contextual tasks, it is first important to remember that the authors chose several ways to incorporate 'context' within the textbook. The inclusion of generative tasks, which invite students to bring their own contextual information into the tasks, has already been covered. Furthermore, it has been explained that 'stories' are used in the textbooks. These include not just conventional word problems, but also more detailed and 'authentic' stories. As the authors themselves have written, they made an explicit effort to embed authenticity (Rampal & Makar, 2012[88]). Beswick (2011) delineated authentic or situated contextual tasks as being distinct from the typical word problem, with the distinction being made on the basis of there being "extra-mathematical information" (p. 45). Further, Palm (2006) claimed authenticity includes not just the information immediately needed for the solution, but also, a description of the "event, question, information, presentation (language and mode), circumstances, solution needed and purpose" (p. 44). In Book 4, 36% of the tasks contain such richness, while in Book 5, 23% have them. Often these contextual themes are also spread over a number of tasks, thus not just being restricted to a particular.

[87] Here, I also want to point out that the textbook, while it does use 'social justice themes' does not necessarily exclusively introduce social justice based problems, in the way in which other authors, such as Gutstein (2006) and Stocker (2006) have done in the North American context. Thus, even as a text to connect social justice to mathematics, it is not able to foreground particular issues. The textbook explicitly mentions social justice issues in very few tasks (Book 4 – 12%, Book 5 – 6%), but these are not central to the task itself. None of the teachers notes convey this element of the textbook to the teachers.

[88] Note that, Anita Rampal was one of the authors of the Math-Magic textbooks, as discussed in Chapter 2, Subsection 2.1.2.

While there has been a clear attempt to make the tasks more ‘authentic’, the textbook still contains many tasks that resemble the word problem (see Subsection 5.2.1). Gerofsky (2004), using a literary genre, defined word problems as having a three-component compositional structure: “set-up”, “information” and “question” (p. 27). Such a genre is typical in mathematics textbooks and can be traced back to Egyptian cultures. Unlike the more elaborate authentic tasks discussed above, these are simpler reductive contextual tasks. In Book 4, 25% of the tasks contain such word problem like tasks and 14% in Book 5.

For example, in Figure 8.2, the story of Kiran[89] can be seen, who is starting her own business and renting rickshaws. The task includes several photographs as well as text, giving a sense of authenticity. However, when analysed through the lens of Gerofsky’s word problem genre, a similar three-component compositional structure appears. In the set-up, a detailed description of Kiran’s improving life conditions is provided, with the task then moving on to ‘information’, and ‘questions’.

Figure 8.2: Book 4, Chapter 6, Task 4.6.3, page 62 through Gerofsky’s (2004) genre perspective

In contrast, tasks, such as that in Figure 8.3, which also uses a story to explore the notion of space, manage to avoid the word problem genre. Here, in this two-page spread, a story about *Gappu* the mouse, who is flying with balloons and can view the world from different perspectives, can be seen. The questions here (marked with a blue star) at the beginning of

[89] It should be noted that this is a task within a special thematic chapter, where the story of Kiran is used across different tasks. Also, as discussed in Subsection 5.2.2, this chapter focuses on bringing to the fore issues of gender and caste equity. Yet, as shown here, the structure of some of the tasks falls into the genre of word problem.

the page set out a problem, which is to be discussed and explored as the students read the story.

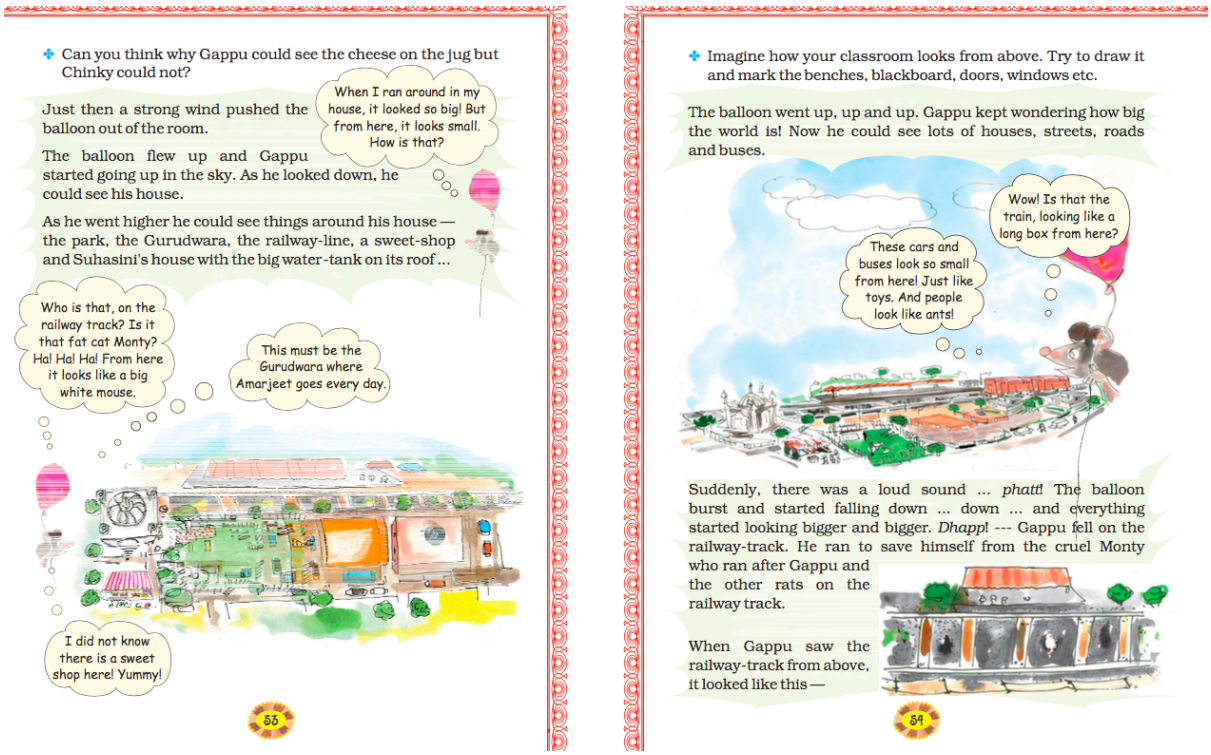


Figure 8.3: Book 4, Chapter 5, Task 4.5.1, page 53-54 through Gerofsky's (2004) genre perspective

This discussion is particularly important as teachers are often more used to the 'word problem genre' and the change in the format of contextualised tasks influences their practices and thinking (this is further discussed in Subsection 8.3.2). There are also theoretical concerns. Gerofsky (2010) warned about the impossibility of this idea that 'real life' can be authentically translated into a school mathematics word problem, because of the distinct nature of school and out-of-school mathematics. Through the lens of situated learning, we know that the situation within which the mathematics occurs is as important as what is being done (Lave, 1992; Nunes, Schliemann, & Carraher, 1993). Real life mathematics represented in the school setting can never become the real problem itself and thus, a fundamental dissonance exists between the two. Gerofsky further argued that the 'real-life' stories in mathematics school settings will always become more like the "word problem genre" than the real problem in a real setting.

The issue of translation of 'real' versus 'mathematical' is heightened in the use of contextual objects. In these textbooks, a lot of visuals to represent 'contextual objects' with varying degrees of authenticity (photographs, illustrations, graphical representations) can be

seen. In Book 4, while most of the illustrations included are less schematised (21%), in Book 5 a shifting trend can be seen, where even if the objects referred to are everyday objects their representation is often schematised (47%). While in some cases, the textbook makes extensive effort to bring in rich context, encouraging the reader to engage with 'authentic' aspects of the illustrations. On the other hand, there are tasks where the readers are to ignore these aspects and focus on the mathematical properties of illustrations. Thus, while an attempt is made to embed authenticity into the tasks by including rich and deep contextual information, authenticity in terms of contextual objects often becomes tokenistic. Even though the authors (Rampal, 2015; Rampal & Makar, 2012) explicitly warned against such tokenism, there are times, such as in the case of contextual objects, when the textbooks fall prey to it (see Subsection 5.2.1, Figure 5.9).

Clearly, the authors have made an effort to make every task 'contextual', by including generation tasks, word problems, authentic story problems and contextual objects (Book 4 – 90%; Book 5 – 75%). Further, they have avoided 'decontextualised' mathematics, whereby there are hardly any tasks with only number-based operations. This is in addition to the lack of facts or information given in explicit mathematical terms (Subsection 5.3.2). Even within the teacher notes, the textbooks explicitly ask not to provide definitions or introduce mathematical terms. Thus, the textbook is not only attempting to contextualise mathematics, for it is also discouraging the introduction of ideas viewed as 'decontextualised mathematics'. This creates a distinction between 'real' and 'mathematical', along with the illusion that all school mathematical objects can always be viewed through an 'authentic real life' lens. From the perspective of realistic mathematics education (RME), this distinction itself is a fallacy. 'Realistic' is defined within such a conception as everything that the student can imagine and does not necessarily have to be confined to 'real-life' authentic experiences (Van Den Heuvel-Panhuizen, 2003). It further acknowledges two dimensions of mathematisation - horizontal and vertical. While horizontal mathematisation deals with bringing mathematical tools to solve problems in daily life; vertical mathematisation pertains to working within the mathematical system (Van Den Heuvel-Panhuizen, 2003). The textbook authors, having resisted providing mathematical tools, limit the extent to which mathematisation can take

place, especially the vertical form. Further, the sole emphasis on 'authentic' real-life tasks limits the scope of any mathematisation[90].

At the same time, the textbook authors, by including wider cultural references (different contexts, art, poems, everyday life references) attempt to move beyond use of typical market-based context examples (see Subsection 5.2.2). The interaction of 'culture' and mathematics has been explored by different scholars within ethnomathematics and culturally relevant mathematics education tradition (D'Ambrosio, 2001; Greer et al., 2009). However, their translation into mathematical tasks (in stable text) as well as the subsequent enactment within lessons is much more complex. In Subsection 8.3.2, I discuss how teachers interpreted students' everyday experiences and included them in their lessons. I will argue, while teachers used these as examples, a richer deeper engagement with the underlying mathematical structures of their everyday experiences was not brought to the lessons.

8.1.3 Support for teachers: limited support via textbook structure

Regarding the introduction of alternative forms (such as generative and thinking tasks), I have already highlighted the lack of explicit support for teachers. While the teachers' notes addressed the teachers directly, instead of providing rationale for the tasks these were re-articulation and extensions of the tasks themselves (see Subsection 5.3.2). Apart from explicit support, there is also a more implicit form provided by the structure of the text and tasks. As Howson (2013) argued, textbooks not only provide tasks to be done, but also a "coherent framework for teachers" (p. 648). With respect to this, a huge shift is seen in these textbooks, which have abandoned traditional formats of presentation of mathematical ideas and taken on a more alternative form. On analysing the textbook, it was found that neither explicit headers are used to signal the pedagogical activity involved in the task nor do the sequencing of the tasks follow any structure of 'introduction, explanation, example, and exercise', as typically seen in other mathematics textbooks (see Subsection 5.3.1). Even within the tasks, there is a lack of repetition, solved examples as well as mathematical information or facts, which are also typical to mathematics textbooks. As discussed in the literature review, alternative forms of presentation, including a spiral curriculum can be seen in many post-colonial contexts, such as Uganda, which are attempting to change their textbook forms (Namukasa, 2018).

[90] It is also important to note that, NCF-2005's position paper on mathematics teaching and learning explicitly makes 'mathematisation of students' mind' as the core aim of school mathematics. Yet, realistic mathematics education (RME) tradition or notions of 'realistic', 'horizontal mathematisation' and 'vertical mathematisation' are not called upon; neither in the policy paper nor in these textbooks.

One of the important consequences of this finding overlaps with a methodological decision taken for this study: identifying a suitable 'unit of analysis' for the textbook investigation. Unlike other textbook analysis studies, which have used the type of task (introduction, exercise, or solved example) as a way of analysing the text (see Ronda & Adler, 2017; Valverde et al., 2002), the lack of such an explicit structure meant I had to 'view' the text as blocks of tasks, each with its own distinct goals. Since most of the tasks appear to introduce a problem in a *context* using an active *voice*, it was clear that these thematic engagements overlapped with the literature on 'task-based' instruction (Winiecke, 2015). The unit of analysis chosen for analysing the textbook, thus, was the 'task', which could be defined as a "*written presentation of a planned mathematical experience for a learner, which could be one action or a sequence of actions that form an overall experience"* (Watson & Thompson, 2015, p. 143). An equivalent unit of analysis for classroom observations was chosen to be 'episodes' and it was crucial to see how they positioned these tasks (discussed further in the following section). This new structure of the textbook was also the most vocalised discontentment with the textbook, as expressed by the teachers (Subsection 7.1.1).

8.2 Teachers' Interpretations of Textbook Affordance

In this section, I discuss the ways in which teachers interpreted the above identified textbook affordances. This is achieved by integrating the findings from Chapter 6 on teachers' textbook use with those from Chapter 7 on teachers' views. While Chapter 6 focused on teachers' interpretations of the textbook affordances during their textbook use (see Sections 6.2 and 6.3), Chapter 7 discussed teachers voices and views on these affordances. Instead of focusing on whether teachers are able to interpret the affordances productively or not during their use; this integrated analysis of views and use helps in understanding the rationale behind the choices, that is, teachers own thinking and reasoning for the decisions. Such an approach is in line with the participatory relationship between the textbook and the teacher, as assumed in this study (Remillard, 2005).

8.2.1 Constructing learners as 'scribblers' but not 'thinkers'

In the Subsection 8.1.1 above, I covered the finding that the textbook makes an explicit effort in constructing the mathematics learner as a 'thinker' by incorporating questions that ask students to 'discuss/explain/think'. In this subsection, I consider how teachers interpreted these tasks and ways in which they constructed the student as the mathematical 'thinker'.

Here, I argue that teachers included students' voice and participation in the lessons primarily from an understanding and equity perspective. To ensure that all students understood what is being taught, teachers deployed different types of engagement strategies – from working with materials 'hands on' to asking students to writing solutions on the blackboard. However, not enough attempts were made to include students' own mathematical thinking and reasoning within the classrooms. Thus, the epistemic authority still seems to have been strongly held by the teachers, despite the textbook tasks making explicit efforts to ensure that this is shared with students. Some of the reasons discussed include lack of teacher knowledge as well as the rigidity of teacher authority roles.

Student voice for understanding

As explained in Chapter 7 Subsection 7.2.1, most of the teachers besides Neetu and Sonali explicitly mentioned that they saw the use of the 'activities' (included in the textbooks) in mathematics learning as helping with understanding. These activities are often associated with 'hands-on' activities, requiring concrete materials for students to work with. This was reflected in their textbook use as well, where teachers attempted to engage students with different activities, such as chart making, making shapes with matchsticks, using an inch-tape and using money bills (see Subsection 6.2.2). Thus, incorporating material based activities aimed at building 'understanding' was viewed as good practice. With this almost universal agreement across the teachers, issues around access to these kinds of 'teaching and learning materials' (constructed as being different from textbook or other printed materials) also arose as a hindrance. Bhumika referred to manipulatives in "maths kits" or "geometric kits", which she complained were not always provided by the school management. This association of good practice with using concrete manipulatives, is not surprising since 'activity based learning' and ideas of doing and learning have now existed in Indian educational arena for a long time. These include Gandhi's idea of work and education (*nai-talim*) and Montessori's (1966) idea of manipulatives, which have influenced primary and early primary schools in India extensively. According to Sarangapani (2015), these ideas further found a footing via international aid-funded programmes, such as 'Joyful Learning' in Karnataka, which focused on activity based learning. Other studies in the government school context in Delhi have found a similar emphasis on activity based learning, using concrete manipulatives (Petersson & Bäckström, 2014). Policy itself has emphasised this approach of hands on or experiential learning by promoting mathematics labs and mathematics kits (NCERT, 2010). For instance, in Figure 8.4 (right), a collection of mathematics kits produced by NCERT is shown, which

are available to be purchased by schools across India. There is a further burgeoning field of creation of mathematics activity materials in the private and NGO sector, for instance, Jodo Gyan, Arvind Gupta Toys, Digantar etc (Sarangapani, Nawani, K, & Banga, 2017). Thus, the messaging of activity-based learning using manipulatives goes beyond the textbook, being influenced both by the historical as well as present policy rhetoric.

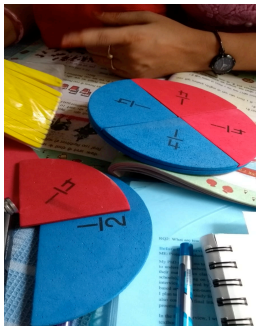


Figure 8.4: Materials Afreen showed me that she uses for mathematics classes (left); Materials at the NCERT office which are sold to schools across India (right)

Other types of attempts were also made by teachers in their effort of ensuring 'understanding'. For example, as shown in the Subsection 6.2.1, some included elaborate explanations of procedures using a 'process-oriented' approach, rather than directly providing solutions. In other cases, teachers were observed using different strategies aimed at engaging students in multiple ways (especially by teachers, such as Mahesh, Bhumika, Mohini, Kanchan, Afreen and Deepali). This included sub-questions inserted within a discussion of a process-oriented teacher explanation (Mahesh) as well as encouraging students to come up to the blackboard to try out solutions on it (Bhumika) (Subsection 6.2.2). Bhumika explained that by engaging students in this way, she discouraged them from simply 'copying' answers from the blackboard or from each other. Afreen, to ensure that all children were included and took part in the lessons; often divided students in groups (those who have 'understood' and those who have 'not') and then addressed these groups separately. Thus, these teachers used strategies to ensure (or attempt to do so) that 'all' children could access what they are explaining. These findings contradict classroom based studies, such as that of Smith, Hardman, and Tooley (2005), which give a monolithic view of teaching in India as "recitation, rote and repetition" (p. 607).

Despite the practices of teachers in ensuring 'understanding' by including hands on activities, process-oriented solutions as well as encouraging students to answer and engage in the lessons, very few examples where teachers explicitly sought to include 'student thinking'

were observed. The textbook encourages students to present their own mathematical rationale (think/explain/guess/imagine) and yet, this was not observed as often. Moreover, in the instances when 'why' was explored by the teachers, there were two types of responses, which seemed to be linked with (a) teacher' authority position (b) teachers' knowledge. As was reported in Subsection 6.2.3, teachers, such as Mahesh, Kanchan, Ganesh, Mohini and Afreen did engage with students and provide opportunity for students to 'think' about the mathematical processes. Yet, only Afreen pursued the student thinking, while the others either did not listen to the answers (Mahesh), did not pursue them (Kanchan), or attempted to find mathematical rationale to address them (Mohini). Ganesh's case was somewhat obstructive, whereby he mocked the students for answering wrongly and disqualified their thinking altogether. Here, Ganesh's case is similar to the findings in Sarangapani's (2003) ethnographic study exploring the 'framing' of the authority role in the classrooms. She pointed out how, while there might be classrooms where student talk emerges, teachers still use different tactics that enable them to retain their own epistemic authority. One of the tactics she discussed is the notion of dismissing the response on the basis of disciplinary grounds. In Ganesh's lessons, this conflict showed up, when he explicitly reprimanded a student for "continuing speaking without understanding", while asking students to express their thinking. This kind of a reprimand discourages students from genuinely participating. While on the surface he asks and even says that there would be no reprimanding, if someone gives 'wrong' answer, the students seemed to be fearful of speaking openly in his class (see Mukhopadhyay & Mukunda, 2017).

On the other hand, teachers, such as Bhumika, Kanchan, Afreen, Mahesh and Mohini were not seen using disciplinary tactics to retain their authority in the lessons. Bhumika and Afreen explicitly explained their approach of being more open and ensuring students talked to them. She remarked:

> My class is actually very talkative. They think that they should come and tell everything to madam. They want to share everything. That 'controlling thing' (E) is actually less in my class. Like, we see this in our homes also, that if father will scold them, they will come to mother, that she will definitely listen to me.
>
> Bhumika, interview 2

As Sharma and Sarangapani (2018) pointed out from their analysis of teachers in government schools in Delhi, they are becoming aware of the teacher-student relationship

and finding ways of breaking the authoritative boundaries. Bhumika's response of being a 'mother-like' figure, who the students can confide in, is similar to the notion of "mother-teacher" (p. 292), which is what these authors discussed.

Despite teachers creating an environment of trust, a genuine pursuance of the notion of 'why' in the lessons was not present. For instance, Mahesh failed to listen to the answers and moved on to his own explanation. Kanchan left the questions hanging by not eliciting answers. Finally, Mohini attempted to provide a mathematical rationale for why a certain answer would not be successful and then, give 'correct' one, without opening it up for others to make suggestions. In addressing the questions around 'why', teachers not only have to 'know' the underlying mathematical notions, but also 'know' the different types of answers that might be given by students, and a way of placing the different perspectives within their understanding. This requires, not only mathematical subject knowledge, but also, pedagogical content knowledge (PCK) (Shulman, 1986). As Kumar and Subramaniam (2015) held, while teachers might believe that it is important to listen to students, the lack of their own knowledge might hinder them in the pursuit of this. Kumar, Dewan and Subramaniam (2012) further pointed to the absence of focus on these elements of PCK or subject matter knowledge in the preparation of elementary teachers in India (as also highlighted above). What is important to raise here is that while there seems to be some element of missing knowledge, the focal teachers (apart from Sonali, as discussed above) did not seem to articulate the issue around the textbook in terms of 'lack' of knowledge at all. While most recognised the importance of asking students 'why', and creating a space that was open and non-threatening for students to answer, the teachers still continued to direct the discussion towards the 'right answer(s)', which they considered their responsibility to explain. Thus, the curriculum developers need to facilitate the move towards explicitly indicating ways in which multiple answers are to be pursued; how teachers can 'choose' and discuss more efficient solutions, or how different types of answers can be discussed within the mathematics lessons. It clearly shows that the approach the textbook takes of simply posing questions of 'why' (thinker tasks) and asking teachers to encourage students to discuss different methods (teachers notes) is not sufficient. The classic case of Mrs Oublier discussed in Cohen's (1990) seminal paper becomes relevant here, which demonstrated how teachers might believe that they are attempting reform-oriented practices, yet they might be reproducing old ones. Here, the recent study by Choppin (2011) on 'professional noticing' is also critical. In his study, he found that teachers who developed means of noticing student thinking (instead of viewing

their answers as right or wrong), were slowly able to adapt those into their use of challenging tasks.

8.2.2 Role of context: students' epistemic knowledge, authenticity and social justice

A second important feature of the textbook is the inclusion contextual tasks, as discussed in Subsection 8.1.3. Here, I cover how teachers interpreted the different types of contextual tasks and their ways of using them in their lessons. I argue that they primarily saw the value of these tasks for affective purposes as well as through the notion of transfer of school mathematical knowledge into their lives. Further, I discuss how the role of 'authentic' contexts seem to be used superficially, as just a 'veneer' (Maier, 1991), resulting in students getting 'stuck' in these aspects as teachers attempt to shift focus on the 'mathematics' beneath this veneer. Finally, in terms of social justice, I consider the lack of emphasis on the 'critical themes' introduced in the textbook. However, teachers are sensitive towards the students' lives, which can become an important entry point towards developing more critical pedagogies.

Students' everyday experiences for affect

In the above subsection, I discussed how students were not often asked 'why' and thus, their voice and thinking was missing from the lessons. Here, I consider the notion of students 'out-of-school' contextual knowledge and how this featured in the lessons. Most of the teachers seemed to agree that context and reference to students' lives builds 'interest', hence being appropriate for drawing upon in mathematics lessons. According to Beswick (2011), the role of context, often spoken of as 'real life/situated/authentic', can serve different purposes and have different theoretical underpinnings. As Sullivan, Tobias, and McDonough (2006) pointed out, mathematics disengagement is often a crucial issue which is countered by using context for affectual purposes. This seemed to be recognised by most of the teachers, who felt that by embedding mathematics in a context, this would make it interesting. This was reflected on their textbook use practices as well, whereby one of the main ways of incorporating context was by asking students to discuss their own experiences (Subsection 6.3.1). Here, we saw that teachers asked students to list their experiences in different everyday contexts such as the marketplace, sports involvement etc; presumably to engage and raise interest among the students. However, these discussions were almost always treated as 'examples' distinct from the mathematics to be followed (or introduced before). These 'examples', on their own, were not viewed as 'mathematical knowledge'. For instance, in

Kanchan's lesson on measurement, she asked the students to 'list' their experience of measurement. One expressed her 'out-of-school' knowledge of measuring bricks using thread (she claimed to have observed her father doing so), yet this was not legitimised as form of knowledge to be engaged with, instead Kanchan moves on to giving the 'school mathematical' information on measurement (using a tape). Studies in India, have indicated that students from working class background often have mathematical knowledge through their home and work contexts (Banerjee, Bhattacharjee, Chattopadhyay, & Alejandro, 2017; Bose & Subramaniam, 2011; Khan, 2004; Sitabkhan, 2011), yet there were no instances of teachers providing space for them to bring these forward. The opportunity that teachers give to speak (and list) their experiences are critical, for they can become pathways to greater engagement (see Webb et al., 2014). For instance, in Bose's (2014) study on using everyday experiences in lessons in urban low-income settlements in Mumbai, glimpses are shown of how this can happen. Yet, teachers in my study neither articulated this intention nor were seen attempting to make this happen, while using the current textbooks. Thus, contexts were purely viewed as a means of making the subject interesting and relatable, thus not seeming to influence school mathematical knowledge.

Context for transfer and conflict with authenticity

Additionally, teachers also believed contextual tasks could help enable application or 'transfer'. Apart from interest building, some teachers, such as Deepali, discussed the importance of contextual tasks for 'application', so that students were able to do '*hisab kitab*' (basic bookkeeping). This notion of transfer, viewed as 'direct application' (Bransford & Schwartz, 1999), is highly contested. While some scholars believe that this can be done through school mathematics (Anderson, Reder, & Simon, 1997), others who place emphasis on situated learning disagree (Lave & Wenger, 1999). However, this continues to be viewed as an important purpose of a contextual task. As Besweck (2011) pointed out, this notion, often viewed through the utilitarian lens, is focused more on the economic aims of school mathematics. Accordingly, some teachers, such as Deepali, discussed how the 'application' of mathematics to marketplaces and in bookkeeping is often seen as having important value acquired from mathematics learning.

Yet, the *Math-Magic* textbooks extend these notions of traditional 'economic' purposes and features several different types of contexts. As discussed in the textbook analysis (Subsection 5.2.3), these are also to question the dominance of market-oriented and middle-

class values for students' lives, as represented in textbooks. Further 'authentic' tasks (Palm, 2008) are introduced with detailed extra mathematical information to move away from traditional 'word problems' (Gerofsky, 1996). Thus, the alternative choices in contexts seem to be attempting both to (a) introduce meaningful and authentic contexts for maths learning; and (b) explore the social (and economic) world more critically, especially the lives of 'poor' and marginalised communities.

Indeed, teachers struggled to understand the intentions of these rich contexts used in the textbooks. Firstly, they seemed to be unclear about why these, in-depth, lengthy contexts have been included. They favoured shorter more 'word-problem-like' questions, where 'irrelevant' information is not included. The teachers, in particular, considered the chapters where using one theme or story, multiple mathematical ideas have been incorporated, too complex and confusing for the students. This was reflected in textbook use as well, where tasks (even those with more in-depth information) were mostly treated as traditional word problems, ignoring the extra mathematical elements. Thus, in line with what Gerofsky (2010) warned, because the teachers were familiar with the genre of word problems they tended to move tasks in that direction, when textbook tasks have been formulated to break away from that genre. Here, what was also critically found was the difficulty teachers faced in 'shedding' the extra-mathematical information as they went about treating tasks as word problems. In Subsection 6.3.3, it illustrated how students would get 'stuck' at several places and to proceed forward, instead of dealing with the 'realistic considerations' teachers recommend ignoring them. This highlights the issue that Boaler and Lubienski raised, especially in relation to dealing with contextual tasks by children from lower-socio-economic background. Lubienski (2000a, 2000b) argued that even though ways of thinking for students from lower SES are more 'contextual' the problem questions that are open and contextual do not necessarily help them. In fact, he elicited that the higher SES continue to find them more accessible. Ruthven (2001) called this the "technical double-bind" (p. 359): while it might be tempting to shed the contextual veneer in favour of more technical mathematics, we cannot deny the educational potential of cultural and contextual mathematics. Boaler (1993) suggested that the way to drop the obsession of creating the most 'authentic' task, is to start shifting the focus on to the individual student instead of the task. If the students are truly given space to explore the context on their own terms, this will enable the most authentic use of tasks. Yet, for these teachers such a discourse on the 'student focus' was missing in both their views and practice.

Social justice and mathematics

The other really important aspect raised by the teachers, is the notion of 'relatable' contexts (Subsection 7.3.3). Teachers pointed to several contexts used in the textbooks which might not have been something that students were aware of in their lived experiences. For instance, the chapter on 'Fish Tale' (Book 5, Chapter 1) talks about the lives of fisherwomen, while students in Delhi most likely have never seen the sea or fishermen in their lives. Here, two important consequences are to be discussed. First, if the purpose of these contexts is about meaningful access to the underlying 'mathematical concept', then the approach that Mohini took of changing the context examples to fit the concept might be a suitable solution. Here, the students' own lives and their experiences were foregrounded, rather than the particular context used in the textbooks. This approach is consistent with a situated learning perspective (Rogoff & Lave, 1984) and Boaler's (1993) suggestion of focusing on students.

On the other hand, from the social justice perspective, the themes themselves are equally important to be discussed. Where the lives of the marginalised, the poor, and diverse experiences are represented, this seem to have been done so for a social purpose. Here, it is interesting that Mohini and Neetu interpreted the authors' intentions as representing lives of 'poor' children, who were likely to be attending their schools. However, they pointed out that the authors seem to have stereotyped them. Mohini explained how the life conditions of the urban poor is complex and often these 'rural' references do not work for her students. Neetu commented on how the authors might have thought that these might work for "slum children", but she did not find this useful. Overall, no teacher explicitly used the social themes embedded within some of the textbook tasks. On the contrary, when teachers did engage with stories of children's lives, they ended up using moralistic discourses about an 'ideal child' (see Subsection 6.3.4). Here, Dowling and Burke's (2012) critical piece on mathematics and social justice is crucial. They talked about the need for the representation of the social world to move away from ''invisibility, tokenism, stereotype to interrogation" (p. 39). Given interrogation is important, they discussed the danger of it becoming stereotypes within a mathematics context. The teachers' comments indicate that the textbook's portrayal of students' lives is either tokenistic or stereotypical and yet, they did not interrogate their own use of stories of the 'ideal' child.

This does not mean that the teachers themselves were not sensitive towards the students' lives and were unsympathetic towards their everyday injustices (Chapter 7, Section 4.4). As Darling-Hammond (2002) purported, teaching for social justice involves engagement of the

teacher in terms of self, society, student and school. A critical reflection on all these aspects is important for an engagement with the social inequality embedded in different processes. From this perspective, the teachers, especially Kanchan and Afreen's empathetic view of the *students* and their concerns around their overall wellbeing, seems to indicate that they were sensitive to the children's lived realities. This resonates with findings by Sharma and Sarangapani (2018), who explored practices of 'good' teachers in Delhi government schools, highlighting that these teachers had a nuanced understanding of the socioeconomic context of their students. This complements conclusions made by Dowling and Burke (2012) who contended: "we can be both mathematics educators and political activists, just not at the same time" (p. 13) .

8.3 Textbook Enactments: Untangling Textbook Culture

In the Indian scholarship and policy there is severe criticism of the overreliance on textbooks in defining classroom activity (GOI, 1993; Kumar, 1988). Kumar (1988) significantly described this overreliance as the 'textbook culture'. Kumar (2005) even claimed that textbooks act as a "de facto curriculum" (p. 67), despite there being an official curriculum framework and syllabus. However, as discussed above these *Math-Magic* textbooks attempt to shift the focus away from an authoritative view of mathematics to one which is co-created by students and is also used with flexibility. Choppin, Davis, McDuffie, and Drake (2015), understanding the change in mathematics curricular materials in the U.S. context, used two metaphors to describe this: curriculum materials as a 'delivery mechanism' or as a 'thinking device'. While the former categorisation views curricular materials primarily as information that can be encoded by the teachers and delivered to the student, the latter one describes the material as a means of multiple meaning making, with the text itself having heterogeneity. Here, the textbook can be categorised more as a 'thinking device' that affords different meanings and interpretations, which prompts the need to examine the predominant 'textbook culture'. Indian scholars, such as Sarangapani (2003) and Vijaysimha (2013), have used sociological notions of 'framing' (see Bernstein, 2003) to explore textbook culture. With this notion, the focus is on the child's role in influencing the curricular knowledge, through an analysis of how strong (teachers as authority) or weak (teachers sharing authority) the framing is. They both argued that despite teachers using textbook or non-textbook knowledge, the framing of the lessons remains strong, with the teacher controlling the epistemic authority. Vijaysimha (2013) argued how this is the case especially in the government school context. While these approaches focus on the child's autonomy in

influencing 'knowledge', they do not delve into teachers' selection and interpretation of curricular knowledge within such a strong (or weak) framing. My analysis shifts the focus to this aspect of the 'textbook culture' and brings to the fore ways in which teachers enact the textbook in their lessons.

In this respect, my findings show that teachers are making diverse selection decisions, which are changing the ways that the textbook-knowledge is positioned in the classroom. As I show below, three teachers seemed to continue to *follow* the textbook using it as the primary source of authority as well as viewing it as a script. Three other teachers, disagreeing with the structure and presentation of the textbook tasks, appeared to have been 'pushed' into taking on a more active role and *customised* the textbooks to align them more with their own aims regarding mathematics teaching and learning. Three other teachers, failing to follow or customise, seemed to be *avoiding* mathematics teaching altogether. Finally, a special case of one teacher is discussed, who both viewed herself and the textbook as a resource; she *designed* her lessons based on student needs. This approach was uniquely observed among the sample teachers and reasons for this are explored in detail. In line with my conceptual framework, the textbook affordance, textbook use as well as the teachers' own thinking are seen to have been influencing these textbook enactments (see Figure 8.1).

8.3.1 Following: using the textbook as a script to structure the lessons

First, as shown in the findings chapter, there were lessons where teachers primarily used the textbooks to structure them, in that they moved from one textbook task to the other. This was especially seen in the lessons of Mohini, Sanchita and Mahesh. They included insertions and adapted textbook tasks only to supplement the textbook (see Subsection 6.1.1). In this section, I discuss how these three teachers enacted the textbooks.

From one point of view, teachers primarily relying on the textbooks can be viewed as 'adhering' (Nicol & Crespo, 2006) or 'offloading[91]' (Brown, 2002) the textbook. As Nicol and Crespo (2006) held, adherence to curricular material involves treating the textbook as an authority and the primary resource in the classroom, which was seen in the lessons of all these three teachers. However, it is important to point out that this adherence does not mean that these teachers necessarily always agreed with the textbook and its reformed features. In fact, two of them, Mohini and Sanchita, were particularly vocal in pointing out what they

[91] Here, it is also important to point out that the categories of 'direct-adapted-inserted' use are not synonymous with 'follow-customise-neglect-design', as discussed in this section. While, the former is a means of categorising episodes, the latter outlines an overall selection style, and not just particular episodes.

considered to be several shortcomings of the textbook. For instance, Mohini felt that the textbook authors have put too much emphasis on activities and ignore practice-based questions. She also claimed that the textbook had made the work of teacher more difficult, by moving away from the format of 'explanation, examples, and questions'. However, when it came to her lessons, she was observed focusing on the textbook tasks, attempting all the different types of questions and only supplementing them with some extra information or repeated questions.

One of the explanations of this kind of a mismatch between the teacher's views on the textbooks and her teaching has to do with the 'official' status of the textbook itself. Her adherence to the textbook task could be explained by the fact that she viewed her role as that of a teacher/employee in the government school who has to follow and comply with this 'official' curriculum. When asked why she used the textbook, she replied "*syllabus to karna hi karna hai*" (We have to do the syllabus) (Interview, 1). As Kumar (2005) remarked, within a larger 'textbook culture', any kind of textbook would always be viewed as a source of authority, irrespective of its nature. Thus, despite the textbook attempting to become a 'thinking device', it continues to be used as a 'delivery mechanism'. The pervasiveness of the textbook culture also indicates that the teacher herself did not conceptualise her teaching as being shaped by her own views, as she has offloaded the agency onto the textbook. Thus, both Sanchita and Mohini, despite disagreeing with several aspects of the textbook, appeared to consider it had to be used as a primary source of material in their classrooms.

Another important aspect to consider in understanding this 'mismatch', is the institutional setting within which the teachers are working. Mohini, especially, was often called out to do several administrative duties during the course of my field work, as she was the acting headteacher in the school[92]. She repeatedly pointed out how this took up a lot of her time, leaving very little time and energy for teaching. Other teachers also reported how disruptions in their schedules caused them to give insufficient attention to their teaching. This would appear to give further explanation for the mismatch between Mohini's thinking and practice further. Stoffels (2005) in his research on South African teachers' implementation of curricular reform, brought to the fore the notion of the intensification of teachers' work. This refers to the move towards teachers' work becoming more clerical and administrative,

[92] This school had been struggling to get a permanent head teacher for some time and while I was there, one had recently been transferred. In the meantime, Mohini took on the role of acting head teacher, doing all the administrative work.

accompanied with a lack of emphasis on craft of teaching (deskilling) (see Gitlin, 2001). Stoffels (2005) went on to argue that the mismatch between teachers' personal views and aims, and their practice, has to do with the "threat of intensification" (p. 531). Since teachers have so many other administrative duties, they fall back on their 'default' teaching (curriculum as delivery mechanism), rather than attempting to bring their own views into their practice. Such a critical view of teachers' work from a labour theory perspective is useful in the Indian context as well. In this context, teachers have to juggle between their multiple roles of "politicians, civil servants and professionals" (Majumdar, 2011, p. 33). Thus, both this cultural context (textbook culture) as well as institutional context (work intensification) could explain why teachers, such as Mohini and Sanchita, are unable to use their views to change their task selection choices.

The third teacher, Mahesh, on the other hand, seemed to have a much closer alignment between his views and textbook use. He was the only teacher who did not explicitly disagree with the textbook's approach. As shown in the findings chapter (Subsection 7.1.5), Mahesh and Afreen were the special cases who did not criticise the textbook's vision. While Mahesh chose to 'follow' the textbook; Afreen took a different approach (discussed in detail in Subsection 8.2.3). It seems that Mahesh's choice of 'following' the textbook was not only influenced by the cultural dominance of the of 'textbook culture', but also his 'curricular trust' (Drake & Sherin, 2009). He appeared to trust the decisions made by the textbook authors in creating a series of tasks that provide a coherent framework and did not raise any questions about either the structure or the approach embedded in it. Instead of using his autonomy to restructure the tasks, he spent time and effort in addressing different task elements within the text. Even his adaptations embraced the ideas of student participation and use of context, as promoted by the textbook.

It is interesting to note the difference between Mahesh and Sanchita: both following the textbook script, from the same school, with similar years of experience and teaching the same grade in adjacent classrooms. Yet, their thinking about the textbook was dissimilar. It is striking that, while Sanchita studied on the four-year BElEd programme in Delhi (where the pedagogies that have influenced these textbooks are explicitly taught), Mahesh had only undertaken a DIET programme in Haryana. Batra (2009), in her paper on teacher education and its role in progressive pedagogies, particularly discussed the potential of this University of Delhi's BElEd programme. Yet, in this case, this does not seem to have influenced the teacher. In fact, while talking about her training, Sanchita mentioned its rigour, but did not

articulate any connection between the pedagogies of the textbooks and those she was taught. Thus, her attitude towards the textbooks does not seem to have been influenced by her training background. This finding is similar to that of a study by Ramoshebi (2017) conducted in Johannesburg, who investigated teachers' use of textbooks using Nicol and Crespo's (2009) framework. Contrary to Nicol and Crespo (2009), they elicited that the level of qualification did not play a role in the use of textbooks by teachers.

When reporting the influences on his teaching, Mahesh credited both the textbook itself (especially the teacher notes), which he believed had instructed him ways of teaching that he might not have attempted on his own and he also stressed the influence of a senior teacher in their school, who was a promoter of progressive pedagogies. While the teacher placement structure does not have any sort of formal mentorship programme, this revelation shows that such informal support would appear to play a role. My access to the school was facilitated by this senior teacher, who is a prominent member of a progressive teacher's collective. While he did not directly work in the development of these textbooks, he has strong affiliations with University of Delhi and the academics behind both the NCF reforms as well as the textbooks. He was, thus, very familiar with the ideologies, politics and rationale behind the reforms. Even though Mahesh was not directly involved in the mentor's activism, he seemed to be aware of these progressive discourses. Mahesh also echoed the views of this mentor teacher, when it came to critiquing the influence of NGOs in government school systems. They had recently filed a complaint (and won) against an NGO which was taking remedial classes on their school premises. This scepticism of NGOs and their influence needs to be contextualised within the larger marketisation discourse of education in India (Kumar, 2008; Nambissan & Ball, 2010). This highlights that Mahesh's choice of not using 'NGO resources' was not 'neutral' and needs to be contextualised within wider debates around state and non-state players in providing educational resources and services. Thus, Mahesh's trust of the state-produced progressive textbook, seems to also have had a political motivation, as much as a pedagogical one. Notably, Sanchita, being within the same school, did not mention the influence of this mentor.

Whilst these teachers primarily used the NCERT textbooks, it is important to mention the omnipresent 'guidebooks' brought into the classrooms by students. That is, many students would bring privately produced guidebooks for the *Math-Magic* textbooks into their classrooms. These guidebooks are typically a compilation of solutions to all the questions posed within the *Math-Magic* textbooks. Other studies have indicated how 'guidebooks' are

often additional costs that students have to make, and there is either direct teacher pressure or an assumption that these are necessary costs of schooling (Ramachandran, Jandhyala, & Saihjee, 2003). While Mohini seemed to frown upon any use of them in her lessons, refusing to give them any official status, Sanchita did not seem to mind them being used by students during hers. The only time I saw an active use of these guidebooks was by Sanchita, who typically adhered to the textbook itself. During this lesson observation, the students and teachers had not received the textbooks for that year, so she used these guidebooks as a proxy. As discussed in the findings chapter, these provide a much more direct-method of solving the textbook tasks, rather than a process-oriented one (this is discussed in the next subsection). Since these textbooks are still supposedly aligned with the NCERT textbooks, they are not too far removed from the 'official curriculum', even though their approach to solutions overlooks the textbooks' approach. Other studies, such as that of Sarangapani (2003), have discussed the existence of these 'guidebooks', which students often end up using for rote-memorisation. Mohini's explicit effort to ban these books, also signifies that she was taking a stand against the use of these as quick solutions that could be learnt by heart. In contrast, Sanchita endorsed their use in her lessons, even drawing upon them herself.

8.3.2 Customising: using own resources to structure the lesson

In the above subsection, those teachers who followed the textbook during their enactment of tasks and the reasons as to why this might be the case were discussed. Moreover, there were also lessons that were structured around insertions, with some adaptations and direct textbook use episodes supplementing them (Subsection 6.1.1). This was seen in almost all the lessons of six teachers, who seem to be using the textbook only sparingly to supplement their own inserted episodes (only 27% of their tasks in total were direct textbook episodes). Yet, these teachers cannot simply be labelled as 'rejecting' the textbooks (viewed in opposition to following). Here, I identify three teachers' textbook use, namely, Deepali, Kanchan and Bhumika, as 'customising' rather than following the textbooks. The reason for this view, is that these teachers still attempted to 'cover' the chapters within them, but were not scripting their lessons based solely on textbook tasks. These teachers used their own aims for mathematics teaching to justify and guide this 'customisation'. As can be seen below, using the rationale of student interest and student previous knowledge, Kanchan customised the use of the textbook.

> For chapter *Gadi aur Pahiya*, <u>I did it my way</u>. Students have been familiar with patterns since 3rd and 4th, so for them this was easy. [] Then, in this chapter there was *matching the*

numbers, which I left out; I thought I will do it later on. I first did this one, because students take a lot of interest in this.

Kanchan, interview 2

Yes, I did these questions in the chapter *Trip to Bhopal*, but before doing this, they had to learn division. That is why I stopped that in between, and first taught them division and counting.

Kanchan, interview 2

A similar technique of breaking the use of the textbook was seen in Deepali and Bhumika's lessons, where information, procedural information, and repeated tasks were interspersed between and around direct textbook use. These teachers also dedicated entire lessons where they only attempted some inserted topic, which they saw as being important within the wider aims of mathematical learning. For instance, Bhumika, in her first lesson, taught place value and numbers in words, which are not included in any of the chapters in the textbooks. In her view, these insertions were necessary: "I always teach them the basics on my own, for example, write in numbers, write in words, profit and loss, addition, subtraction, multiplication" (Interview 1). So, they made adaptations and insertions that they believed aligned more with their own vision of the chapter as well as other mathematical needs of the children. This notion of 'customising' is similar to the 'elaboration' that Nicol and Crespo (2006) identified, who also talked about teachers viewing the textbook as a guide instead of an authority.

To understand the reasons behind this type of textbook use, both its affordances as well as teachers' own thinking have to be considered. First, the textbook, as explained earlier, has introduced a 'task-based' approach, rather than one that presents introduction, explanations and solved examples, before listing a series of questions. This change in structure itself might be one of the reasons that the focal teachers were moving towards using the textbook more as a basis for their own 'customisation', rather than strictly adhering to it. All these three teachers during the interviews expressed their disagreement with the structure of the textbook, either because of the way multiple topics have been conflated (Bhumika), the lack of explicit progression within the chapters (Kanchan) or the insufficient coverage of the mathematical topics introduced (Deepali) (Section 7.1). Teachers' views on the textbook's missing elements (topic coverage and practice questions), further indicates their lack of 'curricular trust' (Drake & Sherin, 2009). That is, these three teachers seemed not to trust the

textbook and thus, used their autonomy to customise their lessons. Customisation has become a means of traversing the 'gap' (what is missing) between their aims and what they saw in the textbooks, borne out of a perceived deficit and mistrust of the textbook.

Apart from their own resources (making their own tasks as they moved along), the teachers relied on 'other' resources to help with the customisation, which included: (a) *Medhavi* question bank books (b) privately published student textbooks and (c) NGO resources. The *medhavi* question bank, seemed to be very important for Bhumika. As we saw in the findings chapter, both her macro-planning for mathematics teaching (finishing the syllabus before the *medhavi* exams), as well as micro-planning (inserting 'exam-type' questions within the lessons) appeared to revolve around the *medhavi* exams. *Medhavi* scholarship examinations are state-wide competitive merit scholarship exams held by the MCD, which high achieving students from the 4th and 5th are eligible for. For Bhumika, it was equally important to prepare her students to be able to address these types of questions, as it was to 'cover' syllabus. Thus, she used a privately published book with sample *Medhavi* questions within her mathematics teaching:

> *Medhavi* exams happens in December, so we complete the syllabus in October and them from November to December, for a stretch of one to one and half months, we make the children to practice these [*Medhavi* book] sums.
>
> Bhumika, interview 1

Here, it is important to mention that there was a scheme of continuous and comprehensive evaluation (CCE) in these schools (RTE, 2009), which meant that formative and summative assessment was being conducted by the school teachers (Nawani, 2013). *Medhavi* exams, contrasting with this CCE approach, are state conducted scholarship examinations. Here, again Kumar's (2005) notion of textbook culture is being reflected. That is, despite the new reforms aimed at moving away from the syllabus-textbook-examination pipeline, institutionalised during British colonialism, the state apparatus continues to reproduce these in some forms: the *Medhavi* exams in this case. In fact, contrary to the egalitarian principles of NCF-2005 and CCE, as abovementioned, these examinations are only taken by high achieving students and the few who 'pass' receive merit scholarships. Here, it is further crucial to note that these textbooks were being sold by private publishers directly to the schools even though this is not legally permissible, as the students are not supposed to buy any additional resource materials. Unlike the guidebooks, which often the parents make

students buy, these *medhavi* books were being sold through the schools. Private publishers also supported schools in publishing their examination papers, even though all the resources were supposed to come through the MCD, they were often not enough. Whenever the teachers spoke about these, they tried to keep it under the radar, since these relationships were not state sanctioned. Thus, the demand for resources within these schools was being fulfilled by small-scale publishers, who had no incentives for creating materials in line with the NCF or the NCERT pedagogical notions and this added additional costs that the students had to cover (see Ramachandran et al., 2004). From an equity perspective, this disadvantage both students (those with better grades versus not) as well as schools (those which have access to these publishers versus not). This kind of a shadow market along with the state apparatus is typical in India (Srivastava, 2008).

The second kind of resource coming into these lessons was the privately published textbooks used by private schools. As discussed in the findings chapter, teachers compared the *Math-Magic* textbooks with these textbooks, which a few of the teachers considered better (Subsection 7.4.3). Neetu, Deepali and Sonali, in particular, discussed the ways in which they brought them into their teaching. During my observations, Deepali was the only teacher who was observed explicitly using these in her lessons. The use of these textbooks was different from the *medhavi* books, especially since it was less inequitable, whereby their usage did not expect students to own their own copies. Deepali used tasks from these textbooks to 'customise' her lesson on a particular textbook topic. It is important to note that all the three teachers who mentioned these textbooks had access to them via their own children, who went to private schools and used them there. As Ramachandran (2005) pointed out and aforementioned in this thesis, in government school contexts, the social distance between the teacher and the student is often wide and most of the teachers do not send their own children to government schools. As became clear from their expressed views, they also saw the pedagogies and resources in the private schools (for *their* children) as being superior to the government resources (for *other* children). One big advantage, that Deepali saw in these privately published textbooks, was their emphasis on practice questions, and clearly outlined mathematical information. Thus, by using the private school textbooks, Deepali was striving to fill the gap she perceived existed. This relates to other research studies, which indicated that teachers often perceive child-centred pedagogy as being pedagogy for the poor, while the rote-based pedagogies are for advantaged children (Sarangapani, 2015; Sriprakash, 2010). Thus, these textbooks (and its pedagogies) also become for the disadvantaged ('other'

children) who attend government schools, whilst there is continuation of private textbooks and their rote-based pedagogies, for the 'advantaged' children (their own children). This is particularly interesting since in other parts of the world, teacher beliefs about 'poor' children and the pedagogies appropriate for them differs. For instance, Sztajn (2003) in her analysis of US teacher beliefs about mathematical pedagogies, shows that teachers tend to provide rote-based learning to children from lower socioeconomic backgrounds, whereas problem-solving based learning is delivered for those from higher ones. Teachers seem to have differential notions of mathematics pedagogies for different children (see Dowling, 2002), and it is peculiar that alternative pedagogies have been linked with poor children in India. An explanation could be that, while explicit interventions on pedagogies (both national and international) have been focused on the government schools and in turn on poor children, private (middle to elite) schools and their pedagogies have not come under similar scrutiny, so they continue to promote rote-based teaching. Talking about aid-programmes and their use of child-centred pedagogies, as Sarangapani (2015) explains:

> Worse still, aid programmes seem to only target the poor who are studying in government schools–to many teachers it seems that such 'simplified education' is meant for children of the poor, while the better-off ones in society continue to labour at the serious business of rote learning to pass examinations in private English-medium schools, which are untouched by these aid-driven reforms. (p. 649)

While Sarangapani wrote about aid-driven reforms, the fact that these textbooks are also only subscribed to government schools lends itself to a similar wider discourse around alternative pedagogies. The focal teachers believed that the private textbooks and their pedagogies are better and Deepali, specifically, was seen bringing them into her lessons to fill the 'gap', which she perceived was being created government and private school contexts, owing to the pedagogies within these new textbooks.

Finally, Kanchan and Afreen included resources produced by NGOs and which had entered the school 'formally' (and legally) through sanctioned MCD programmes. These included the teaching materials that had received along with a teacher award from Mahindra Tech NGO[93] and materials that Kanchan had found during her work with the SCERT[94]

[93] Awards/Recognition. (2019). Retrieved May 11, 2019, from Tech Mahindra Foundation website: https://techmahindrafoundation.org/awards-recognition/

curriculum development. Kanchan seemed to be aware of different types of materials being developed at the SCERT, including question banks, additional workbook (more in line with her idea of mathematics teaching) and expressed disappointment that these never had never come to the MCD schools.

> I had told you that administrative schools [Delhi state schools, unlike MCD schools] have worksheets available for practising which are prepared by the SCERT. I saw the worksheets there and I asked the madam to give me one sample of each, but I haven't got any yet.
>
> Kanchan, Interview 2

This further shows the dissonance within the state schooling system. Since the MCD schools (part of my study) are run by the municipality, the facilities are very different from other state schools run by the Delhi's state governing body. This difference became even more pronounced in the schooling system since the Delhi state in the last few years has increased their education budget by twofold and have made a concerted effort in reforming their schools (Khanna, 2015). The benefits of these reforms or funding have not reached the MCD schools. Studies in the US have shown how district policy is not always monolithic (Spillane, 1998) and although the non-monolithic nature of the nature of 'public' schools is not the focus of this study it is an important aspect to explore within the Indian education system. The resource availability and distribution seems to be different even across the schools within the three zones of the MCD. The South Delhi school (School 1) had more access to NGO teaching resources; while the North Delhi MCD struggled with basic resources such as money to print their exam question papers. Thus, resource 'difference' is not just created between the private and government schools; but also within government schools of different governing bodies (both across and within). This has implications in the kinds of resources teachers have access to for 'customising' their textbook enactment.

8.3.3 Designing: using textbook and own resources to create lessons

In the above subsection, I have argued how teachers seemed to be 'pushed' into customising their textbook use and in turn challenging its place 'in' authority, due to the intrinsic incompatibility of the textbook (task-based) with their notions of mathematics teaching

[94] State Council of Educational Research and Training (SCERT) is the state body which is responsible for research and development of school curricular materials. However, these do not directly come to the MCD schools since MCD schools come under the municipality jurisdiction.

(information/explanation first). Additionally, the efforts the teachers made to include other resources in their teaching and the institutional and cultural context within which these found a place in their work was discussed. In this subsection, I consider a special case, that of Afreen, who did not articulate her way of using the textbook as arising from her perceived deficiency of the textbook. Instead, she seemed to have internalised an agentic role of the teacher, who is *supposed* to be using the textbook as a 'thinking device', instead of the expectation that it would be ready-made for use.

As reported in the chapter on teachers' views, Afreen was one of the teachers, who did not have any explicit disagreement with either the pedagogical approach or the structural approach of the textbook (section 7.1.5). She even expressed an ease and confidence in terms of her ability to navigate it. Yet, when we compare this to her use, we rarely find her 'directly' using the textbook tasks, but rather adapting them (32%) or inserting her own tasks (64%). This gives an opportunity to discuss Afreen's own unique *design* (Pepin et al., 2017). Pepin et al. (2017) describe 'teachers' design' as a "deliberate/conscious act" of "creating something new" (p. 801), thus bringing dimensions of intentionality and genesis to the fore. I argue that Afreen's views and use of the textbook could be conceptualised through such a lens of *teachers' design*.

First, unlike teachers who customise their textbook use, Afreen did not conceptualise the 'adaptations' or even the 'insertions' as something that had to be done when you "stop" (see above) textbook use, but rather, this was to be considered as being a part of its 'use'. For instance, when asked to explain her insertions she stated "yes, this is related to the book" (Lesson 3, post-lesson interview), thus indicating that did not view them as being very distinct from the textbook. Similarly, in lesson 1, after using an adaptation of a task which involved asking the students to measure the distance between two points, she moved on to an insertion that asked them to draw lines of a particular measurement. She justified her decision by saying that: "I saw students were able to do this much, so I thought I will move to another aspect, which many students were not able to complete". Thus, both based on how she viewed the tasks being 'related' to the textbook and her perception of the level of student understanding, she integrated adaptations and insertions within her textbook use. Further, like her rationale given above, she was the only teachers who could articulate 'why' and 'how' she was planning to integrate student understanding and her own insertions into textbook

use[95]. Thus, this indicates an intentional act of creating new lessons, thereby demonstrating that some *designing* was involved.

It also becomes important to discuss why Afreen is such a unique case, in a system that does not encourage teachers to develop their *design capacities*: neither at the teacher education level, nor during in-service (as discussed in the literature review) (see Chapter 2, Subsection 2.2.1). Afreen, despite getting admission and wanting to study at a prestigious university-based teacher training institute, got her teacher training diploma from a private DIET for personal reasons. To an extent, her motivation for professional development seemed personal, as she regretted not getting trained at a better institution. She was motivated as a teacher and was actively seeking opportunities for professional development. There were two ways in which this was made evident: (a) teacher award scheme and other opportunities outside the school; (b) and support from her fellow teachers within school. Afreen was clearly encouraged by the teacher award that was provided (also received by Kanchan, as discussed above), which both helped motivate her as well as (re)source other materials through this exposure. The other important dimension in Afreen's teaching was the 'collective'. As Pepin et al. (2013; 2017) discussed in their work, the collective dimension of the resource system is very important in defining how teachers use curricular materials. Afreen's school stands out as an exception compared to all the other three schools, in terms of teachers sharing pedagogical ideas as a collective, as mentioned by all the three teachers - Afreen, Kanchan, and Bhumika. She explicitly talked about 'like-minded teachers', who were willing to share their weaknesses, difficulties as well as solutions with each other (see Subection 7.4.2). In a context, where accountability measures to ensure adequate attention to pedagogy is missing and teachers have no incentive to work as a collective, this is a unique example. Finally, Afreen also seemed to be open to sourcing materials using technology, with her being the only one who mentioned the Internet, in particular, for sourcing educational videos that she showed in her lessons. Banks and Dheram (2012), in their discussion on potential avenues for in-service teacher training[96], also talked about the potential of ICT in

[95] Note that, Afreen was the only teacher who was able to articulate her decisions of episodes both during her post-observation discussions as well as her final interview. More about 'intentionality' and teachers lack of expressing their rationale, especially during post-observation interviews, is discussed in Chapter 9 regarding the limitations of the study.

[96] Note that as Subitha (2018) pointed out, India still primarily relies on 'in-service training' models, which are often one-off-training programmes rather than 'continuous professional development' (CPD). Dheram and Banks (2012), while arguing for an emphasis on teachers' in-service development, did not necessarily challenge this over-arching model. Discussion on the different models of CPD are beyond the scope of this study, however, several of the findings indicate possible avenues that could be integrated within CPD policies.

schools. Afreen's case indicates that this can become a possible avenue for continuous professional development.

8.3.4 Avoiding: neglecting the mathematics textbook and teaching

In the above subsections, I have discussed the extent to which and the ways the textbook was being followed, customised or even designed. Yet, just as Afreen and Kanchan warned, in my sample too I found teachers who neither attempted to use the textbook as a 'designer' nor 'customised' it nor 'followed' it. These teachers seemed to be 'avoiding' or 'neglecting' the textbook (in turn mathematics teaching) altogether. Three teachers, namely Neetu, Ganesh and Sonali, appeared to be doing this in different ways. All three of them reported their inability to understand what is required with these textbooks. This lack of understanding or clarity of purpose has also been revealed in the South African reform context (Bantwini, 2010), where the author reported how there was often a lack of understanding as well as any point of reference on how and why the reform was introduced. Here, Mahesh's case can be contrasted. He, had some understanding of the reforms and their ideation due to the mentor teacher (he is the only one who discussed the NCF policies – see Subsection 7.1.5). On the other hand, in case of these three teachers, they seemed to be speculating on the purpose and their implications. Sonali and Neetu were unable even to articulate their discomfort with the textbook and were completely dismissive about them. Ganesh, while being more articulate in terms of expressing his concerns, especially the futility of using context in mathematics lessons, expressed the view that the textbook was not "worthy" enough to be taught from. This dismissal of the textbook, and inability to comprehend it was leading to neglect of not just the textbook, but also, of the subject itself. All three of them, for instance, had very short lessons (only about 20 minutes) and attempted only a few of the chapters in the textbooks, paying less attention to the subject compared to the other teachers (who included mathematics almost every day in their teaching). Since they did not seem to follow the textbook either as a script or to structure their lessons, Sonali and Neetu often asked me what I wanted them to teach as I observed their lessons.

This kind of avoidance of the textbook and neglect of the subject, can be attributed to other reasons. Firstly, primary school teachers are responsible for teaching all subjects – mathematics being only one (Hindi, English, environmental science, art, library, games). They are 'free' to use the time during the day and organise it however they want for their teaching. Thus, the importance given to mathematics teaching within the day/week/year varied among the teachers. Not all had similar commitment towards mathematics as a subject.

For instance, Ganesh attempted to finish multiple chapters of a single subject in one week. During my field work, he explained how he had 'covered' most of the mathematics syllabus even though only a few of the textbook chapters were attempted (Appendix E shows that Ganesh only attempted four chapters out of seven). Neetu too, hardly seemed to pay attention to mathematics, and did not spend time on the subject (she attempted only two chapters). This is very different from Bhumika, Afreen and Kanchan, who talked about how it took 2-3 weeks just to finish one chapter in mathematics. This 'non-seriousness' around teaching (mathematics in this case) is related to the lack of academic emphasis in schools. A report on primary school teachers' status in India by Ramachandran et al. (2008), discussed how by not emphasising teaching and learning (while stressing other aspects), the system implicitly discourages teachers from teaching. Further, Vasavi (2015) reported how teachers soon realise that privileging administrative work over teaching will also be beneficial to the "administrative ladder of career success" (p. 42). Ganesh is a good example of using this strategy. He spent a large amount of time in the headteachers' room, and also would bring his personal laptop to complete some of the administrative work. In addition, he was the only male teacher and exclaimed that this meant that he often also took up much of the administrative work, which required teachers to go outside of the school. It is interesting to keep in mind that men often over-represent school leadership positions despite being smaller in number in the teaching profession (Mythili, 2019).

Neither was good teaching being rewarded, nor was neglect or non-teaching accounted for. Even within a school, the head teacher is hardly responsible for keeping track of what happens in classrooms. Regarding which, Bhumika talked about how it would be encouraging, if classroom observations were performed within their school, as I did, which would encourage teachers to focus on their teaching. Also, Mohini, who was the acting head teacher in School 3, asked me what my assessment of Ganesh's teaching was (she seemed worried about his teaching), as there was no formal way of knowing what was going on in other teachers' classrooms even within a school. On the contrary teachers seem to be under pressure to meet administrative requirements. Kanchan explained how if the school did not submit the needed information constantly required by the administrative bodies, there was often some form of punitive action. Yet, no mechanism for keeping track on teaching activities were enforced. During my fieldwork, often I would have to cancel visits as teachers would be busy fulfilling these requirements, such as ensuring that all children had bank accounts, identity cards (see Subsection 4.4.2). Even the official audits focused only on

administrative aspects. Thus, while schools and teachers are under constant scrutiny, these are not pedagogical in nature. Note that often scholars, such as Muralidharan and Sundararaman (2011), have proposed incentivising teachers to teach by linking pay to test scores. These are not just contradictory to the values of NCF-2005, which moves away from narrow visions of learning through test scores, but also completely ignores these administrative burdens on the teachers. The issue seems to be more about how teachers are viewed as 'dispensable labour' instead of professional teachers (Jain, 2018). The question remains how their work can be re-oriented towards a teaching oriented professional role, without introducing accountability measures that would increase the 'threat of intensification' (see Subsection 8.3.1).

Finally, it is important to examine Sonali's neglect of the subject, which seems to have originated from her own anxiety towards mathematics. She was unsure and nervous while I observed her teaching and when discussing her teaching said: "Not all the teachers are experts, who can churn out examples and explain to the students, can they?" In this 'avoidance', maths anxiety and confidence in 'customising' or 'designing' their own lessons is an important issue to be considered, especially among primary teachers who are themselves not required to have studied mathematics beyond Grade 12 (Rajput & Walia, 2001). A textbook that presents itself in a complex way, demanding careful and intense reading, as with the prescribed one, can lead to further anxiety. Clearly, the discomfort, the uncertainty, and lack of confidence also translated in the textbook use, where Sonali seemed to be misinterpreting the textbook tasks (see Subsection 6.2.1). A similar argument was made by Bapat and Takker (2016), who highlighted teachers' subject matter knowledge[97] that would be required to attend to the complexity of the tasks. Curriculum designers, thus, have to consider how to support teachers, who are struggling with the textbook, for they should not assume that they will have the resource to re-orient their teaching on their own.

[97] While the focus of my study has not been on subject matter knowledge or pedagogical content knowledge (two elements important for Brown's framework of textbook enactment); Sonali's case shows how this is also crucially important.

CHAPTER 9: CONCLUSION

9.0 Introduction

For this study, primary school teachers' use of reform-oriented mathematics textbooks in government schools in Delhi was investigated. The literature review revealed that while in India textbooks have been contentious both in the policy and academic realms, with their overreliance criticised, there have been very few empirical studies focusing on their use, in particular, from the perspective of teachers. More specifically, there is neither theoretical nor empirical clarity on how primary teachers view and use mathematics textbooks in their classrooms in India. This study has filled this gap by focusing on the mathematics textbook use from the perspective of primary government school teachers. Furthermore, reforms that are most commonly studied in textbook-use studies in the field of mathematics education, relate to policy and research in the Northern contexts. Thus, several of the reform ideals relevant for postcolonial contexts (such as the reform ideals of NCF-2005 in India) have not been focused upon. The outcomes of this study build upon some of the current textbook-use theorisation, after focusing on reforms in the Indian context, one that has not been researched in this manner previously. To achieve this, both conceptual and methodological tools were developed that enabled investigation of teachers' use of reform-oriented textbooks in the Indian context. In the following sections, the main contributions of the study in terms of its theoretical, methodological and empirical contributions are discussed in detail (Section 9.1). Section 9.2 outlines the study's policy, practical, and political implications. Section 9.3 then highlights the limitations of the study and also contains proposals for future research.

9.1 Contributions of the Study

9.1.1 Theoretical contributions: adapting Northern 'context-neutral' textbook-use conceptualisations

This study problematises Northern 'context-neutral' mathematics education theorisations and illustrates how Northern concepts can be usefully adapted into a Southern context. This type of adaptation is often missing in the mathematics education literature, where context is treated more accidental than central. For example, terms such as 'reform-oriented' or 'reform-based' curriculum which often feature in mathematics education literature, hardly ever acknowledge the policy or ideological context wherein these 'reforms' originate. Understanding the policy as well as ideological setting of the particular NCF-2005 reforms

was integral to studying the textbook-teacher dynamic in India. For instance, the NCF-2005 reforms foregrounds issues of equity and social justice – themes which are often neglected in the study of 'reform-oriented mathematics textbooks' in the larger mathematics education literature. Thus, within the conception of 'reform-oriented textbooks' issues of equity and social justice were also central to this thesis. This kind of contextualisation is very important for countries in the Global South, where reforms originate from varied political agendas including issues of social justice and decolonising mathematics curriculum. This framework and the process of adaption can become useful for other studies which are exploring mathematics education theorisations to study teacher-curriculum relationships in contexts unique from Northern contexts.

Secondly, another important enhancement was the conceptualisation of teachers' resources. Instead of focusing purely on their beliefs and knowledge, I considered teachers' institutional and socio-cultural realities along with their individual views. This effort located teachers' work within a wider socio-political context (beyond the individual). This enhancement broadens the way teacher-textbook relationship is conceptualised, moving it beyond an individual interaction to a contextual one.

9.1.2 Developing suitable methodologies for India in the study of the teacher-textbook relationship

By focusing on ordinary classrooms in Delhi, this research contributes to the methodological literature on reflexivity within mathematics education and qualitative studies in terms of navigating research in Southern contexts. Two important notions were explored. First, researchers' positionality and permission processes within the Delhi school context brought forth the need to consider the political realities of the field. It especially brought up the question as to how 'research' itself is viewed within such a context. In the case of Delhi schools, there is often a deficit-narrative that has been created by research and media, which has made the institution and teachers wary of the researcher and their intentions. Secondly, in a context of 'disruptions', where teachers are engaged in several different things other than teaching, a more 'dynamic' research plan needs to be devised, rather than the prescribed research methods often applied in mathematics education studies in the Northern contexts. Through exploring issues of positionality and disruptions in fieldwork, the study contributes in terms of developing suitable methodologies for Southern contexts.

Furthermore, three distinct types of data were integrated, namely, the textbook, lesson observations and teacher interviews, to produce knowledge about the teacher-textbook relationship. The appropriate common unit of analysis to do so was deemed to be 'task'. Task-design research is ever expanding in the field of mathematics education (See Watson & Ohtani, 2015) and hence, this study adds to this growing literature. However, this task-based analysis is novel for the Indian context and thus, this thesis sets an example of how such a conceptualisation could be used across a range of contexts.

9.1.3 Empirical contributions: International education

Within the field of International education, there is growing attention given to teaching and learning, especially within the larger context of the 'learning crisis'. Yet, conceptions of teachers' work are limited. Teachers are growingly viewed as 'managers' who have to produce certain level of learning outcomes and thus approached through the notions of teacher absenteeism and teacher efficiency. However, this thesis provides empirical evidence which complicates teachers work. It provides evidence that teachers' work is complex and multi-dimensional. For example, the four enactments that I have discussed – following, customising, designing and avoiding showcases how teachers use of textbook is hardly straightforward. While one teacher in this study was able to use her own capacity to 'design' her teaching using the textbook, one of the worrying types of enactment was 'avoiding', where teachers ended up avoiding the textbook, its affordances and mathematics teaching itself. The field of international education will benefit from these empirical findings in the effort to broaden their conceptualisations of teachers' work.

9.1.4 Policy and political implications

Initial teacher education and continuous professional development

This first important policy implication of this thesis lies in initial teacher education as well as teachers' continuous professional development. Teachers directly work with textbooks every day, especially in countries of the Global South, where the textbooks remain the primary educational resource. However, very little is known about how teachers interact with textbooks. Insights from the study can become integral to both pre-service teacher education as well as in thinking about teachers' in-service professional development. For instance, recognising that teachers' engagement with textbooks is not homogenous is a salient matter that calls for the designing of adequate teacher education support. This should allow for the flexible conceptualisation of teacher education programmes, such that they are suited to teachers at different levels of their design capacities. Currently, textbook-use or resource-use

is not focused within teacher education in India (both pre-service and in-service) and the findings from this research show they must become central to teacher education.

Curriculum development

The findings from the textbook analysis (addressing the first research sub-question) are important for the curriculum development. The focus on voice, context and support could become useful frames for the development and analysis for future mathematics textbooks aimed at changing teaching and learning. This is especially important in the Indian context, where a new education policy is going to be introduced, and as a consequence, new textbooks are likely to be developed. Moreover, accountability pressures are being witnessed in India, much as in the rest of the world, bringing with them a narrower focus on learning outcomes (see Chapter 2, Subsection 2.1.3). This also brings a danger that reductionist curricula and textbooks might be introduced. In such a context, the project of developing reform-oriented textbooks must not be abandoned. Furthermore, by focusing on teachers use the thesis also brings to highlights the role of teachers in curriculum development. It argues for the importance of creating 'educative' textbooks which are progressive yet also keep in mind the role of the teacher who is negotiating the textbook (Davis & Krajcik, 2005). Thus, the thesis outcomes contribute to knowledge building regarding development of progressively-oriented mathematics textbooks which are also educative for teachers.

Political implications of the study

Since the inception of this study in 2015, there has been a drastic change in the political environment of India. As discussed in Chapter 2, Section 2.1.2, NCF-2005 came out as product of rejection of the earlier policy document of NCF-2000, which was viewed as promoting Hindu Nationalist agenda. Since May 2014, once again the same right-wing Hindu nationalist party has been the ruling political party. This has severe consequences for the social justice and critical pedagogy ideals that are at the core of NCF-2005. Since these textbooks were introduced in 2010, the federal government has not developed any other textbooks on NCF-2005. This highlights the uniqueness of *Math-Magic* textbooks. While , no formal revisions to NCF-2005 or NCERT *Math-Magic* have been introduced, there are several attempts to influence the curriculum. For instance, we see changes in History textbooks which are actively altering narratives of India's history using a Hindu-nationalist lens (Jaffrelot & Jairam, 2019). In this context, a critical question about mathematics textbooks arise. Reforms of NCF-2005 were unique in its suggestion of making mathematics

‘political’ using a lens of critical pedagogy. It remains to be seen whether future mathematics textbooks explicitly (or implicitly) include Hindu nationalist ideologies, or whether Mathematics will be delegated as simply a ‘technical’ subject devoid of contextual, cultural or political associations.

9.2 Limitations and future research

In this section, I discuss two limitations of the study, which opens up avenues for further research. The first limitation is in terms of the inferences that can be drawn about the textbook-teacher relationship. That is, the inferences drawn in this study are limited by several factors: limited understanding of teachers’ intentions, small number of observed lessons, and lack of focus on a particular mathematical topic. In terms of teachers’ intentions, the study was unable to capture, in-depth, the teachers’ rationale underpinning some the decisions made within their lessons. As discussed in Chapter 4, while post-observation interviews were planned, they did not seem to ‘work’ as planned (Subsection 4.5.3). I believe that this is an important enquiry and different methodological tools need to be developed to access teachers’ intentions, and the typical format of conducting post-lesson interviews might not be the best method, particularly in a context like India. For instance, the narrative approaches to teachers’ work, as used by Clandinin and Connelly (1992) and Bien and Selland (2018), could be useful. For these studies, narratives are used to engage with teachers’ identities, their life histories as well as their own schooling experiences to understand their intentions regarding the reforms. However, considering the limited scope of the PhD study as well as my restricted positionality as an independent researcher, I could not explore these approaches adequately. In terms of lesson observations, I was only able to observe limited number of lessons and no specific mathematical topic could, thus, be explored. Different mathematical topics call for different pedagogical approaches, yet this was not considered within this thesis.

A second important limitation, which opens up possibilities for future research, is the exploration of ‘language’ in mathematics education. While, I conducted textbook analysis focusing on the language of the text (voice of the text), one of the issues that was not engaged with was the interaction between Hindi and English. The English versions of the textbooks were analysed, yet a thorough comparison with the Hindi-version was not conducted. Further, one of the issues that came up during the analysis of lessons was the ways in which teachers used both Hindi and English in their mathematics lessons (see Subsection 6.3.5). However,

this was not dealt with in detail in this study and requires a focused enquiry. In India, with the large multi-linguistic population, this becomes one of the most important aspects of understanding context and mathematics learning (see Bose & Choudhury, 2010; Bose & Clarkson, 2016; Halai, 2009).

Finally, based on this study several research questions for future studies can be posed, both to be explored within India and internationally, including:

- How can teachers' design capacities for textbook enactments be enhanced?
- Does the teacher-textbook relationship vary for different primary school subjects?
- Does the teacher-textbook relationship vary for secondary school teachers?
- How does the adaptation of NCF-2005 differ in different state-produced textbooks in relation to the use of voice, context and support?
- What is the role of the student in teachers' textbook enactments?

Overall, while my intention of understanding textbook use stemmed from my own experience as a publisher, this work over the last four years has broadened my interest. One of the areas that particularly interests me is teachers' professional development. Ideas for 'improving' teaching and learning can come through textbook. How teachers respond, view and use them are important considerations for professional development. This thesis becomes important in understanding these links between textbooks in teachers' pre- and in-service professional development. Another important personal interest that has grown through this thesis is the exploration of issues of equity and social justice through textbook reforms. Can textbooks encourage teachers to develop a social justice mind-set? Can both the goals of learning essential school mathematics and social justice be incorporated into the development of curriculum materials as well as teachers' professional development? In my own future academic work, I hope to take this enquiry forward.

REFERENCES

AAP. (2017). Harvard University Begins Research on SMCs in Delhi Govt Schools – Aam Aadmi Party. Retrieved December 21, 2017, from http://aamaadmiparty.org/harvard-university-doing-research-on-aap-govts-smc-intervention-in-govt-schools/

Adler, J. (2000). Conceptualising resources as a theme for teacher education. *Journal of Mathematics Teacher Education*, *3*(3), 205–224.

Ahl, L., & Koljonen, T. (2017). When teacher guides speak "past" the teacher: Two Swedish mathematics teacher guides. *ICME13, Hamburg*.

Akai, H., & Sarangapani, P. M. (2017). Preparing to Teach: Elementary Teacher Education at a District Institute. *Economic and Political Weekly*, *52*(34), 47–55.

Alcott, B., & Rose, P. (2015). Schools and learning in rural India and Pakistan: Who goes where, and how much are they learning? *Prospects*, *45*(3), 345–363.

Alexander, R. J. (2001). *Culture and pedagogy: International comparisons in primary education*. Blackwell Oxford.

Ali, S., Mukherjee, A., & Rajan, J. (2007). Study of change in primary mathematics textbooks at Grade 3 in Delhi government/municipal schools. *EpiSTEME 2 International Conference to Review Research on Science, Technology and Mathematics Education*. Presented at the EpiSTEME-2 Conference, India.

Alshwaikh, J., & Morgan, C. (2015). The creation of mathematics in school textbooks: Palestine and England as example. *European Society for Research in Mathematics Education- CERME 7*. Presented at the University of Southampton, UK. University of Southampton, UK.

Anand, G. (2016, February 19). Fighting Truancy Among India's Teachers, With a Pistol and a Stick. *The New York Times*. Retrieved from

http://www.nytimes.com/2016/02/20/world/asia/india-primary-school-system-uttar-pradesh.html

Anderson, J. R., Reder, L. M., & Simon, H. A. (1997). Situative versus cognitive perspectives: Form versus substance. *Educational Researcher*, *26*(1), 18–21.

Angen, M. J. (2000). Evaluating interpretive inquiry: Reviewing the validity debate and opening the dialogue. *Qualitative Health Research*, *10*(3), 378–395.

Anwar, T. (2016, January 30). Civic body protest: Why trifurcation of MCD is the source of all troubles. *Firstpost*. Retrieved from https://www.firstpost.com/india/civic-body-protest-why-trifurcation-of-mcd-is-the-source-of-all-troubles-2604956.html

Apple, M. W. (1992). Do the Standards Go Far Enough? Power, Policy, and Practice in Mathematics Education. *Journal for Research in Mathematics Education*, *23*(5), 412–431. https://doi.org/10.2307/749562

Apple, M. W., & Christian-Smith, L. K. (2017). The politics of the textbook. In *The politics of the textbook* (pp. 1–21). Routledge.

ASER. (2019). *Annual Status of Education Report: 2018*. Retrieved from Pratham ASER website: http://img.asercentre.org/docs/ASER%202018/Release%20Material/aserreport2018.pdf

Aslam, M., Malik, R., Rawal, S., Rose, P., Vignoles, A., & Whitaker, L. (2019). Methodological lessons on measuring quality teaching in Southern contexts, with a focus on India and Pakistan. *Research in Comparative and International Education*, *14*(1), 77–98. https://doi.org/10.1177/1745499919828929

Aslam, M., Rawal, S., Kingdon, G., Moon, B., Banerji, R., Das, S., … Sharma, S. K. (2016). *Reforms to Increase Teacher Effectiveness in Developing Countries: Systematic*

Review, September 2016. London: EPPI-Centre, Social Science Research Unit, UCL Institute of Education, University College London.

Atweh, B., Barton, A. C., Borba, M. C., Gough, N., Keitel-Kreidt, C., Vistro-Yu, C., & Vithal, R. (2007). *Internationalisation and globalisation in mathematics and science education*. Springer Science & Business Media.

Babu, D. S. (2012). Indigenous traditions and the colonial encounter: A historical perspective on Mathematics education in India. In K. Subramaniam & R. Ramanujam (Eds.), *Mathematics education in India: Status and outlook* (pp. 37–63). Mumbai, India: Homi Bhabha Centre for Science Education Tata Institute of Fundamental Research.

Bagchi, A. (2015). *Documentation of Teacher Recruitment Practices in Government Schools in New Delhi* (Working Paper No. 339). Retrieved from Centre for Civil Society website: https://ccs.in/internship_papers/2015/339_documentation-of-teacher-recruitment-practices-in-government-schools-in-new-delhi_adrita-bagchi.pdf

Bakhtin, M. M. (1986). *Speech genres and other late essays*. Austin: University of Texas Press.

Ball, D. L., & Cohen, D. K. (1996). Reform by the Book: What Is: Or Might Be: The Role of Curriculum Materials in Teacher Learning and Instructional Reform? *Educational Researcher*, *25*(9), 6–14. https://doi.org/10.2307/1177151

Banerjee, A., Banerji, R., Berry, J., Duflo, E., Kannan, H., Mukherji, S., … Walton, M. (2016). *Mainstreaming an Effective Intervention: Evidence from Randomized Evaluations of "Teaching at the Right Level" in India* (Working Paper No. 22746). https://doi.org/10.3386/w22746

Banerjee, A. V., Bhattacharjee, S., Chattopadhyay, R., & Alejandro, J. G. (2017). *The Untapped Math Skills of Working Children in India: Evidence, Possible Explanations, and Implications*. Retrieved from

https://static1.squarespace.com/static/5990cfd52994ca797742fae9/t/59a896aee6f2e11b76983238/1504220847338/Banerjee+et+al.+2017+-+2017-08-17.pdf

Banerjee, R. (2012). Mathematics education research in India: Issues and challenges. In R. Ramanujam & K. Subramaniam (Eds.), *Mathematics Education in India Status and Outlook Editors* (pp. 191–205). Mumbai, India: Homi Bhabha Centre for Science Education Tata Institute of Fundamental Research.

Banerjee, R. (2015). Students' understanding of algebra and curriculum reform. In B. Sriraman, J. Cai, K. Lee, L. Fan, Y. Shimizu, C. S. Lim, & K. Subramaniam (Eds.), *The First Sourcebook on Asian Research in Mathematics Education: Korea, Singapore, China, Japan, Malaysia and India* (Vol. 2, pp. 1607–1630). IAP.

Banerjee, R., & Seshaiyer, P. (2019). Challenges in School Mathematics Curriculum Reform in India: Transforming Teacher Practices Through Pedagogical Innovations. In C. P. Vistro-Yu & T. L. Toh (Eds.), *School Mathematics Curricula: Asian Perspectives and Glimpses of Reform* (pp. 227–237). https://doi.org/10.1007/978-981-13-6312-2_12

Banerji, R. (2000). Poverty and Primary Schooling: Field Studies from Mumbai and Delhi. *Economic and Political Weekly*, *35*(10), 795–802.

Banerji, R., & Chavan, M. (2016). Improving literacy and math instruction at scale in India's primary schools: The case of Pratham's Read India program. *Journal of Educational Change*, *17*(4), 453–475.

Bantwini, B. D. (2010). How teachers perceive the new curriculum reform: Lessons from a school district in the Eastern Cape Province, South Africa. *International Journal of Educational Development*, *30*(1), 83–90. https://doi.org/10.1016/j.ijedudev.2009.06.002

Bapat, A., & Takker, S. (2016). *Enabling teachers for effective teaching learning in the constructivist curriculum framework*. Presented at the 13th International Congress on Mathematical Education.

Barcelos Amaral, R., & Hollebrands, K. (2017). An analysis of context-based similarity tasks in textbooks from Brazil and the United States. *International Journal of Mathematical Education in Science and Technology*, *48*(8), 1166–1184.

Bartlett, Lesley, & Vavrus, F. (2016). *Rethinking case study research: A comparative approach*. Taylor & Francis.

Bartlett, Lora. (2004). Expanding teacher work roles: A resource for retention or a recipe for overwork? *Journal of Education Policy*, *19*(5), 565–582. https://doi.org/10.1080/0268093042000269144

Bassey, M. (1999). *Case study research in educational settings*. McGraw-Hill Education (UK).

Batra, P. (2005). Voice and Agency of Teachers: Missing Link in National Curriculum Framework 2005. *Economic and Political Weekly*, *40*(40), 4347–4356.

Batra, P. (2008). *Social science learning in schools: Perspective and challenges*. SAGE Publications India.

Batra, P. (2009). Teacher Empowerment: The Education Entitlement–Social Transformation Traverse. *Contemporary Education Dialogue*, *6*(2), 121–156. https://doi.org/10.1177/0973184913411184

Batra, P. (2011). Teacher education and classroom practice in India: A critique and propositions. *EpiSTEME-4 Conference*.

Batra, P. (2012). Positioning teachers in the emerging education landscape of contemporary India. In *India Infrastructure Report 2012* (pp. 219–231). Delhi: IDFC Foundation.

Batra, P. (2014). Problematising teacher education practice in India: Developing a research agenda. *Education as Change*, *18*(sup1), S5–S18.

Batra, P. (2015). Curriculum in India: Narratives, debates, and a deliberative agenda. In W. Pinar (Ed.), *Curriculum studies in India: Intellectual histories, present circumstances* (pp. 35–65). Springer.

Batra, P., & Nawani, D. (2008). Social science texts: A pedagogic perspective. *Social Science Learning in Schools: Perspective and Challenges*, 197.

Beatty, A., & Pritchett, L. (2012). *The Negative Consequences of Overambitious Curricula in Developing Countries* (Scholarly Articles No. 9403174). Retrieved from Harvard Kennedy School of Government website: https://ideas.repec.org/p/hrv/hksfac/9403174.html

Behar, A. (2016, April 28). Researching education. *Livemint*. Retrieved from http://www.livemint.com/Opinion/bYZZrRAoW6ZLJrw5mWcpMN/Researching-education.html

Ben-Peretz, M. (1990). *The teacher-curriculum encounter: Freeing teachers from the tyranny of texts*. SUNY Press.

Bernstein, B. (2003). *Class, codes and control: The structuring of pedagogic discourse* (Vol. 4). Psychology Press.

Besamusca, A. (2013). *The impact of participation in a community of practice on teachers' professional development concerning the use of ICT in the classroom* (Master's Thesis). Freudenthal Institute, Utrecht University, Netherlands.

Beswick, K. (2011). Putting context in context: An Examination of the evidence for the benefits of "contextualised" tasks. *International Journal of Science and Mathematics Education*, *9*(2), 367–390. https://doi.org/10.1007/s10763-010-9270-z

Beteille, T. (2009). *Absenteeism, transfers and patronage: The political economy of teacher labor markets in India*. Stanford University.

Béteille, T., & Ramachandran, V. (2016). Contract teachers in India. *Economic and Political Weekly*, *51*(25), 40–47.

Bhattacharya, N. (2009). Teaching History in Schools: The Politics of Textbooks in India. *History Workshop Journal*, *67*(1), 99–110. https://doi.org/10.1093/hwj/dbn050

Bhog, D., Mullick, D., Bharadwaj, P., & Sharma, J. (2009). *Textbook regimes: A feminist critique of nation and identity*. New Delhi: Nirantar.

Bien, A., & Selland, M. (2018). Living the stories we tell: The sociopolitical context of enacting teaching stories. *Teaching and Teacher Education*, *69*, 85–94. https://doi.org/10.1016/j.tate.2017.10.005

Boaler, J. (1993). The Role of Contexts in the Mathematics Classroom: Do they Make Mathematics More" Real"? *For the Learning of Mathematics*, *13*(2), 12–17.

Boaler, J. (2002). Learning from Teaching: Exploring the Relationship between Reform Curriculum and Equity. *Journal for Research in Mathematics Education*, *33*(4), 239–258.

Bolitho, R., & Padwad, A. (2013). Continuing professional development lessons from India. *New Delhi: Ishtihaar*.

Borasi, R. (1986). On the nature of problems. *Educational Studies in Mathematics*, *17*(2), 125–141.

Bose, A. (2014). Revisiting transfer of learning in mathematics: Insights from an urban low-income settlement. In C. Nicol, P. Liljedahl, S. Oesterle, & D. Allan (Eds.), *Proceedings of the 38th Conference of the International Group for the Psychology of Mathematics Education and the 36th Conference of the North American Chapter of the Psychology of Mathematics Education* (Vol. 2, pp. 177–184). Vancouver, Canada.

Bose, A., & Choudhury, M. (2010). Language Negotiation in a Multilingual Mathematics Classroom: An Analysis. In L. Sparrow, B. Kissane, & C. Hurst (Eds.), *Shaping the Future of Mathematics Education* (pp. 93–100). Freemantle, Australia.

Bose, A., & Clarkson, P. (2016). Students' Use of Their Languages and Registers. In A. Halai & P. Clarkson (Eds.), *Teaching and Learning Mathematics in Multilingual Classrooms* (pp. 125–141). Springer.

Bose, A., & Subramaniam, K. (2011). Exploring school children's out of school mathematics. *Proceedings of the 35th Conference of the International Group for the Psychology of Mathematics Education*, *2*, 177–184.

Bowie, L. (2014). The interplay of the social, pedagogical and mathematical in a Mathematics textbook. In M. Berger, K. Brodie, V. Frith, & K. le Roux (Eds.), *Proceedings of the Seventh International Mathematics Education and Society Conference* (Vol. 2, pp. 243–251). Cape Town, South Africa: Hansa Print.

Bransford, J. D., & Schwartz, D. L. (1999). Chapter 3: Rethinking transfer: A simple proposal with multiple implications. *Review of Research in Education*, *24*(1), 61–100.

Brantlinger, A. (2011). Rethinking critical mathematics: A comparative analysis of critical, reform, and traditional geometry instructional texts. *Educational Studies in Mathematics*, *78*(3), 395.

Brinkmann, S. (2015). Learner-centred education reforms in India: The missing piece of teachers' beliefs. *Policy Futures in Education*, *13*(3), 342–359.

Brinkmann, S. (2016). *The role of teachers' beliefs in the implementation of learner-centred education in India* (PhD Thesis). UCL (University College London).

Brinkmann, S. (2018). Teachers' beliefs and educational reform in India: From 'learner-centred' to 'learning-centred' education. *Comparative Education*, 1–21.

Brown, M. W. (2002). *Teaching by design: Understanding the intersection between teacher practice and the design of curricular innovations* (PhD Thesis). Northwestern University, Evanstan, IL.

Brown, M. W. (2009). The teacher–tool relationship: Theorizing the design and use of curriculum materials. In J. T. Remillard, B. A. Herbal-Eisenmann, & G. M. Lloyd (Eds.), *Mathematics teachers at work: Connecting curriculum materials and classroom instruction* (pp. 37–56). Routledge.

Brown, S. A., Pitvorec, K., Ditto, C., & Kelso, C. R. (2009). Reconceiving fidelity of implementation: An investigation of elementary whole-number lessons. *Journal for Research in Mathematics Education*, 363–395.

Bryant, B. R., Bryant, D. P., Kethley, C., Kim, S. A., Pool, C., & Seo, Y.-J. (2008). Preventing Mathematics Difficulties in the Primary Grades: The Critical Features of Instruction in Textbooks as Part of the Equation. *Learning Disability Quarterly*, *31*(1), 21–35. https://doi.org/10.2307/30035523

Buchanan, D. A., & Bryman, A. (2007). Contextualizing methods choice in organizational research. *Organizational Research Methods*, *10*(3), 483–501.

Charalambous, C. Y., Delaney, S., Hsu, H.-Y., & Mesa, V. (2010). A comparative analysis of the addition and subtraction of fractions in textbooks from three countries. *Mathematical Thinking and Learning*, *12*(2), 117–151.

Charalambous, C. Y., & Philippou, G. N. (2010). Teachers' concerns and efficacy beliefs about implementing a mathematics curriculum reform: Integrating two lines of inquiry. *Educational Studies in Mathematics*, *75*(1), 1–21.

Chávez-López, Ó. (2003). *From the textbook to the enacted curriculum: Textbook use in the middle school mathematics classroom* (PhD Thesis). University of Missouri–Columbia.

Chazan, D., & Ball, D. (1999). Beyond being told not to tell. *For the Learning of Mathematics*, *19*(2), 2–10.

Chien, C. Y., & Young, K. (2007). The centrality of textbooks in teachers' work: Perceptions and use of textbooks in a Hong Kong primary school. *The Asia-Pacific Education Researcher*, *16*(2), 155–163.

Choppin, J. (2011). Learned adaptations: Teachers' understanding and use of curriculum resources. *Journal of Mathematics Teacher Education*, *14*(5), 331–353.

Choppin, J., Davis, J., McDuffie, A. R., & Drake, C. (2016). Implementations of CCSSM-Aligned Lessons. *North American Chapter of the International Group for the Psychology of Mathematics Education*. Presented at the Tucson, AZ. Retrieved from https://eric.ed.gov/?id=ED583692

Choppin, J., McDuffie, A. R., Drake, C., & Davis, J. (2015). Curriculum Metaphors in U.S. Middle School Mathematics. *North American Chapter of the International Group for the Psychology of Mathematics Education*. Presented at the Tucson, AZ. Retrieved from https://eric.ed.gov/?id=ED584207

Choppin, J., Roth McDuffie, A., Drake, C., & Davis, J. (2018). Curriculum ergonomics: Conceptualizing the interactions between curriculum design and use. *International Journal of Educational Research*, *92*, 75–85. https://doi.org/10.1016/j.ijer.2018.09.015

Chval, K. B., Chávez, Ó., Reys, B. J., & Tarr, J. (2009). Considerations and limitations related to conceptualizing and measuring textbook integrity. *Mathematics Teachers at Work: Connecting Curriculum Materials and Classroom Instruction*, 70–84.

Clandinin, D. J., & Connelly, F. M. (1992). Teacher as curriculum maker. *Handbook of Research on Curriculum*, (s 363), 401.

Clarke, P. (2001). *Teaching & learning: The culture of pedagogy*. Sage Publications New Delhi.

Clarke, P. (2003). Culture and classroom reform: The case of the district primary education project, India. *Comparative Education*, *39*(1), 27–44.

Clarkson, P. (1993). Gender, Ethnicity and Textbooks. *Australian Mathematics Teacher*, *49*(2), 14–16.

Cohen, D. K. (1990). A Revolution in One Classroom: The Case of Mrs. Oublier. *Educational Evaluation and Policy Analysis*, *12*(3), 311–329. https://doi.org/10.3102/01623737012003311

Cohen, D. K., Raudenbush, S. W., & Ball, D. L. (2003). Resources, instruction, and research. *Educational Evaluation and Policy Analysis*, *25*(2), 119–142.

Cohen, L., Manion, L., & Morrison, K. (2013). *Research methods in education*. Routledge.

Connell, R. (2014). Using southern theory: Decolonizing social thought in theory, research and application. *Planning Theory*, *13*(2), 210–223. https://doi.org/10.1177/1473095213499216

Connole, H., Smith, B., & Wiseman, R. (1993). Issues and methods in research: Study guide. *University of South Australia, Adelaide*.

Creswell, J. W., & Miller, D. L. (2000). Determining validity in qualitative inquiry. *Theory into Practice*, *39*(3), 124–130.

Cross Francis, D. I. (2015). Dispelling the notion of inconsistencies in teachers' mathematics beliefs and practices: A 3-year case study. *Journal of Mathematics Teacher Education*, *18*(2), 173–201. https://doi.org/10.1007/s10857-014-9276-5

CTET result 2019 out on ctet.nic.in, 352,000 pass; all you need to know. (2019, July 31). *Business Standard India*. Retrieved from https://www.business-standard.com/article/jobs/ctet-result-2019-declared-on-ctet-nic-in-3-52-lakh-pass-

cbse-ctet-exam-steps-to-check-marks-cete-certificate-qualifying-marks-all-you-need-to-know-119073100139_1.html

d'Ambrósio, U. (2006). *Ethnomathematics: Link between traditions and modernity*. BRILL.

Dale, E., & Chall, J. S. (1949). The concept of readability. *Elementary English*, *26*(1), 19–26.

D'Ambrosio, U. (2001). *Mathematics across cultures: The history of non-Western mathematics* (Vol. 2). Springer Science & Business Media.

Darling-Hammond, L. (2002). Educating a profession for equitable practice. *Learning to Teach for Social Justice*, 201–212.

Dauben, J. W., Yee, L. P., Raina, D., & Xu, Y. (2014). Mathematics Education in Modern Asia. In A. Karp & G. Schubring (Eds.), *Handbook on the History of Mathematics Education* (pp. 361–390). https://doi.org/10.1007/978-1-4614-9155-2_18

Davis, E. A., & Krajcik, J. S. (2005). Designing Educative Curriculum Materials to Promote Teacher Learning. *Educational Researcher*, *34*(3), 3–14.

Davis, E. A., Palincsar, A. S., Smith, P. S., Arias, A. M., & Kademian, S. M. (2017). Educative Curriculum Materials: Uptake, Impact, and Implications for Research and Design. *Educational Researcher*, *46*(6), 293–304. https://doi.org/10.3102/0013189X17727502

Davis, E., Palincsar, A. S., Arias, A. M., Bismack, A. S., Marulis, L., & Iwashyna, S. (2014). Designing educative curriculum materials: A theoretically and empirically driven process. *Harvard Educational Review*, *84*(1), 24–52.

De Abreu, G. (2000). Relationships between macro and micro socio-cultural contexts: Implications for the study of interactions in the mathematics classroom. *Educational Studies in Mathematics*, *41*(1), 1–29.

Delamont, S. (2016). *Fieldwork in educational settings: Methods, pitfalls and perspectives*. Routledge.

Delpit, L. (1988). The silenced dialogue: Power and pedagogy in educating other people's children. *Harvard Educational Review*, *58*(3), 280–299.

Demosthenous, E. (2015). *Algebra-related topics: A multiple case study in Cypriot primary school classrooms*. University of Cambridge.

Derry, S. J., Pea, R. D., Barron, B., Engle, R. A., Erickson, F., Goldman, R., … Sherin, M. G. (2010). Conducting video research in the learning sciences: Guidance on selection, analysis, technology, and ethics. *The Journal of the Learning Sciences*, *19*(1), 3–53.

Dheram, P., & Banks, F. (2012). India: Committing to change. In B. Moon (Ed.), *Teacher Education and the Challenge of Development* (pp. 92–106). Routledge.

Dietiker, L., & Riling, M. (2018). Design (In) tensions in mathematics curriculum. *International Journal of Educational Research*, *92*, 43–52.

Dowling, P. (1996). A sociological analysis of school mathematics texts. *Educational Studies in Mathematics*, *31*(4), 389–415.

Dowling, P. (2002). *The sociology of mathematics education: Mathematical myths/pedagogic texts*. Routledge.

Dowling, P., & Burke, J. (2012). Shall we do politics or learn some maths today? Representing and interrogating social inequality. In *Towards equity in mathematics education* (pp. 87–103). Springer.

Doyle, W., & Carter, K. (1984). Academic tasks in classrooms. *Curriculum Inquiry*, *14*(2), 129–149.

Draisma, J. (2018). Mathematics textbook development for primary grades and its teachers in Mozambique. *ZDM*, *50*(5), 949–963.

Drake, C., & Sherin, M. G. (2009). Developing curriculum vision and trust. In J. T. Remillard, B. A. Herbal-Eisenmann, & G. M. Lloyd (Eds.), *Mathematics teachers at*

work: Connecting curriculum materials and classroom instruction (pp. 321–337). Routledge.

Dyer, C., Choksi, A., Awasty, V., Iyer, U., Moyade, R., Nigam, N., … Sheth, S. (2004). Knowledge for teacher development in India: The importance of 'local knowledge' for in-service education. *International Journal of Educational Development*, *24*(1), 39–52. https://doi.org/10.1016/j.ijedudev.2003.09.003

Eco, U. (1979). *The role of the reader: Explorations in the semiotics of texts* (Vol. 318). Indiana University Press.

Edson, A. J., Phillips, E., Slanger-Grant, Y., & Stewart, J. (2019). The Arc of Learning framework: An ergonomic resource for design and enactment of problem-based curriculum. *International Journal of Educational Research*, *93*, 118–135. https://doi.org/10.1016/j.ijer.2018.09.020

Ellsworth, E. (1997). *Teaching positions: Difference, pedagogy, and the power of address.* Teachers College Pr.

Ernest, P., Sriraman, B., & Ernest, N. (2016). *Critical mathematics education: Theory, praxis and reality*. IAP.

Fan, L., Trouche, L., Qi, C., Rezat, S., & Visnovska, J. (2018). *Research on Mathematics Textbooks and Teachers' Resources: Advances and Issues*. Springer.

Fan, L., & Zhu, Y. (2007). Representation of problem-solving procedures: A comparative look at China, Singapore, and US mathematics textbooks. *Educational Studies in Mathematics*, *66*(1), 61–75. https://doi.org/10.1007/s10649-006-9069-6

Fan, L., Zhu, Y., & Miao, Z. (2013). Textbook research in mathematics education: Development status and directions. *ZDM*, *45*(5), 633–646.

Fauvel, J. (1991). Tone and the teacher: Instruction and complicity in mathematics textbooks. In D. Pimm & E. Love (Eds.), *Teaching and learning school mathematics* (pp. 111–121). London: Hodder & Stoughton.

Feldman, M. S., Bell, J., & Berger, M. T. (2004). *Gaining access: A practical and theoretical guide for qualitative researchers*. Rowman Altamira.

Fereday, J., & Muir-Cochrane, E. (2006). Demonstrating rigor using thematic analysis: A hybrid approach of inductive and deductive coding and theme development. *International Journal of Qualitative Methods*, *5*(1), 80–92.

Flyvbjerg, B. (2006). Five misunderstandings about case-study research. *Qualitative Inquiry*, *12*(2), 219–245.

Foote, M. Q., & Bartell, T. G. (2011). Pathways to equity in mathematics education: How life experiences impact researcher positionality. *Educational Studies in Mathematics*, *78*(1), 45–68. https://doi.org/10.1007/s10649-011-9309-2

Forbes, C. T., & Davis, E. A. (2010). Curriculum design for inquiry: Preservice elementary teachers' mobilization and adaptation of science curriculum materials. *Journal of Research in Science Teaching*, *47*(7), 820–839.

Fredriksen, B., & Brar, S. (2015). *Getting textbooks to every child in Sub-Saharan Africa: Strategies for addressing the high cost and low availability problem*. The World Bank.

Frölich, M., & Michaelowa, K. (2011). Peer effects and textbooks in African primary education. *Labour Economics*, *18*(4), 474–486. https://doi.org/10.1016/j.labeco.2010.11.008

Gandhi, H., Dewan, H., & Ahuja, A. (2018). Searching for Didactical Negotiations in Mathematics Textbooks. *Voices of Teachers and Teacher Educators*, *6*(2), 50–57.

Garcia, J. (1990). The Portrayal of Females and Minorities in Selected Elementary Mathematics Series. *School Science and Mathematics*, *90*(1), 2–12.

Gerdes, P. (1996). Ethnomathematics and Mathematics Education. In A. J. Bishop, K. Clements, C. Keitel, J. Kilpatrick, & C. Laborde (Eds.), *International Handbook of Mathematics Education* (pp. 909–943). https://doi.org/10.1007/978-94-009-1465-0_25

Gerofsky, S. (1996). A Linguistic and Narrative View of Word Problems in Mathematics Education. *For the Learning of Mathematics*, *16*(2), 36–45.

Gerofsky, S. (2004). *A man left Albuquerque heading east: Word problems as genre in mathematics education*. New York: Peter Lang.

Gerofsky, S. (2010). The impossibility of 'real-life' word problems (according to Bakhtin, Lacan, Zizek and Baudrillard). *Discourse: Studies in the Cultural Politics of Education*, *31*(1), 61–73. https://doi.org/10.1080/01596300903465427

Gibson, J. J. (1977). The concept of affordances. In R. Shaw & J. Bransford (Eds.), *Perceiving, acting, and knowing: Toward an ecological psychology* (pp. 67–88). Erlbaum, NJ.

Gitlin, A. (2001). Bounding teacher decision making: The threat of intensification. *Educational Policy*, *15*(2), 227–257.

Glewwe, P., Kremer, M., & Moulin, S. (2009). Many children left behind? Textbooks and test scores in Kenya. *American Economic Journal: Applied Economics*, *1*(1), 112–35.

Goel, D. R., & Goel, C. (2016). Teacher education scenario in India: Current problems & concerns. *MIER Journal of Educational Studies, Trends and Practices*, *2*(2).

GOI. (1993). *Learning without burden: Report of the National Advisory Committee*. New Delhi: Ministry of Human Resources Development.

GOI. (2019). *Draft National Education Policy 2019*. Retrieved from Ministry of Human Resources Development website: https://innovate.mygov.in/wp-content/uploads/2019/06/mygov15596510111.pdf

Govinda, R., & Josephine, Y. (2005). Para-teachers in India: A Review. *Contemporary Education Dialogue*, *2*(2), 193–224. https://doi.org/10.1177/097318490500200204

Goyal, S., & Pandey, P. (2013). Contract teachers in India. *Education Economics*, *21*(5), 464–484. https://doi.org/10.1080/09645292.2010.511854

Graddol, D., Maybin, J., & Stierer, B. (1994). *Researching language and literacy in social context: A reader*. Multilingual matters.

Gravemeijer, K. P. E. (2014). Transforming Mathematics Education: The Role of Textbooks and Teachers. In Y. Li, E. A. Silver, & S. Li (Eds.), *Transforming Mathematics Instruction* (pp. 153–172). https://doi.org/10.1007/978-3-319-04993-9_10

Gray, E. (1991). The primary mathematics textbook: Intermediary in the cycle of change. In D. Pimm & E. Love (Eds.), *Teaching and learning school mathematics* (pp. 122–136). London: Hodder & Stoughton.

Greer, B., Mukhopadhyay, S., Powell, A. B., & Nelson-Barber, S. (2009). *Culturally responsive mathematics education*. Routledge.

Gueudet, G., Pepin, B., & Trouche, L. (2013). Collective work with resources: An essential dimension for teacher documentation. *ZDM*, *45*(7), 1003–1016. https://doi.org/10.1007/s11858-013-0527-1

Gueudet, Ghislaine, Pepin, B., & Trouche, L. (2011). *From text to'lived'resources: Mathematics curriculum materials and teacher development* (Vol. 7). Springer Science & Business Media.

Gupta, R. (2014). Expectations vs. Reality: The Readability of Texts in the Primary Grades in India. *Procedia - Social and Behavioral Sciences*, *116*, 3916–3920. https://doi.org/10.1016/j.sbspro.2014.01.866

Gupta, S., & Ahmad, F. (2016). Teaching and the Transformative Promise of Public Education: What Went Wrong? Have We Lost Our Way? A Perspective from Two Government School Teachers. *Contemporary Education Dialogue*, *13*(2), 266–272.

Gutstein, E. (2006). *Reading and writing the world with mathematics: Toward a pedagogy for social justice*. Taylor & Francis.

Gutstein, E., & Peterson, B. (2005). *Rethinking mathematics: Teaching social justice by the numbers*. Rethinking Schools.

Haggarty, L., & Pepin, B. (2002). An Investigation of Mathematics Textbooks and Their Use in English, French and German Classrooms: Who Gets an Opportunity to Learn What? *British Educational Research Journal*, *28*(4), 567–590.

Halai, A. (2009). Politics and practice of learning mathematics in multilingual classrooms: Lessons from Pakistan. In R. Barwell (Ed.), *Multilingualism in mathematics classrooms: Global perspectives* (pp. 47–62). Bristol: Multilingual Matters.

Halliday, M. A., & Hasan, R. (1989). *Language, context, and text: Aspects of language in a social-semiotic perspective*. Oxford University Press.

Harris, M. (1999). *Gender Sensitivity in Primary School Mathematics in India*. Commonwealth Secretariat.

Hennessy, S., Rojas-Drummond, S., Higham, R., Márquez, A. M., Maine, F., Ríos, R. M., … Barrera, M. J. (2016). Developing a coding scheme for analysing classroom dialogue across educational contexts. *Learning, Culture and Social Interaction*, *9*, 16–44. https://doi.org/10.1016/j.lcsi.2015.12.001

Herbel-Eisenmann, B. A. (2007). From Intended Curriculum to Written Curriculum: Examining the "Voice" of a Mathematics Textbook. *Journal for Research in Mathematics Education*, *38*(4), 344–369. https://doi.org/10.2307/30034878

Herbel-Eisenmann, B. A., Lubienski, S. T., & Id-Deen, L. (2006). Reconsidering the Study of Mathematics Instructional Practices: The Importance of Curricular Context in Understanding Local and Global Teacher Change. *Journal of Mathematics Teacher Education*, *9*(4), 313–345. https://doi.org/10.1007/s10857-006-9012-x

Herbel-Eisenmann, B. A., & Wagner, D. (2007). A framework for uncovering the way a textbook may position the mathematics learner. *For the Learning of Mathematics*, *27*(2), 8–14.

Hett, G., & Hett, J. (2013). Ethics in intercultural research: Reflections on the challenges of conducting field research in a Syrian context. *Compare: A Journal of Comparative and International Education*, *43*(4), 496–515.

Hill, H. C., & Charalambous, C. Y. (2012). Teacher knowledge, curriculum materials, and quality of instruction: Lessons learned and open issues. *Journal of Curriculum Studies*, *44*(4), 559–576. https://doi.org/10.1080/00220272.2012.716978

Holstein, K. A. (2012). *A Characterization of Teachers' Implementations of a Mathematical Decision-Making Curriculum.* NC State University.

Howson, G. (2013a). The development of mathematics textbooks: Historical reflections from a personal perspective. *ZDM*, *45*(5), 647–658. https://doi.org/10.1007/s11858-013-0511-9

Howson, G. (2013b). The development of mathematics textbooks: Historical reflections from a personal perspective. *ZDM*, *45*(5), 647–658. https://doi.org/10.1007/s11858-013-0511-9

Hsu, H.-Y., & Silver, E. A. (2014). Cognitive complexity of mathematics instructional tasks in a Taiwanese classroom: An examination of task sources. *Journal for Research in Mathematics Education*, *45*(4), 460–496.

Iyer, S. (2013). An Ethnographic Study of Disciplinary and Pedagogic Practices in a Primary Class. *Contemporary Education Dialogue*, *10*(2), 163–195. https://doi.org/10.1177/0973184913484996

Jaffrelot, C., & Jairam, P. (2019, November). BJP Has Been Effective in Transmitting Its Version of Indian History to Next Generation of Learners. *Indian Express*.

Jain, M. (2018). Public, private and education in India: A historical overview. In M. Jain, A. Mehendale, R. Mukhopadhyay, P. M. Sarangapani, & C. Winch (Eds.), *School Education in India: Market, State and Quality* (pp. 31–66). Routledge India.

Jayathirtha, G. (2018). An Analysis of the National Intended Geometry Curriculum. *Contemporary Education Dialogue*, *15*(2), 143–163.

Jones, D. L., & Tarr, J. E. (2007). An Examination of the levels of Cogitive Demand Required by Probability Tasks in Middle Grades Mathematics Textbooks. *Statistics Education Research Journal*, *6*(2).

Jung Kang, H. (2014). A Cross-National Comparative Study of First-and Fourth-Grade Math Textbooks between Korea and the United States. *Curriculum & Teaching Dialogue*, *16*.

Kamat, S. (2004). Postcolonial aporias, or what does fundamentalism have to do with globalization? The contradictory consequences of education reform in India. *Comparative Education*, *40*(2), 267–287. https://doi.org/10.1080/0305006042000231383

Kang, W., & Kilpatrick, J. (1992). Didactic Transposition in Mathematics Textbooks. *For the Learning of Mathematics*, *12*(1), 2–7.

Kar, T., Güler, G., Şen, C., & Özdemir, E. (2018). Comparing the development of the multiplication of fractions in Turkish and American textbooks. *International Journal of Mathematical Education in Science and Technology*, *49*(2), 200–226.

Kaul, V., Gupta, D., Bala, N., Barbhuiya, A. R., Rao, K. N., & Mallikarjun, B. (1995). Readibility of Primary-Level Textbooks. *Department of Pre-School and Elementary Education, National Council of Educational Research and Training, New Delhi. Processed*.

Khan, F. (2015a). Evolving concerns around mathematics as a school discipline: Curricular vision, educational policy and the national curriculum framework 2005. In B. Sriraman, J. Cai, K. Lee, L. Fan, Y. Shimizu, C. S. Lim, & K. Subramaniam (Eds.), *The First Sourcebook on Asian Research in Mathematics Education: Korea, Singapore, China, Japan, Malaysia and India* (Vol. 2, pp. 1515–1537). IAP.

Khan, F. (2015b). *Mathematics and its discontents: How well does Mathematics pedagogy serve the children of the poor?* [Working Paper Series 5]. Retrieved from Max Weber Stiftung: Foundation German Humanities Institutes Abroad website: http://www.ghil.ac.uk/fileadmin/redaktion/dokumente/trg_india/Paper%205%20Farida%20Khan.pdf

Khan, F. (2004). Living, learning and doing mathematics: A study of working-class children in Delhi. *Contemporary Education Dialogue*, *1*(2), 199–227.

Khanna, P. (2015, June 25). AAP govt doubles Delhi's education budget. *Https://Www.Livemint.Com*. Retrieved from https://www.livemint.com/Politics/FFaQrcfaRuCg4FbLxuoqKM/AAP-govt-doubles-allocation-for-education-in-Delhi-budget.html

Kim, O.-K., & Atanga, N. A. (2014). Teacher fidelity decisions and their impact on lesson enactment. *National Council of Teachers of Mathematics Research Conference in New Orleans, LA*.

Kingdon, G., & Muzammil, M. (2013). The School Governance Environment in Uttar Pradesh, India: Implications for Teacher Accountability and Effort. *The Journal of Development Studies*, *49*(2), 251–269. https://doi.org/10.1080/00220388.2012.700397

Kothari, R., & Snell, R. (2011). *Chutnefying English: The Phenomenon of Hinglish*. Penguin Books India.

Kuhnke, H. F. (1977). Update on sex-role stereotyping in elementary mathematics textbooks. *The Arithmetic Teacher*, *24*(5), 373–376.

Kumar, A. (2012). Indian social studies curriculum in transition: Effects of a paradigm shift in curriculum discourse. *TCI (Transnational Curriculum Inquiry)*, *9*(1), 20–53.

Kumar, K. (1986). Textbooks and Educational Culture. *Economic and Political Weekly*, *21*(30), 1309–1311.

Kumar, K. (1988). Origins of India's "Textbook Culture." *Comparative Education Review*, *32*(4), 452–464.

Kumar, K. (1989). *Social character of learning*. SAGE Publications India.

Kumar, K. (2005a). *Political agenda of education: A study of colonialist and nationalist ideas*. SAGE Publications India.

Kumar, K. (2005b). Quality of Education at the Beginning of the 21st Century: Lessons from India. *Indian Educational Review*, *40*(1), 3–28.

Kumar, K. (2008). Partners in Education? *Economic and Political Weekly*, *43*(3), 8–11. Retrieved from JSTOR.

Kumar, K. (2015). The meek dictator: The Indian teacher in historical perspective. In *Handbook of Educational Ideas and Practices (Routledge Revivals)*.

Kumar, R. S., Dewan, H., & Subramaniam, K. (2012). The preparation and professional development of mathematics teachers. In R. Ramanujam & K. Subramaniam (Eds.), *Mathematics Education in India Status and Outlook Editors* (pp. 151–183). Mumbai, India: Homi Bhabha Centre for Science Education Tata Institute of Fundamental Research.

Kumar, R. S., & Subramaniam, K. (2015). From "Following" to Going Beyond the Textbook: Inservice Indian Mathematics Teachers' Professional Development for Teaching Integers. *Australian Journal of Teacher Education*, *40*(12). https://doi.org/10.14221/ajte.2015v40n12.7

Kumar, S. M. (2017). Comparing private and government schools in India: The devil is in the maths. *Applied Economic Letters*, 1–6. https://doi.org/10.1080/13504851.2017.1327118

Kumari, J. (2018). Analysis of Work and Employment Conditions of Contractual teachers in India. *NMIMS Journal of Economics and Public Policy*, *University Day Special*.

Kundu, P. (2019). Deteriorating Quality of Education in Schools: Are teachers responsible? *Economic and Political Weekly*, *54*(24), 34–41.

Kvale, S., & Brinkmann, S. (2009). *Interviews: Learning the craft of qualitative research interviewing*. Sage.

Lave, J. (1992). Word problems: A microcosm of theories of learning. *Context and Cognition: Ways of Learning and Knowing*, 74–92.

Leatham, K. R. (2006). Viewing Mathematics Teachers' Beliefs as Sensible Systems. *Journal of Mathematics Teacher Education*, *9*(1), 91–102. https://doi.org/10.1007/s10857-006-9006-8

Lemke, J. L. (1990). *Talking science: Language, learning, and values.* Ablex Publishing Corporation.

Leshota, M. (2015). *The relationship between textbook affordances and mathematics' teachers' pedagogical design capacity (PDC)* (PhD Thesis). University of the Witwatersrand, Johannesburg.

Leshota, M., & Adler, J. (2018). Disaggregating a Mathematics Teacher's Pedagogical Design Capacity. In *Research on Mathematics Textbooks and Teachers' Resources* (pp. 89–117). Springer.

Li, Y. (2000). A comparison of problems that follow selected content presentations in American and Chinese mathematics textbooks. *Journal for Research in Mathematics Education*, 234–241.

Li, Y., Chen, X., & An, S. (2009). Conceptualizing and organizing content for teaching and learning in selected Chinese, Japanese and US mathematics textbooks: The case of fraction division. *ZDM*, *41*(6), 809–826. https://doi.org/10.1007/s11858-009-0177-5

Lloyd, G. M., & Wilson, M. (1998). Supporting Innovation: The Impact of a Teacher's Conceptions of Functions on His Implementation of a Reform Curriculum. *Journal for Research in Mathematics Education*, *29*(3), 248–274. https://doi.org/10.2307/749790

Love, E., & Pimm, D. (1996). 'This is so': A text on texts. In A. J. Bishop, K. Clements, C. Keitel, J. Kilpatrick, & C. Laborde (Eds.), *International Handbook of Mathematics Education* (pp. 371–409). Retrieved from http://link.springer.com/chapter/10.1007/978-94-009-1465-0_11

Lubienski, S. T. (2000a). A Clash of Social Class Cultures? Students' Experiences in a Discussion-Intensive Seventh-Grade Mathematics Classroom. *The Elementary School Journal*, *100*(4), 377–403. https://doi.org/10.1086/499647

Lubienski, S. T. (2000b). Problem Solving as a Means toward Mathematics for All: An Exploratory Look through a Class Lens. *Journal for Research in Mathematics Education*, *31*(4), 454–482. https://doi.org/10.2307/749653

Luttrell, W. (Ed.). (2009). *Qualitative Educational Research: Readings in Reflexive Methodology and Transformative Practice* (1 edition). New York, NY: Routledge.

Mahajan, S. (2018). Hindutva Agenda and History Writing: Imaginings of Nation. *Revista Canaria de Estudios Ingleses*, (76), 211–221. https://doi.org/10.25145/j.recaesin.2018.76.015

Maher, F., & Tetreault, M. K. (1994). *The Feminist Classroom: Dynamics of gender, race, and privilege*. Rowman and Littlefield: Lanham, MD.

Maier, E. (1991). Folk Mathematics. In M. Harris (Ed.), *Schools, Mathematics and Work* (pp. 62–66). Basingstoke: The Falmer Press.

Maithreyi, R. (2012). Rethinking Primary School Mathematics: Directions for a Process-Oriented Curriculum. *National Conference on Mathematics Education*, 34.

Majumdar, M. (2011). Politicians, civil servants or professionals? Teachers' voices on their work and worth. *Contemporary Education Dialogue*, *8*(1), 33–65.

Majumdar, M., & Mooij, J. E. (2011). *Education and inequality in India: A classroom view*. Routledge.

Manjrekar, N. (2007). Ideal child in the ideal nation: Gender, class and work in a school lesson. *EMIGRA Working Papers*, 0001–11. Retrieved from http://ddd.uab.cat/record/98532

Manouchehri, A., & Goodman, T. (2000). Implementing Mathematics Reform: The Challenge within. *Educational Studies in Mathematics*, *42*(1), 1–34.

Martinie, S. L., Kim, J.-H., & Abernathy, D. (2016). "Better to be a pessimist": A narrative inquiry into mathematics teachers' experience of the transition to the Common Core.

The Journal of Educational Research, *109*(6), 658–665. https://doi.org/10.1080/00220671.2015.1020913

Maxwell, J. A. (2012). *A realist approach for qualitative research*. Sage.

Mbekwa, M., & Julie, C. (2009). Nature of Contexts in School Mathematical Literacy Textbooks. *Souther African Association for Research in Mathematics, Science and Technology Education*, 178.

McClain, K., Zhao, Q., Visnovska, J., & Bowen, E. (2009). Understanding the role of the institutional context in the relationship between teachers and text. In J. T. Remillard, B. A. Herbal-Eisenmann, & G. M. Lloyd (Eds.), *Mathematics teachers at work: Connecting curriculum materials and classroom instruction* (pp. 56–69).

McNaught, M. D., Tarr, J. E., & Sears, R. (2010). Conceptualizing and Measuring Fidelity of Implementation of Secondary Mathematics Textbooks: Results of a Three-Year Study. *Annual Meeting of the American Educational Research Association*. Presented at the Denver, CO. Denver, CO.

Merton, R. K. (1972). Insiders and outsiders: A chapter in the sociology of knowledge. *American Journal of Sociology*, *78*(1), 9–47.

Miglani, N., Subramanian, J., & Agnihotri, V. (2017). Unpacking Participation: The Case of Child-Centered Pedagogy in India. In H. Kidwai, R. Iyengar, M. A. Witenstein, E. J. Byker, & R. Setty (Eds.), *Participatory Action Research and Educational Development: South Asian Perspectives* (pp. 129–159). https://doi.org/10.1007/978-3-319-48905-6_6

Mili, & Winch, C. (2019). Teaching through textbooks: Teachers as practitioners of a discipline? *Theory and Research in Education*, *17*(2), 181–201.

Milligan, L. O., Koornhof, H., Sapire, I., & Tikly, L. (2018). Understanding the role of learning and teaching support materials in enabling learning for all. *Compare: A*

Journal of Comparative and International Education, *0*(0), 1–19. https://doi.org/10.1080/03057925.2018.1431107

Milligan, L. O., Tikly, L., Williams, T., Vianney, J.-M., & Uworwabayeho, A. (2017). Textbook availability and use in Rwandan basic education: A mixed-methods study. *International Journal of Educational Development*, *54*, 1–7. https://doi.org/10.1016/j.ijedudev.2017.01.008

Mohammad, R. (2001). "Insiders" and/or "outsiders": Positionality, theory and praxis. In *Qualitative methodologies for geographers: Issues and debates* (pp. 101–117).

Mohammed, R. F., & Harlech-Jones, B. (2008). The fault is in ourselves: Looking at 'failures in implementation.' *Compare: A Journal of Comparative and International Education*, *38*(1), 39–51. https://doi.org/10.1080/03057920701420825

Montessori, M. M. (1966). *The human tendencies and Montessori education*. Association Montessori Internationale.

Mooij, J. (2008). Primary education, teachers' professionalism and social class about motivation and demotivation of government school teachers in India. *International Journal of Educational Development*, *28*(5), 508–523. https://doi.org/10.1016/j.ijedudev.2007.10.006

Morgan, C. (2016). Studying the role of human agency in school mathematics. *Research in Mathematics Education*, *18*(2), 120–141.

Morris, A. K., & Hiebert, J. (2011). Creating Shared Instructional Products: An Alternative Approach to Improving Teaching. *Educational Researcher*, *40*(1), 5–14. https://doi.org/10.3102/0013189X10393501

Mukherjee, M., & Mukherjee, A. (2001). Communalisation of Education, The History Textbook Controversy: An Overview. *Delhi Historians' Group, Communalisation of Education, Delhi Historians' Group, Delhi*.

Mukherjee, A., & Varma, V. S. (2015). The school mathematics project: An account of a Mathematics curriculum project. In B. Sriraman, J. Cai, K. Lee, L. Fan, Y. Shimizu, C. S. Lim, & K. Subramaniam (Eds.), *The First Sourcebook on Asian Research in Mathematics Education: Korea, Singapore, China, Japan, Malaysia and India* (Vol. 2, pp. 1539–1558). IAP.

Mukherji, A., & Mukul, A. (2009, September 26). Ma'am, the textbook has changed. *The Times of India*. Retrieved from https://timesofindia.indiatimes.com/india/Maam-the-textbook-has-changed/articleshow/5060338.cms

Mukhopadhyay, R., & Mukunda, K. V. (2017). Cultures of fear: Children in school. In *Childhoods in India* (pp. 275–296). Routledge India.

Muralidharan, K., & Sundararaman, V. (2011). Teacher opinions on performance pay: Evidence from India. *Economics of Education Review*, *30*(3), 394–403. https://doi.org/10.1016/j.econedurev.2011.02.001

Muralidharan, K., & Sundararaman, V. (2013). *Contract teachers: Experimental evidence from India*. Retrieved from National Bureau of Economic Research website: http://www.nber.org/papers/w19440

Mustafa, M., & Cullingford, C. (2008). Teacher autonomy and centralised control: The case of textbooks. *International Journal of Educational Development*, *28*(1), 81–88.

Mythili, N. (2019). Legitimisation of Women School Leaders in India. *Contemporary Education Dialogue*, *16*(1), 54–83. https://doi.org/10.1177/0973184918804396

Nag Chowdhuri, M. (2015). *Primary School Teachers' Perceptions of Reform-based Mathematics Textbooks in India* (Unpublished Master's Thesis). University of Cambridge, Cambridge, UK.

Nambissan, G. B., & Ball, S. J. (2010). Advocacy networks, choice and private schooling of the poor in India. *Global Networks*, *10*(3), 324–343.

Namukasa, I. K. (2018). Renewing textbooks to align with reformed curriculum in former colonies: Ugandan school mathematics textbooks. *ZDM*, *50*(5), 937–948.

Namukasa, I. K., Kaahwa, J., Quinn, M., & Ddungu, R. (2012). Critical curriculum renewal in Africa: The character of school mathematics in Uganda. In *Decolonizing philosophies of education* (pp. 177–191). Brill Sense.

Nargund-Joshi, V. (2012). *An exploration of the science teaching orientations of Indian science teachers in the context of curriculum reform* (Unpublished PhD Thesis). Indiana University.

Nath, B. K., & PS, S. (2009). Research Perspectives in Issue Based Curriculum and Critical Pedagogy. *Online Submission*.

Nawani, D. (2010). School Textbooks Understanding Frameworks for Analysis. *Contemporary Education Dialogue*, *7*(2), 157–192.

Nawani, D. (2013). Continuously and comprehensively evaluating children. *Economic & Political Weekly*, *48*(2), 33.

NCERT. (1975). *National Curriculum Framework 1975*. Retrieved from National Council of Educational Research and Training website: http://www.ncert.nic.in/oth_anoun/NCF_10_Year_School_eng.pdf

NCERT. (1988). *National Curriculum Framework 1988*. Retrieved from National Council of Educational Research and Training website: http://www.ncert.nic.in/oth_anoun/NCESE_1988.pdf

NCERT. (2000). *National Curriculum Framework 2000*. Retrieved from National Council of Educational Research and Training website: http://www.ncert.nic.in/oth_anoun/NCF_2000_Eng.pdf

NCERT. (2005). *National Curriculum Framework 2005*. Retrieved from National Council of Educational Research and Training website: http://www.ncert.nic.in/rightside/links/pdf/framework/english/nf2005.pdf

NCERT. (2006a). *Math-Magic: Textbook for Mathematics for Class I*. Retrieved from http://ncert.nic.in/textbook/textbook.htm

NCERT. (2006b). *Math-Magic: Textbook for Mathematics for Class III*. Retrieved from http://ncert.nic.in/textbook/textbook.htm

NCERT. (2006c). *Position Paper: National Focus Group on Curriculum, Syllabus and Textbooks*. Retrieved from National Council of Educational Research and Training website: http://www.ncert.nic.in/new_ncert/ncert/rightside/links/pdf/focus_group/cst_final.pdf

NCERT. (2006d). *Position Paper: National Focus Group on Teaching of Mathematics*. Retrieved from National Council of Educational Research and Training website: http://www.ncert.nic.in/new_ncert/ncert/rightside/links/pdf/focus_group/math.pdf

NCERT. (2006e). *Position Paper: National Focus Group on Teaching of Science*. Retrieved from National Council of Educational Research and Training website: http://www.ncert.nic.in/new_ncert/ncert/rightside/links/pdf/focus_group/math.pdf

NCERT. (2007a). *Math-Magic: Textbook for Mathematics for Class II*. Retrieved from http://ncert.nic.in/textbook/textbook.htm

NCERT. (2007b). *Math-Magic: Textbook for Mathematics for Class IV*. Retrieved from http://ncert.nic.in/textbook/textbook.htm

NCERT. (2008). *Math-Magic: Textbook for Mathematics for Class V*. Retrieved from http://ncert.nic.in/textbook/textbook.htm

NCERT. (2010). *Manual of Upper Primary Mathematics Kit*. Retrieved from National Council of Educational Research and Training website:

http://www.ncert.nic.in/departments/nie/niew/school_kits/upper_prm_level/pdf/kit_manual_UP_math.pdf

NCTE. (2009). *National Curriculum Framework for Teacher Education: Towards Preparing Professional and Humane Teacher*. Retrieved from National Council for Teacher Education website: http://ncte-india.org/ncte_new/pdf/NCFTE_2010.pdf

NCTM. (1989). *Curriculum and evaluation standards for school mathematics*. Reston, Va: National Council of Teachers of Mathematics Commission on Standards for School.

Nicol, C. C., & Crespo, S. M. (2006). Learning to Teach with Mathematics Textbooks: How Preservice Teachers Interpret and Use Curriculum Materials. *Educational Studies in Mathematics*, *62*(3), 331–355.

NUEPA. (2015). *Elementary education in India: Where do we stand?* Delhi: National Institute of Educational Planning and Administration.

Nunes, T., Schliemann, A. D., & Carraher, D. W. (1993). *Street mathematics and school mathematics*. Cambridge University Press.

Nyabanyaba, T. (1999). Whither Relevance? Mathematics Teachers' Discussion of the Use of "Real-Life" Contexts in School Mathematics. *For the Learning of Mathematics*, *19*(3), 10–14.

O'Donoghue, T. (2006). *Planning Your Qualitative Research Project: An Introduction to Interpretivist Research in Education*. Routledge.

OECD. (2004). *The PISA 2003 assessment framework: Mathematics, reading, science and problem solving knowledge and skills*. Organisation for Economic Co-operation and Development Publishing.

O'Keeffe, L., & O'Donoghue, J. (2015). A role for language analysis in mathematics textbook analysis. *International Journal of Science and Mathematics Education*, *13*(3), 605–630.

Opoku-Amankwa, K. (2010). What happens to textbooks in the classroom? Pupils' access to literacy in an urban primary school in Ghana. *Pedagogy, Culture & Society*, *18*(2), 159–172. https://doi.org/10.1080/14681366.2010.488042

O'Sullivan, M. (2006). Lesson observation and quality in primary education as contextual teaching and learning processes. *International Journal of Educational Development*, *26*(3), 246–260. https://doi.org/10.1016/j.ijedudev.2005.07.016

Paliwal, R., & Subramaniam, C. N. (2006). Contextualising the curriculum. *Contemporary Education Dialogue*, *4*(1), 25–51.

Palm, T. (2006). Word problems as simulations of real-world situations: A proposed framework. *For the Learning of Mathematics*, *26*(1), 42–47.

Palm, T. (2008). Impact of authenticity on sense making in word problem solving. *Educational Studies in Mathematics*, *67*(1), 37–58.

Palmér, H. (2018). How to Understand Changes in Novice Mathematics Teachers' Talk About Good Mathematics Teaching? In B. Rott, G. Törner, J. Peters-Dasdemir, A. Möller, & Safrudiannur (Eds.), *Views and Beliefs in Mathematics Education: The Role of Beliefs in the Classroom* (pp. 127–136). https://doi.org/10.1007/978-3-030-01273-1_12

Panda, B. N. (2016). *Bihar Primary Text Books Analysis: A report*. Retrieved from Regional Institute of Education: National Council of Educational research and Training website: http://www.ncert.nic.in/departments/nie/dee/pdf/Biharstate.pdf

Pathmarajah, M. (2014). *"Seeing like a constructivist": Learner-centered pedagogy and teacher education in Chennai, Tamil Nadu* (Unpublished EdD Thesis). Teachers College, Columbia University, United States, New York.

Pepin, B., Gueudet, G., & Trouche, L. (2013). Re-sourcing teachers' work and interactions: A collective perspective on resources, their use and transformation. *ZDM*, *45*(7), 929–943. https://doi.org/10.1007/s11858-013-0534-2

Pepin, Birgit, Gueudet, G., & Trouche, L. (2017). Refining teacher design capacity: Mathematics teachers' interactions with digital curriculum resources. *ZDM*, *49*(5), 799–812.

Petersson, M., & Bäckström, C. (2014). *How does a Government Lower Primary School in India work with mathematics? - A study on how the teachers' mathematical beliefs affect the norms operating in the classroom* (Unpublished Master's Thesis). Malmö University.

Philipp, R. A. (2007). Mathematics teachers' beliefs and affect. *Second Handbook of Research on Mathematics Teaching and Learning*, *1*, 257–315.

Pillow, W. (2003). Confession, catharsis, or cure? Rethinking the uses of reflexivity as methodological power in qualitative research. *International Journal of Qualitative Studies in Education*, *16*(2), 175–196. https://doi.org/10.1080/0951839032000060635

Pinar, W. (2015). *Curriculum studies in India: Intellectual histories, present circumstances*. Springer.

Planas, N., & Valero, P. (2016). Tracing the socio-cultural-political axis in understanding mathematics education. In *The second handbook of research on the psychology of mathematics education* (pp. 447–479). Brill Sense.

Polya, G. (2002). The Goals of Mathematical Education: Part 1. *Mathematics Teaching*, *181*, 6–7.

Powell, A. B., Francisco, J. M., & Maher, C. A. (2003). An analytical model for studying the development of learners' mathematical ideas and reasoning using videotape data. *The Journal of Mathematical Behavior*, *22*(4), 405–435.

Pritchett, L., & Beatty, A. (2012). The negative consequences of overambitious curricula in developing countries. *Center for Global Development Working Paper*, (293). Retrieved from http://papers.ssrn.com/sol3/papers.cfm?abstract_id=2102726

Punch, K. F. (2009). *Introduction to Research Methods in Education*. SAGE.

Raina, J. (2018). Teacher Education and Inclusionary Practices. *The Wiley International Handbook of Educational Foundations*, 157.

Rajput, J. S., & Walia, K. (2001). Reforms in Teacher Education in India. *Journal of Educational Change*, *2*(3), 239–256. https://doi.org/10.1023/A:1012753608348

Raju, C. K. (2014, September 3). Nothing Vedic in 'Vedic Maths.' *The Hindu*. Retrieved from https://www.thehindu.com/opinion/op-ed/nothing-vedic-in-vedic-maths/article6373689.ece

Ramachandran, V. (2005). Why school teachers are demotivated and disheartened. *Economic and Political Weekly*, 2141–2144.

Ramachandran, V., Bhattacharjea, S., & Sheshagiri, K. M. (2008). Primary school teachers: The twists and turns of everyday practice. *Education Resource Unit, New Delhi and Azim Premji Foundation, Bengaluru*.

Ramachandran, V., Jandhyala, K., Mehrotra, N., Krishnamurty, L., Periodi, V., & Saihjee, A. (2004). *Snakes and ladders: Factors influencing successful primary school completion for children in poverty contexts* (Discussion Paper Series No. 6). Retrieved from South Asia Human Development Sector, The World Bank website: http://archiv.ub.uni-heidelberg.de/savifadok/3487/

Ramachandran, V., Jandhyala, K., & Saihjee, A. (2003). Through the Life Cycle of Children: Factors That Facilitate/Impede Successful Primary School Completion. *Economic and Political Weekly*, *38*(47), 4994–5002.

Ramachandran, V., Pal, M., Jain, S., Shekar, S., & Sharma, J. (2005). *Teacher motivation in India* [Discussion Paper]. Bangalore: Azim Premji Foundation.

Ramoshebi, C. S. (2017). *Teachers' use of mathematics textbooks in their teaching of mathematics* (Unpublished PhD Thesis). University of the Witwatersrand.

Rampal, A. (2015). Curriculum and Critical Agency: Mediating Everyday Mathematics. In S. Mukhopadhyay & B. Greer (Eds.), *Proceedings of the Eighth International Mathematics Education and Society Conference* (Vol. 1, pp. 83–110). Portland, Oregon, United States: Ooligan Press, Portland State University, Oregon, US.

Rampal, A., & Makar, K. (2012). Embedding authenticity and cultural relevance in the primary mathematics curriculum. *The Twelfth International Congress of Mathematics Education*, 6616–6625. Seoul, Korea: International Commission on Mathematical Education (ICME).

Rampal, A., Ramanujan, R., & Saraswathi, L. S. (1997). Numeracy Counts!: A Handbook for Literacy Activists and Resource Persons. *National Literacy Resource Centre, Mussoorie*.

Rampal, A., & Subramanian, J. (2012). Transforming the Elementary Mathematics Curriculum: Issues and Challenges. In R. Ramanujam & K. Subramaniam (Eds.), *Mathematics Education in India Status and Outlook Editors* (pp. 63–88). Mumbai, India: Homi Bhabha Centre for Science Education Tata Institute of Fundamental Research.

Read, T. (2015). *Where have all the textbooks gone?: Toward sustainable provision of teaching and learning materials in Sub-Saharan Africa*. The World Bank.

Reinke, L., & Hoe, N. (2011). *Characterizing the Tasks Involved in Teachers' Use of Curriculum*. *3*. New Orleans, LA: Annual Meeting of the American Educational Research Association.

Remillard, J. T. (2000). Can Curriculum Materials Support Teachers' Learning? Two Fourth-Grade Teachers' Use of a New Mathematics Text. *The Elementary School Journal*, *100*(4), 331–350.

Remillard, J. T. (2005). Examining Key Concepts in Research on Teachers' Use of Mathematics Curricula. *Review of Educational Research*, *75*(2), 211–246.

Remillard, J. T. (2011). Modes of engagement: Understanding teachers' transactions with mathematics curriculum resources. In Ghislaine Gueudet, B. Pepin, & L. Trouche (Eds.), *From text to "lived" resources* (pp. 105–122). Springer.

Remillard, J. T., Kim, O. K., Atanga, N., Ciganik, S., Hoe, N. D., Reinke, L., & Taton, J. (2011). Comparative analysis of mathematical and pedagogical components of five elementary mathematics curricula. *Annual Meeting of the American Educational Research Association, New Orleans, LA*.

Remillard, J. T., & Kim, O.-K. (2017). Knowledge of curriculum embedded mathematics: Exploring a critical domain of teaching. *Educational Studies in Mathematics*, *96*(1), 65–81. https://doi.org/10.1007/s10649-017-9757-4

Remillard, J. T., Reinke, L. T., & Kapoor, R. (2019). What is the point? Examining how curriculum materials articulate mathematical goals and how teachers steer instruction. *International Journal of Educational Research*, *93*, 101–117. https://doi.org/10.1016/j.ijer.2018.09.010

Ren, L., & Smith, W. M. (2018). Teacher characteristics and contextual factors: Links to early primary teachers' mathematical beliefs and attitudes. *Journal of Mathematics Teacher Education*, *21*(4), 321–350. https://doi.org/10.1007/s10857-017-9365-3

Rezat, S. (2006). The structures of German mathematics textbooks. *ZDM*, *38*(6), 482–487.

Robinson-Pant, A., & Singal, N. (2013). Researching ethically across cultures: Issues of knowledge, power and voice. *Compare: A Journal of Comparative and International Education*, *43*(4), 417–421. https://doi.org/10.1080/03057925.2013.797719

Roehrig, G. H., & Kruse, R. A. (2005). The role of teachers' beliefs and knowledge in the adoption of a Reform-Based curriculum. *School Science and Mathematics*, *105*(8), 412–422.

Rogoff, B. E., & Lave, J. E. (1984). *Everyday cognition: Its development in social context.* Harvard University Press.

Ronda, E., & Adler, J. (2017). Mining Mathematics in Textbook Lessons. *International Journal of Science and Mathematics Education*, *15*(6), 1097–1114.

Rotman, B. (1988). Toward a semiotics of mathematics. *Semiotica*, *72*(1–2), 1–36.

Roy, K. (2017). Handmaidens of history? Exploring English, Hindi and Sanskrit textbooks for schools. *Contemporary Education Dialogue*, *14*(2), 122–140.

Ruthven, K. (2001). Issues of cultural diversity in school mathematics. *International Journal of Mathematical Education in Science and Technology*, *32*(3), 355–364. https://doi.org/10.1080/00207390110040175

Ruthven, K. (2013). From design-based research to re-sourcing 'in the wild': Reflections on studies of the co-evolution of mathematics teaching resources and practices. *ZDM*, *45*(7), 1071–1079. https://doi.org/10.1007/s11858-013-0547-x

Ruthven, K. (2016). Numeracy In, Across and Beyond the School Curriculum. In *The SAGE Handbook of Curriculum, Pedagogy and Assessment: Two Volume Set* (Vols. 1–2, pp. 638–653). https://doi.org/10.4135/9781473921405

Sabarwal, S., Evans, D., & Marshak, A. (2013). The permanent textbook hypothesis: School inputs and student outcomes in Sierra Leone. *Washington, DC: The World Bank*.

Sáenz, C. (2009). The role of contextual, conceptual and procedural knowledge in activating mathematical competencies (PISA). *Educational Studies in Mathematics*, *71*(2), 123–143. https://doi.org/10.1007/s10649-008-9167-8

Sahni, B. (2018). *An Implementation Plan to Improve Student Learning Outcomes in Delhi* (SSRN Scholarly Paper No. ID 3134743). Rochester, NY: Social Science Research Network.

Saigal, A. (2012). Demonstrating a situated learning approach for in-service teacher education in rural India: The Quality Education Programme in Rajasthan. *Teaching and Teacher Education*, *28*(7), 1009–1017. https://doi.org/10.1016/j.tate.2012.05.007

Saldaña, J. (2015). *The coding manual for qualitative researchers*. Sage.

Sankar, D., & Linden, T. (2014). *How much and what kind of teaching is there in elementary education in India? Evidence from three States* (No. 67). International Bank for Reconstruction and Development/The World Bank.

Sarangapani, P. (2003). *Constructing school knowledge: An ethnography of learning in an Indian village*. Delhi: Sage Publications Pvt. Ltd.

Sarangapani, P. (2011). Teachers first. *Frontline*, *28*(14), 13.

Sarangapani, P. (2015). Viewing CCE through an 'indigenous' lens. *Compare: A Journal of Comparative and International Education*, *45*(4), 647–650.

Sarangapani, P. M., Jain, M., Mukhopadhyay, R., & Winch, C. (2013). *Baseline survey of the school scenario in some states in the context of RTE: Study of educational quality, school management, and teachers: Andhra Pradesh, Delhi and West Bengal* [Report Submitted to Sarva Siksha Abhiyan Ministry of Human Resource Development New Delhi]. Mumbai: Tata Institute of Social Sciences, School of Education.

Sarangapani, P., Nawani, D., K, L., & Banga, J. (2017). *Teacher Resource Centres in India: A Sourcebook*. Mumbai, India: Tata Institute of Social Science.

Sarangapani, Padma M. (2003). Childhood and schooling in an Indian village. *Childhood*, *10*(4), 403–418.

Sarangapani, Padma M. (2014). Knowledge, curricula, and teaching methods: The case of India. *Revue Internationale d'éducation de Sèvres*.

Sarangapani, Padma M., Mukhopadhyay, R., Jain, M., & Parul. (2018). Recovering the practice and profession of teaching. In M. Jain, A. Mehendale, R. Mukhopadhyay, P. M. Sarangapani, & C. Winch (Eds.), *School Education in India: Market, State and Quality* (pp. 141–156). Routledge India.

Sarangapani, Padma M., & Winch, C. (2010). Tooley, Dixon and Gomathi on private education in Hyderabad: A reply. *Oxford Review of Education*, *36*(4), 499–515. https://doi.org/10.1080/03054985.2010.495465

Sawyer, R. (2017). Curriculum Deliberations Over Time: A Nexus of Teacher Dilemmas, Questions, Experimentation, and Agency. *Teachers College Record*, *119*(14).

SCERT. (2008). *Bihar curriculum framework*. Patna: State Council of Educational Research and Training.

Schmidt, W. H. (Ed.). (1996). *Characterizing Pedagogical Flow: An Investigation of Mathematics and Science Teaching in Six Countries*. Dordrecht ; Boston: Springer.

Schmidt, William H., McKnight, C. C., Valverde, G., Houang, R. T., & Wiley, D. E. (1997). *Many visions, many aims: A cross-national investigation of curricular intentions in school mathematics* (Vol. 1). Springer Science & Business Media.

Schoen, R. C., & LaVenia, M. (2019). Teacher beliefs about mathematics teaching and learning: Identifying and clarifying three constructs. *Cogent Education*, *6*(1), 1599488. https://doi.org/10.1080/2331186X.2019.1599488

Schoenfeld, A. H. (2013). Classroom observations in theory and practice. *ZDM*, *45*(4), 607–621. https://doi.org/10.1007/s11858-012-0483-1

Schubring, G. (2017). Mathematics teaching in the process of decolonization. In K. Bjarnadóttir, F. Furinghetti, M. Menghini, J. Prytz, & G. Schubring (Eds.), *Dig where you stand: Proceedings of the Fourth International Conference on the History of Mathematics Education* (pp. 349–368). Edizioni Nuova Cultura.

Schubring, G., & Fan, L. (2018). Recent advances in mathematics textbook research and development: An overview. *ZDM*, 1–7.

Scrase, T. J. (1993). *Image, ideology, and inequality: Cultural domination, hegemony, and schooling in India*. Sage Publications.

Seah, W. T., & Bishop, A. J. (2000). Values in mathematics textbooks: A view through two Australasian regions. *81st Annual Meeting of the American Educational Research Association*. Presented at the New Orleans, LA. New Orleans, LA.

Sengupta, S. (2007, August 15). Politics Is the New Star of India's Classrooms. *The New York Times*. Retrieved from https://www.nytimes.com/2007/08/15/world/asia/15india.html

Seshadri, C. (2000). *Primary Teacher Training in the EFA Decade*. National Institute of Educational Planning and Administration.

Setty, R. (2014). Dialogism in India's New National Curriculum Framework for Teacher Education. *Contemporary Education Dialogue*, *11*(1), 67–94. https://doi.org/10.1177/0973184913509753

Sharma, A., & Chunawala, S. (2011). Teachers' understanding of nature of science and their views about the primary school environment studies curriculum. *Proceedings of EpiSTEME 4*, *1*, 75–80. Mumbai, India: Homi Bhabha Centre for Science Education (TIFR).

Sharma, N., & Sarangapani, P. M. (2018). Teaching because it matters: Beliefs and practices of government school teachers. In M. Jain, A. Mehendale, R. Mukhopadhyay, P. M.

Sarangapani, & C. Winch (Eds.), *School Education in India: Market, State and Quality* (pp. 281–297). Routledge India.

Sherin, M. G., & Drake, C. (2009). Curriculum strategy framework: Investigating patterns in teachers' use of a reform-based elementary mathematics curriculum. *Journal of Curriculum Studies*, *41*(4), 467–500. https://doi.org/10.1080/00220270802696115

Shuard, H., & Rothery, A. (1984). *Children Reading Mathematics*. London: John Murray (Publishers) Ltd.

Shulman, L. S. (1986). Those Who Understand: Knowledge Growth in Teaching. *Educational Researcher*, *15*(2), 4–14. https://doi.org/10.3102/0013189X015002004

Silver, E. A., & Stein, M. K. (1996). The QUASAR project: The" revolution of the possible" in mathematics instructional reform in urban middle schools. *Urban Education*, *30*(4), 476–521.

Simic-Muller, K., Fernandes, A., & Felton-Koestler, M. D. (2015). "I Just Wouldn't Want to Get as Deep into It": Preservice Teachers' Beliefs about the Role of Controversial Topics in Mathematics Education. *Journal of Urban Mathematics Education*, *8*(2), 53–86.

Sinclair, J. M., & Coulthard, M. (1975). *Towards an analysis of discourse: The English used by teachers and pupils*. Oxford University Press.

Singh, R., & Sarkar, S. (2015). Does teaching quality matter? Students learning outcome related to teaching quality in public and private primary schools in India. *International Journal of Educational Development*, *41*, 153–163. https://doi.org/10.1016/j.ijedudev.2015.02.009

Sitabkhan, Y. (2011). *The Use of Convenient Value Strategies among Young Train Vendors in Mumbai, India*. Retrieved from

http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.496.3917&rep=rep1&type=pdf

Smail, A. (2014). Rediscovering the teacher within Indian child-centred pedagogy: Implications for the global Child-Centred Approach. *Compare: A Journal of Comparative and International Education*, *44*(4), 613–633.

Smart, A., & Jagannathan, S. (2018). *Textbook Policies in Asia: Development, Publishing, Printing, Distribution, and Future Implications*. Asian Development Bank.

Smith, F., Hardman, F., & Tooley, J. (2005). Classroom Interaction in Private Schools Serving Low-Income Families in Hyderabad, India. *International Education Journal*, *6*(5), 607–618.

Son, J. W., & Diletti, J. (2017). What Can We Learn from Textbook Analysis? In J. W. Son, T. Watanabe, & J. J. Lo (Eds.), *What Matters? Research Trends in International Comparative Studies in Mathematics Education* (pp. 3–32). https://doi.org/10.1007/978-3-319-51187-0_1

Son, J. W., & Senk, S. L. (2014). Teachers' knowledge and the enacted mathematics curriculum. In D. R. Thompson & Z. Usiskin (Eds.), *Enacted Mathematics Curriculum: A Conceptual Framework and Research Needs* (pp. 75–95). Charlotte, North Carolina: IAP.

Son, J. W., Watanabe, T., & Lo, J. J. (2017). *What Matters? Research Trends in International Comparative Studies in Mathematics Education*. Springer.

Song, S. (2015). Cambodian teachers' responses to child-centered instructional policies: A mismatch between beliefs and practices. *Teaching and Teacher Education*, *50*, 36–45. https://doi.org/10.1016/j.tate.2015.04.004

Sood, S., & Jitendra, A. K. (2007). A comparative analysis of number sense instruction in reform-based and traditional mathematics textbooks. *The Journal of Special Education*, *41*(3), 145–157. https://doi.org/10.1177/00224669070410030101

Spillane, J. P. (1998). State policy and the non-monolithic nature of the local school district: Organizational and professional considerations. *American Educational Research Journal*, *35*(1), 33–63.

Spillane, J. P. (1999). External reform initiatives and teachers' efforts to reconstruct their practice: The mediating role of teachers' zones of enactment. *Journal of Curriculum Studies*, *31*(2), 143–175. https://doi.org/10.1080/002202799183205

Srinivasan, R. (2016). Teaching about Teaching: Examining the Pedagogy of Teacher Education in India. *Higher Education for the Future*, *3*(2), 197–212. https://doi.org/10.1177/2347631116650551

Sriprakash, A. (2010). Child-centred education and the promise of democratic learning: Pedagogic messages in rural Indian primary schools. *International Journal of Educational Development*, *30*(3), 297–304. https://doi.org/10.1016/j.ijedudev.2009.11.010

Sriprakash, A. (2011). Being a teacher in contexts of change: Education reform and the repositioning of teachers' work in India. *Contemporary Education Dialogue*, *8*(1), 5–31.

Sriprakash, A., & Mukhopadhyay, R. (2015). Reflexivity and the politics of knowledge: Researchers as 'brokers' and 'translators' of educational development. *Comparative Education*, *51*(2), 231–246.

Srivastava, P. (2006). Reconciling multiple researcher positionalities and languages in international research. *Research in Comparative and International Education*, *1*(3), 210–222.

Srivastava, P. (2008a). School choice in India: Disadvantaged groups and low-fee private schools. In M. Forsey, S. Davies, & G. Walford (Eds.), *The globalisation of school choice?* (pp. 185–208). Symposium Books Ltd.

Srivastava, P. (2008b). The shadow institutional framework: Towards a new institutional understanding of an emerging private school sector in India. *Research Papers in Education*, *23*(4), 451–475.

Stein, M. K., Grover, B. W., & Henningsen, M. (1996). Building student capacity for mathematical thinking and reasoning: An analysis of mathematical tasks used in reform classrooms. *American Educational Research Journal*, *33*(2), 455–488.

Stein, M. K., & Kim, G. (2009). The role of mathematics curriculum materials in large-scale urban reform. In J. T. Remillard, B. A. Herbel-Eisenmann, & G. M. Lloyd (Eds.), *Mathematics teachers at work: Connecting curriculum materials and classroom instruction* (pp. 37–55). Routledge.

Stipek, D. J., Givvin, K. B., Salmon, J. M., & MacGyvers, V. L. (2001). Teachers' beliefs and practices related to mathematics instruction. *Teaching and Teacher Education*, *17*(2), 213–226. https://doi.org/10.1016/S0742-051X(00)00052-4

Stocker, D. (2017). *Maththatmatters: A teacher resource linking math and social justice*. Canadian Centre for Policy Alternatives.

Stoffels, N. T. (2005). 'Sir, on what page is the answer?' Exploring teacher decision-making during complex curriculum change, with specific reference to the use of learner support material. *International Journal of Educational Development*, *25*(5), 531–546.

Subrahmaniam, V. (2005, April 21). Making text-books a joy to read. *The Hindu*. Retrieved from https://www.thehindu.com/todays-paper/tp-national/making-text-books-a-joy-to-read/article27351223.ece

Subramaniam, C. (2016). Multiple Dilemmas of Textbook Development and Use. In D. Nawani (Ed.), *Teaching-Learning Resources for School Education* (pp. 129–149). SAGE Publications India.

Subramanian, J. (2015). One mathematics for all: Can it be realized in a multicultural, multilingual country? *Intercultural Education*, *26*(4), 266–277. https://doi.org/10.1080/14675986.2015.1072303

Subramanian, J. (2017). Beyond poverty and development: Caste dynamics and access to mathematics education in India. In A. Chronaki (Ed.), *Mathematics Education and Life at Times of Crisis* (pp. 924–935). Volos, Greece.

Subramanian, V. (2019). Parallel partnerships: Teach for India and new institutional regimes in municipal schools in New Delhi. *International Studies in Sociology of Education*, *0*(0), 1–20. https://doi.org/10.1080/09620214.2019.1668288

Subramanian, V. K. (2018). From government to governance: Teach for India and new networks of reform in school education. *Contemporary Education Dialogue*, *15*(1), 21–50.

Sullivan, P., Tobias, S., & McDonough, A. (2006). Perhaps the Decision of Some Students not to Engage in Learning Mathematics in School is Deliberate. *Educational Studies in Mathematics*, *62*(1), 81–99. https://doi.org/10.1007/s10649-006-1348-8

Swartz, S. (2011). 'Going deep' and 'giving back': Strategies for exceeding ethical expectations when researching amongst vulnerable youth. *Qualitative Research*, *11*(1), 47–68.

Syeed, E. (2018). Conflict between covers: Confronting official curriculum in Indian textbooks. *Curriculum Inquiry*, *48*(5), 540–559. https://doi.org/10.1080/03626784.2018.1546099

Sztajn, P. (2003). Adapting Reform Ideas in Different Mathematics Classrooms: Beliefs Beyond Mathematics. *Journal of Mathematics Teacher Education*, *6*(1), 53–75. https://doi.org/10.1023/A:1022171531285

Takker, S. (2011). Reformed Curriculum Framework: Insights from Teachers' Perspectives. *Journal of Mathematics Education at Teachers College*, *2*(1). Retrieved from http://journal.tc-library.org/ojs/index.php/matheducation/article/view/637

Takker, S. (2017). Challenges in Dealing with Social Justice Concerns in Mathematics Classrooms. In A. Chronaki (Ed.), *Mathematics Education and Life at Times of Crisis* (pp. 936–945). Volos, Greece.

Takker, S., & Subramaniam, K. (2018). Teacher Knowledge and Learning "In-situ": A Case Study of the Long Division Algorithm. *Australian Journal of Teacher Education*, *43*(3), 1–20.

Tan, K. J., Ismail, Z., & Abidin, M. (2018). A comparative analysis on cognitive domain for the Malaysian primary four textbook series. *EURASIA Journal of Mathematics, Science and Technology Education*, *14*(4), 1273–1286.

Tarr, J. E., McNaught, M. D., Grouws, D. A., Weiss, I., Heck, D., Chval, K., & Zeibarth, S. (2012). The development of multiple measures of curriculum implementation in secondary mathematics classrooms: Insights from a three-year curriculum evaluation study. *Approaches to Studying the Enacted Curriculum*, 89–115.

Teacher test results show abysmal pass percentage: Sibal. (2012, April 27). *Business Standard India*. Retrieved from https://www.business-standard.com/article/pti-stories/teacher-test-results-show-abysmal-pass-percentage-sibal-112042700413_1.html

Thompson, A. G. (1984). The relationship of teachers' conceptions of mathematics and mathematics teaching to instructional practice. *Educational Studies in Mathematics*, *15*(2), 105–127. https://doi.org/10.1007/BF00305892

Thompson, D. R., & Usiskin, Z. (Eds.). (2014). *Enacted Mathematics Curriculum: A Conceptual Framework and Research Needs*. IAP.

Tooley, J., Dixon, P., & Gomathi, S. V. (2007). Private Schools and the Millennium Development Goal of Universal Primary Education: A Census and Comparative Survey in Hyderabad, India. *Oxford Review of Education*, *33*(5), 539–560.

Tooley, J., Dixon, P., & Gomathi, S. V. (2010). A rejoinder to Sarangapani and Winch. *Oxford Review of Education*, *36*(4), 517–520. https://doi.org/10.1080/03054985.2010.509169

Tripathi, P. (2006). Review: Mathematics Text books. *Contemporary Education Dialogue*, *4*(1), 142–151.

Trouche, L., Gitirana, V., Miyakawa, T., Pepin, B., & Wang, C. (2019). Studying mathematics teachers interactions with curriculum materials through different lenses: Towards a deeper understanding of the processes at stake. *International Journal of Educational Research*, *93*, 53–67.

U-DISE. (2016). *Elementary Education in India: Where do we stand?* [State Report Cards 2015-16]. Retrieved from National University of Educational Planning and Administration website: http://dise.in/Downloads/Elementary-STRC-2015-16/Elementary-State_Report_Cards_2015-16.pdf

UNESCO. (2014). *EFA Global Monitoring Report. Teaching and learning: Achieving quality for all*. Paris, France: United Nations Educational, Scientific and Cultural Organization.

Subitha, V. G. (2018). Re-conceptualizing teachers' continuous professional development within a new paradigm of change in the Indian context: An analysis of literature and policy documents. *Professional Development in Education*, *44*(1), 76–91. https://doi.org/10.1080/19415257.2017.1299029

Valero, P., & Zevenbergen, R. (2004). Introduction: Setting the scene of this book. In P. Valero & R. Zevenbergen (Eds.), *Researching the socio-political dimensions of mathematics education: Issues of power in theory and methodology* (pp. 1–4). Kluwer Academic Publishers.

Valero, Paola, & Vithal, R. (1999). Research Methods of the "North" revisited from the "South." *Perspectives in Education*, *18*(2), 5–12.

Valverde, G. A., Bianchi, L. J., Wolfe, R. G., Schmidt, W. H., & Houang, R. T. (2002). *According to the Book*. Dordrecht: Springer Netherlands.

Van den Heuvel-Panhuizen, M. (2000). Mathematics education in the Netherlands: A guided tour. *Freudenthal Institute CD-Rom for ICME9*, 1–32.

Van Den Heuvel-Panhuizen, M. (2003). The didactical use of models in realistic mathematics education: An example from a longitudinal trajectory on percentage. *Educational Studies in Mathematics*, *54*(1), 9–35.

Van Steenbrugge, H., Larsson, M., Insulander, E., & Ryve, A. (2018). Curriculum support for teachers' negotiation of meaning: A collective perspective. In L. Fan, L. Trouche, C. Qi, S. Rezat, & J. Visnovska (Eds.), *Research on Mathematics Textbooks and Teachers' Resources: Advances and Issues* (pp. 167–191). Springer.

Varma, P. (2011). *Being Indian: Inside the real India*. Random House.

Vasavi, A. R. (2015). Culture and life of government elementary schools. *Economic and Political Weekly*, *50*(33), 36–50.

Verschaffel, L. (2009). *Words and worlds: Modelling verbal descriptions of situations*. Sense Publishers.

Verschaffel, L., Greer, B., & De Corte, E. (2000). *Making sense of word problems*. Swets & Zeitlinger Lisse.

Vijaysimha, I. (2013). 'We are Textbook Badnekais!': A Bernsteinian Analysis of Textbook Culture in Science Classrooms. *Contemporary Education Dialogue*, *10*(1), 67–97. https://doi.org/10.1177/0973184912465161

Visnovska, J., & Cobb, P. (2013). Classroom video in teacher professional development program: Community documentational genesis perspective. *ZDM*, *45*(7), 1017–1029. https://doi.org/10.1007/s11858-013-0523-5

Visweswaran, K., Witzel, M., Manjrekar, N., Bhog, D., & Chakravarti, U. (2009). The Hindutva View of History: Rewriting Textbooks in India and the United States. *Georgetown Journal of International Affairs*, *10*(1), 101–112.

Vithal, R. (1998). Data and disruptions: The politics of doing mathematics education research in South Africa. *Proceedings of the Sixth Annual Meeting of the Southern African Association for Research in Mathematics and Science Education*, 475–481.

Vithal, Renuka, & Skovsmose, O. (1997). The end of innocence: A critique of'ethnomathematics'. *Educational Studies in Mathematics*, *34*(2), 131–157.

Wadhwa, T. (2018). Heterogeneity and Dynamism in Indian Classrooms. In V. Kapur & S. Ghose (Eds.), *Dynamic Learning Spaces in Education* (pp. 301–317). https://doi.org/10.1007/978-981-10-8521-5_17

Wagner, D. (2012). Opening mathematics texts: Resisting the seduction. *Educational Studies in Mathematics*, *80*(1), 153–169. https://doi.org/10.1007/s10649-011-9372-8

Wang, C. (2018). Mathematics Teachers' Expertise in Resources Work and Its Development in Collectives: A French and a Chinese Cases. In L. Fan, L. Trouche, C. Qi, S. Rezat,

& J. Visnovska (Eds.), *Research on Mathematics Textbooks and Teachers' Resources: Advances and Issues* (pp. 193–213). Springer.

Wang, T.-L., & Yang, D.-C. (2016). A Comparative Study of Geometry in Elementary School Mathematics Textbooks from Five Countries. *European Journal of STEM Education*, *1*(3). Retrieved from https://eric.ed.gov/?id=EJ1167500

Wartofsky, M. W. (1973). *Models*. Dordrecht: D. Reidel Publishing Company.

Watson, A., & Ohtani, M. (Eds.). (2015). *Task design in mathematics education: An ICMI Study 22*. Springer.

Watson, A., & Thompson, D. R. (2015). Design issues related to text-based tasks. In A. Watson & D. R. Thompson (Eds.), *Task design in mathematics education: An ICMI Study 22* (pp. 143–190). Springer.

Webb, N. M., Franke, M. L., Ing, M., Wong, J., Fernandez, C. H., Shin, N., & Turrou, A. C. (2014). Engaging with others' mathematical ideas: Interrelationships among student participation, teachers' instructional practices, and learning. *International Journal of Educational Research*, *63*, 79–93. https://doi.org/10.1016/j.ijer.2013.02.001

Wenger, E. (1998). *Communities of practice: Learning, meaning, and identity*. Cambridge university press.

Westaway, L., & Graven, M. (2019). Exploring grade 3 teachers' resistance to 'take up' progressive mathematics teaching roles. *Mathematics Education Research Journal*, *31*(1), 27–46. https://doi.org/10.1007/s13394-018-0237-7

Wheeler, D. (1982). Mathematization matters. *For the Learning of Mathematics*, *3*(1), 45–47.

Widjaja, W. (2011). Towards mathematical literacy in the 21st century: Perspectives from Indonesia. *Southeast Asian Mathematics Education Journal*, *1*(1), 75–84.

Wijaya, A., Heuvel-Panhuizen, M. van den, & Doorman, M. (2015). Opportunity-to-learn context-based tasks provided by mathematics textbooks. *Educational Studies in Mathematics*, *89*(1), 41–65. https://doi.org/10.1007/s10649-015-9595-1

Winiecke, T. J. (2015). *Problems Faced by Reform Oriented Novice Mathematics Teachers Utilizing a Traditional Curriculum*.

Winthrop, R., Anderson, K., & Cruzalegui, I. (2015). A review of policy debates around learning in the post-2015 education and development agenda. *International Journal of Educational Development*, *40*, 297–307.

Yackel, E., & Cobb, P. (1996). Sociomathematical Norms, Argumentation, and Autonomy in Mathematics. *Journal for Research in Mathematics Education*, *27*(4), 458–477. https://doi.org/10.2307/749877

Yeo, J. B. W. (2017). Development of a Framework to Characterise the Openness of Mathematical Tasks. *International Journal of Science and Mathematics Education*, *15*(1), 175–191. https://doi.org/10.1007/s10763-015-9675-9

Yin, R. K. (2017). *Case study research and applications: Design and methods*. Sage publications.

Ying, C. C., Kathryn, T., & Young, I. (2007). Are 'Textbooks' a Barrier for Teacher Autonomy? A Case Study from a Hong Kong Primary School. *Education and Society*, *25*(2), 87–102.

Appendix A

List of tasks with description in Chapter 4, Book 5: Fractions

5.4.1: *Our Flag*: Dividing a flag into three equal parts
5.4.2: *Find Out*: making flags and dividing them into three to five equal parts and colouring them; making tangrams
5.4.3: *Magic Top*: Dividing a circle into 8 parts and colouring them (making a top)
5.4.4: *Practice time*: Word problem of dividing a chocolate bar in fractions among children; finding 1/3rd of hats (collections of distinct objects); Dividing a triangle into three equal parts; dividing a rectangle into six different parts (in four different ways)
5.4.5: *Greedy gatekeepers*: Story of Birbal and Akbar and share of slaps: story-based word problem
5.4.6: *Pattern in parts*: dividing squares into equal parts and finding fractions of the parts which are coloured (also finding equivalent fractions)
5.4.7: *Ramu's vegetable Field*: Word problem related to the vegetable produced in a field (finding fractions)
5.4.8: *Game: Who colours first?* : Dividing a circle into 12 parts and colouring them based on the token drawn (fractions written in the token)
5.4.9: *The Card puzzle*: Dividing a square into different parts
5.4.10: *Guess and check*: Dividing rectangles and hexagons into parts
5.4.11: *Coloured parts*: Representation of equivalent fractions in circles
5.4.12: *Cutting the halwa*: Word problem about dividing a whole into equivalent fractions
5.4.13: *parts of the strip*: Modelling equivalent fractions in a fraction strip
5.4.14: *Patterns*: Modelling equivalent fractions in a square
5.4.15: *Puzzle: is it equal*?: Equivalent fractions in a word problem
5.4.16: *From a part to the whole*: Drawing parts of a whole in contextual objects
5.4.17: *Rupees and paise*: fractions in money
5.4.18: *An old woman's will*: Long story word problem in fractions
5.4.19: *Arun's timetable*: Dividing a day into fractions (hours of the day) and representing in a fraction strip within a word problem
5.4.20: *School magazine*: Short word problem: Converting a fraction of a day in number of hours and representing on a fraction strip
5.4.21: *Sleeping beauty*: Fractions within the number of hours in a day, its relation to days and years
5.4.22: *Answer*: *Card puzzle (page 61):* The answer to a previous puzzle
5.4.23: *Keerti's shopping list*: multiplication in fractions presented in a word problem
5.4.24: *Practice time: 1) Raheem's journey:* Addition in fractions in word problem; 2) *What coins?*: Money in fractions in word problem; 3) *At the railway station*: addition in fractions in word problem

Appendix B

B.1 Voice: task specification

Task specification	
Specified eliciting components	Tasks where adequate information to address (some or all) eliciting components is provided within the task. Thus, admitting some solution strategy requiring only the information already provided within the task.
Generation eliciting components	Tasks where adequate information to address (some or all) eliciting components is not provided within the task. Thus, only admitting solution strategies which require students to source supplementary information on their own.

B.2 Voice: type of task questions

State/Answer	Eliciting questions (specified or generation) seeking response from students in written or oral work form. The response can be obtained using any mathematical skill or procedure (by measuring, reading the time, using multiplication). The answer could be in the form of written numbers, oral, by drawing, making a line, marking the correct answer etc.
Explain	Eliciting questions (specified or generation) seeking an explanation or justification of the mathematical thinking or process underlying the solution of the task.
Think	Eliciting questions asking students to think about the answer or process in the task.
Discuss	Eliciting sub-tasks asking students to discuss (among peers or with the teacher) the answer or process in the task.
Expression	Eliciting questions (specified or generation) invites students to express their interests, thoughts or experiences. This is different from the explanation task which is specifically asking for justification or explanation for the mathematical process; whereas these are mostly to engage within students thinking, feeling, experiences from out-of-school contexts (which are being integrated into the task).
Estimation	Eliciting questions asking students to guess the answer or process in the task.
Check	Eliciting questions asking students to verify or check the answer or process in the task.
Construction	Eliciting questions, where students engage with a task in a format other than answering questions, thinking, expressing experiences or justifying their product or process (in the textbook or notebook). These require students to either use or (and) create additional materials and artefacts, play games, or conduct experiments.

B.3 Context: choice, objects and social justice

Students' everyday life context	Everyday objects related directly to students' lives being called upon and its mathematical properties being discussed or explored. These include using own body, information from people or surrounding objects.
Contextual stories	These are realistic contexts pre-determined by the authors as contexts that students might see around their environments. These tasks often include information about real life phenomenon or other real-life events (students may or may not know this). These also include imaginary contexts (folk stories, historical characters, animals celebrating birthdays).
Contextual objects	*Cosmetic- illustrated* (CI): Illustrations used to support the tasks have no relevance to the task but are only used to enrich the context of the task by giving a visual representation or photograph. *Substantive-illustrated* (SI)*:* Illustrations or photographs accompanying tasks which are fundamental to the tasks and needed for its interpretation and solution. *Substantive- (semi/) schematic* (SS): Illustrations used in the text with some level of schematised representation of the mathematical object being discussed. Even if some aspect of the illustration is more 'mathematised', then it is coded as such.
Social Issues	Tasks which might have some significance in terms of social justice, and might be interpreted (even implicitly) as critical social issues.

B.4 Support: teacher notes, prompts and structure

Teachers notes	At the bottom of some of the pages, there is information provided to help teachers make sense of the tasks. These are either generalised notes (G) or specific to the content being discussed (S).
Prompts	*Fact or information:* Non-eliciting component intended to provide information/fact about the mathematical object or procedure. (Information about the context of the tasks are not coded here) *Repetition:* If the task contains repeated eliciting components where the same mathematical skill or process is to be used, then they are coded as repeated task. Or if there are parts within the tasks (or across) where the students are able to repeat a similar task again. Tables to be filled by listing answers (even if generation tasks) are coded as repetition. *solution/answer:* Non-eliciting component intended to provide prompting the solution, answers or some prompts to the solving eliciting questions are coded as 'prompts/answer'.
Structure	Micro-structures within each chapter or across chapters, providing an overarching narrative to the textbook.

Appendix C

C.1 Content of textbook: Book 4

	Chapter name	Implicit mathematical topic	# of pages
1	Building with bricks	*Thematic*: Geometrical patterns based on symmetry	12
2	Long and short	Measurement of length	10
3	Bhopal trip	*Thematic*: Mixed concepts: four operations, measurement, number estimation	12
4	Tick tick tick	Time	17
5	The way the world looks	Space	8
6	The junk seller	*Thematic chapter:* multiplication, division, loan	9
7	Jugs and mugs	Measurement of Volume	12
8	Carts and wheels	Shapes & Spatial Understanding	13
9	Halves and quarters	Fractions	13
10	Play with patterns	Patterns: geometrical and numerical	13
11	Tables and shares	Multiplication	13
12	How heavy? How light?	Measurement of Weight	16
13	Fields and Fences	Perimeter	13
14	Smart charts	Data handling	8

C.2 Content of textbook: Book 5

	Chapter name	Implicit mathematical topic	# of pages
1	The fish tale	*Thematic chapter*	15
2	Shapes and Angles	Shapes & Spatial Understanding	18
3	How many squares?	Area and perimeter	16
4	Parts and wholes	Fractional numbers	21
5	Does it look the same?	Symmetry of shapes	16
6	Be my multiple, I'll be your factor	Factors and multiples	12
7	Can you see the pattern?	Patterns	13
8	Mapping your way	Maps	14
9	Boxes and Sketches	Nets	8
10	Tenths and hundredths	Decimals	12
11	Area and its boundary	Measurement of area	13
12	Smart charts	Data handling	11
13	Ways to multiply and divide	Multiplication and division	17
14	How big? How heavy?	Measurement and four operations	14

Appendix D

D.1 Interview one: Teacher questions for the semi-structured interview

Interview questions asked in the first semi-structured interview to elicit views on the feature of contextual tasks in the textbook

What are the most important learning goals for mathematics at this grade level, name four goals? Also, for the readiness of grades 5 or 6 (upper primary) what mathematics is important? *What are the features of the books?* *Probe 1: There are some parts in the books which are linked to the child's life, comment.* Are they needed for mathematics learning? Why did the authors include these in the books*?* Comment. *Probe 2: Other teachers I have spoken to mention that different activities are presented in which students seem to be engaging with mathematics in different formats. Comment.* Are they needed for mathematics learning? Why did the authors include these in the books*?* *Probe 3: Other teachers I have spoken to mention that text has deemphasised both memorisation and practice questions. Comment.* Are they needed for mathematics learning? Why did the authors include these in the books*?*

D.2 Interview two: Teacher questions for the semi-structured interview

1. What all chapters did you teach this term? List them and describe what you did in them. How did you find them? So that is what, if I ask you about the chapters that which chapter could be easily done from the book and which chapter was difficult or faced difficulty while teaching it. So, if you can tell me chapter wise, it will be good.
2. Rank the chapters according to what you thought was the best.

Chapter 1
Chapter 2
Chapter 3
Chapter 4
Chapter 5
Chapter 6
Chapter 7

a) Why do you think this was the best?
b) Any suggestions to improve it?
c) In case she did not use the book much, what did she use?
d) If you had to write that chapter, how would you have written it?
e) If you had to explain how to teach that chapter, how would you do it?
f) What kind of additional support do you think you would need? Trainings, guidebooks, other books, TLMs, infrastructure

Appendix E

E.1 Teachers' rankings of textbook chapters: Book 4

Ranking	Afreen	Kanchan	Deepali	Neetu	Mahesh	Sanchita	Average
Chapter 4: Tick tick tick	1	2	1	2	3	1	1.67
Chapter 7: Jugs and mugs	2	1	NA*	NA	NA	2.	1.67
Chapter 2: Long and short	5	5	2	1	2	5	3.33
Chapter 6: The junk seller	3	4	NA	NA	NA	3	3.33
Chapter 3: A trip to Bhopal	4	7	3	NA	1	4	3.80
Chapter 1: Building with Bricks	5	3	4	NA	4	7	4.60
Chapter 5: The way the world looks	NA	6	4	NA	5	6	5.25

*Not applicable as the teacher had not attempted the chapter

E.2 Teachers' rankings of textbook chapters: Book 5

Ranking	Ganesh	Mohini	Sonali	Bhumika	Average
Chapter 6: Be my multiple, I'll be your factor	1	NA	1	3	1.67
Chapter 4: Parts and wholes	4	1	2	1	2.00
Chapter 2: Shapes and Angles	NA	1	3	2	2.00
Chapter 7: Can you see the pattern?	2	NA	NA	4	3.00
Chapter 3: How many squares	3	2	4	5	3.50
Chapter 5: Does it look the same	NA	NA	5	5	5.00
Chapter 1: The fish tale	NA	4	5	7	5.33

Appendix F

Request letter for permission to conduct fieldwork in government schools

UNIVERSITY OF CAMBRIDGE
Faculty of Education

To:
To: Director of Education, North Delhi Municipal Corporation
Education Department, Civic Centre
15th floor, S.R. Mukherjee Marg
New Delhi 110002

Subject: Request for fieldwork permission for Ms Meghna Nag Chowdhuri, University of Cambridge

August 16, 2016

Dear Director,

This is to certify that Ms. Meghna Nag Chowdhuri is a *bona fide* PhD student at the Faculty of Education, University of Cambridge, United Kingdom, and I am her primary supervisor. She enrolled in October 2015 and will continue here as a student until October 2018. The title of her project is "*Innovative mathematics teaching using NCERT textbooks in primary schools*".

Please see the attached detailed description of the project. We have taken great care to make sure the research is ethical and feasible. We would be most grateful if you would allow Ms. Nag Chowdhuri to conduct fieldwork in a maximum of four MCD schools in order to complete her PhD project. This fieldwork is essential to her project, and will provide valuable data for researchers to understand in detail how the NCERT textbooks are being used innovatively by primary school teachers.

Please do not hesitate to contact me if you have any questions about the project or about Ms. Nag Chowdhuri.

Thank you in advance for extending your help to her.

Sincerely,

Professor Kenneth Ruthven
Professor of Education

Dr. Nidhi Singal
Senior Lecturer in Education

UNIVERSITY OF CAMBRIDGE FACULTY OF EDUCATION

Enclosure (1): Detailed Project Description

Head of Faculty: Professor Geoff Hayward Secretary to the Faculty: Kate Allen
Faculty of Education, University of Cambridge, 184 Hills Road, Cambridge CB2 8PQ, UK
Tel: +44 (0) 767600 Fax: +44 (0) 767602 Email: reception@educ.cam.ac.uk www.educ.cam.ac.uk

Detailed Project Description

Innovative mathematics teaching using NCERT textbooks in primary schools
Researcher: Ms Meghna Nag Chowdhuri; PhD student at University of Cambridge

The proposed PhD research focuses on mathematics education in primary schools in Delhi by exploring teachers' innovative use of textbooks. Mathematics is a core subject that is taught all through the years of compulsory schooling to children everywhere in India, yet it remains one of the subjects feared the most. To make mathematics teaching more child-centred and more relevant for children, NCERT produced innovative textbooks in 2010, based on NCF 2005. This leads to an important research questions:

> *How are teachers attempting to use innovative NCERT textbooks in their classrooms?*
> *What are the successes and difficulties they encounter while using these innovative textbooks?*

Most of the literature that looks at teaching practices looks for 'typical' teaching across urban and rural settings, often concluding by proposing the need for 'improvement'. Instead by looking at *good cases* within the system my study can help in not focusing on what is lacking, but bring out important learnings on the possibilities within the government school system. Thus, to answer these questions, this study will focus on 2-4 innovative school teachers who are attempting to use these textbooks and believe in child-friendly pedagogies. The teachers have been identified based on interviews over the last year (as a part of an MPhil study I conducted), and now I plan to engage more deeply into their efforts.

Findings from the study will make the following contributions that would directly benefit the teachers. I plan to compile these findings into a report for the DOE so that they benefit other teachers who can find information about usable teaching methods.

1. *Highlighting innovative practices:* Firstly, it is important to give voice to the work of good teachers who are working within the government system, so that we not only get insight into teachers work but also get an understanding of feasible teaching practices that can help other teachers.

2. *Mathematics as a fundamental subject:* Mathematics being a basic subject that all children need access to, it is important to delve into the possibilities of how teaching can be made more relevant and effective for the children in government schools.

3. *Policy and curriculum development:* This study would help understand needs of the schools and teachers better which will help in developing more relevant curriculum materials, which are based on the context specific needs.

4. *Collaboration with teachers*: The University of Cambridge has been involved in cutting edge work in schools and teacher training for mathematics education and through this thesis I hope to be able to collaborate with respective school teachers to provide them insights and information in improving their work.

I plan to conduct case studies by collecting data using multiple methods such as semi-structured classroom observations and interviews of the teachers, students, and other staff members. I will ensure that I do not interrupt any school work including classes, exams, meetings etc, and will only schedule my data collection after seeking requisite permission from the school principal and under the consent of the respective school teacher. The field work would be conducted from October 2016 to July 2017 and cover a sample of a maximum of four DOE Sarvodaya schools. It is hoped that the DOE will grant me permission to carry out my work which I believe will be greatly beneficial to the school teachers and help them better their mathematics teaching practices.

Appendix G

Letter of permission granted by EDMC (East Delhi Municipal Corporation)

EAST DELHI MUNICIPAL CORPORATION
EDUCATION DEPARTMENT: H.Q.
419-UDYOG SADAN, PATPARGANJ
INDUSTRIAL AREA, DELHI-92

No.: D/ADE/Project/HQ/EDMC/2017/57 Dated:21.04.2017

To,
Professor Kenneth Ruthven
Professor Education

Sub:- Permission for Field Work for Ms. Meghna Nag Chowdhuri, University of Cambridge.

Sir,

This has reference to your letter on the subject cited above. In this regard I am directed to convey you that Director (Edn.) has accorded permission to Ms. Meghna Nag Chowdhuri, University of Cambridge for her project titled **"Innovative mathmetics teaching using NCERT textbooks in primary schools"** w.e.f 21.04.2017 to 31.03.2018 in following Schools of EDMC:

[redacted]

The Permission has been accorded with the under mentioned conditions:-

1. There should not be any disturbance in the school administration, discipline, routine, activities and study work of the children in schools.
2. Ms. Meghna Nag Chowdhuri will have to comply with the directions of Principal of the Schools.
3. After the study the finding should be discussed and shared with authorities of Education Department of EDMC for appropriate measures.
4. Permission granted can be withdrawn at any time without assigning any reason there to.

All concerned are requested to extend their corportation for conducting the study.

[redacted]
ADE/Project

Distribution :-

1. Principal, [redacted]
2. Principal, [redacted]
3. Principal, [redacted]
4. Principal, [redacted]

Through

ADE/Shah.South

Copy to :-

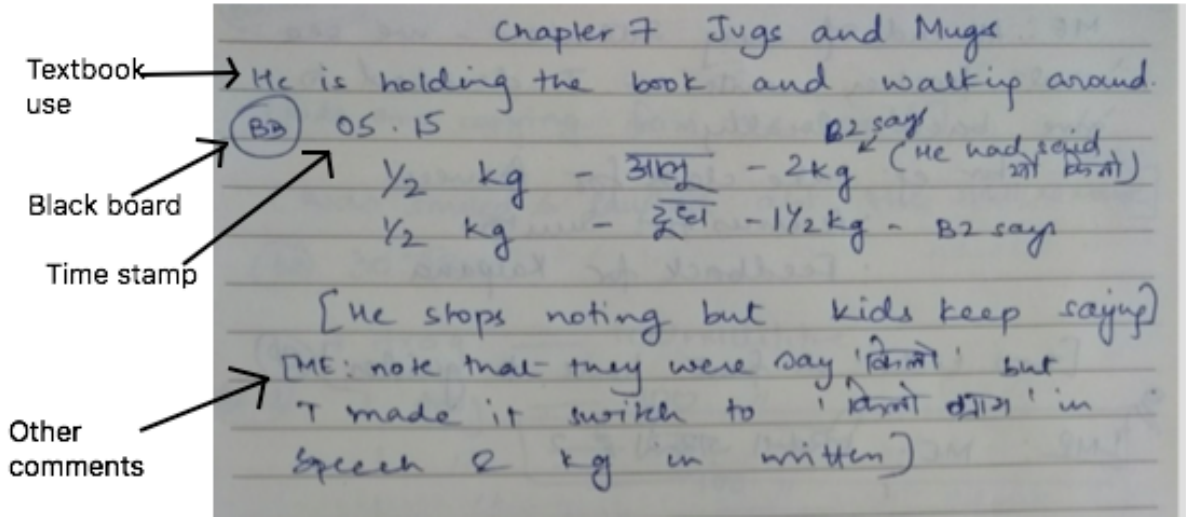
1. ADE/Shah.South
2. Ms. Meghna Nag Chowdhuri

Copy for kind information to:-

1. Director(Edn.)
2. Office Copy

Appendix H

Classroom observation fieldnotes



Excerpt from the classroom observation notes, capturing teachers' work with the textbook, blackboard work, significant student response and other comments about the lesson.

Appendix I

Sample of textbook analysis coding

		Task specification		Task solution									Support				Context					
		SP	GEN	State/Answer*	Explain	Expression	Estimation	Check	Construction	Think	Discuss	open	Teachers notes	Repetition	Fact/Information	Prompt/soltuon/answer	Context/no context	Larger Contextual theme	students lives	Story	Objects (0,1,2,3)	Social justice
4.1.1	Jagriti school mein eeton ka pattern	1	0	1	0	1	0	0	0	0	0	Y	0	0	0	0	Y		1	1	1	maybe
4.1.2	Eeth ka chitra kaise banaye	1	0	1	0	0	0	0	0	0	0	Y	0	0	1	0	YN		0	0	1,2	0
4.1.3	yah deewar gir nahi sakti	1	1	1	0	0	0	0	0	1	0	N	0	0	0	1	Y		1	0	1	0
4.1.4	deewar ke alag alag pattern	1	0	1	0	0	0	0	0	0	0	Y	0	0	0	0	Y		0	0	1,2	0
4.1.5	jharoke se jhako	1	0	1	0	1	0	0	0	0	0	Y	0	0	1	0	Y		0	0	1,2	0
4.1.6	pata karo/Find out	0	1	1	0	1	0	0	0	0	0	Y	0	0	0	0	Y		1	0	1	0
4.1.7	ek vishesh mehrab	1	1	1	0	1	0	0	0	0	0	Y	0	0	0	0	Y		1	0	1	0
4.1.8	pata karo- eet ka akar	0	1	1	0	1	0	0	0	0	0	Y	0	0	0	0	Y		1	0	NA	0
4.1.9	eete hi eete- bhatti se nikli	1	0	1	0	1	1	0	0	1	1	Y	0	0	1	0	Y	Context	1	0	1	1
4.1.10	pata karo	0	1	1	0	0	1	0	0	0	0	N	0	0	0	0	Y	of Bricks	1	0	1	0
4.1.11	man hi man ganit - bhajan ne eeten khareedi	1	0	1	0	0	1	0	0	0	0	N	0	0	0	0	Y	(no Teachers notes)	0	1	NA	0

Appendix J

Sample of classroom observation analysis coding

M37 | fx | 0

	A	B	C	D	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z
1		DTU			Comments on how they d	Nam	SP	GEN	State	Expla	Expre	Gues	Chec	Cons	Think	Discu	Teach	Repe	Fact/	Prom	Cont	Large	STE	Story
2	Bhumika	S1_T1	O3_A1	5.6.2	Own procedure	Find out	1	0	1	0	0	0	0	0	0	0	1	1	0	0	Y	0	0	0
3	Bhumika	S1_T1	O3_A2	5.6.3	Book procedure, student participation, meta c	Who is mon	1	0	1	0	0	0	0	0	0	0	0	0	0	0	YN	0	0	0
4	Bhumika	S1_T1	O3_A3	5.6.4	Reading exercise/Activity with children partici	Meow game	1	0	1	0	0	0	0	1	0	0	1	0	1	0	YN	0	0	0
5	Bhumika	S1_T1	O4_A1	5.6.6	Book procedure with meta comments and nes	Common mu	1	0	1	0	0	0	0	0	1	0	0	1	1	1	N	0	0	0
6	Bhumika	S1_T1	O4_A2	5.6.10	Own procedure (Multiple representation)	some more	1	1	1	0	0	0	0	0	0	0	1	1	0	1	N	0	0	0
7	Bhumika	S1_T1	O5_A1	5.5.8	Own procedure	One-fourth	1	0	1	0	0	0	0	0	0	0	0	0	0	1	YN	0	0	1
8	Bhumika	S1_T1	O5_A3	5.5.9	repeated task, students attempt them	practice tim	1	0	1	0	0	0	0	0	0	0	0	1	0	0	N	0	0	0
9	Afreen	S1_T2	O3_A1	4.4.2		Practice tim	1	1	1	0	0	1	0	0	0	0	0	1	0	0	YN	0	1	0
10	Kanchan	S1_T3	O3_A1	4.5.1	This has been coded as one sub-task but in the	Gappu's air	1	0	1	1	0	0	0	0	1	1	1	0	0	0	Y	Gappu's	1	1
11	Deepali	S2_T1	O1_A1	4.2.7	Own procedure (Multiple approaches)	Race	1	0	1	0	1	0	0	0	0	0	0	0	1	0	Y	ace sports	0	1
12	Deepali	S2_T1	O1_A1	4.2.7	Own procedure (Multiple approaches)	Race																		
13	Deepali	S2_T1	O2_A7	4.4.2	No method needed - not sure what to say abo	Practice tim	1	1	1	0	0	1	0	0	0	0	0	1	0	0	YN	0	1	0
14	Deepali	S2_T1	O4_A2	4.4.7	Ignored context - no method needed (math fa	Holidays are	1	1	1	0	1	0	0	0	0	0	0	0	1	0	Y		1	1
15	Sonali	S2_T2	O2_A4	5.4.3	Own procedure (how to construct a circle) (do	Magic top	1	0	1	0	0	0	0	1	0	0	0	0	0	0	Y	0	1	0
16	Sonali	S2_T2	O2_A5	5.4.5	Misinterpretaion of the task (stuck)	Practice tim	1	0	1	0	0	0	0	0	0	0	0	0	0	0	Y	0	0	1
17	Sonali	S2_T2	O3_A1	5.4.11		Ramu's vege	1	1	1	0	0	0	0	0	0	0	0	0	0	0	Y	0	0	1
18	Sonali	S2_T2	O3_A3	5.5.2		Make your	1	0	1	0	0	0	0	1	0	0	1	1	1	0	YN	0	0	1
19	Sonali	S2_T2	O3_A4	5.5.6		practice tim	1	0	1	0	0	0	0	0	0	0	0	1	0	1	N	0	0	0
20	Ganesh	S3_T1	O1_A1	5.6.1	Own procedure (same as S1_T1_O3_A1)	The mouse	1	0	1	0	0	0	0	0	0	0	0	0	0	1	Y	0	0	0
21	Ganesh	S3_T1	O1_A4	5.6.6	Own procedure (same as S1_T1_O3_A1)	Common mu	1	0	1	0	0	0	0	0	1	0	0	1	1	1	N	0	0	0
22	Ganesh	S3_T1	O5_A4	No specific - self work (not whole class)																				
23	Mohini	S3_T2	O1_A1	5.2.11		activity	1	0	1	1	0	0	0	1	0	0	0	0	0	0	Y	0	1	0
24	Mohini	S3_T2	O1_A2	5.2.13		shapes and	1	1	1	1	0	1	0	0	0	0	1	0	0	0	Y	0	1	1
25	Mohini	S3_T2	O1_A3	5.2.14	No method needed - not sure what to say abo	angle and ti	1	0	1	0	0	0	0	0	0	0	0	1	0	1	Y	0	0	1
26	Mohini	S3_T2	O1_A7	5.2.18		angles with	0	1	1	0	0	0	0	0	0	0	0	0	0	0	Y	0	1	0
27	Mohini	S3_T2	O2_A1	5.2.4		angle tester	1	1	1	0	0	0	0	1	0	0	0	0	1	0	Y	0	1	0
28	Mohini	S3_T2	O4_A1	5.3.6/5.3.7	Misinterpretaion of the task (stuck)	How many s	1	0	1	0	0	0	0	0	0	0	1	1	0	1	YN	0	0	0
29	Mohini	S3_T2	O4_A2	5.3.8	Misinterpretaion of the task (stuck)	Complete th	1	1	1	1	0	0	0	0	1	1	0	0	0	1	YN	0	1	0
30	Mohini	S3_T2	O4_A3	5.3.9	Misinterpretaion of the task (stuck)	Practice tim	1	0	1	0	0	0	0	0	0	0	1	1	0	1	N	0	0	0
31	Mohini	S3_T2	O5_A1	5.4.4		Practice tim	1	0	1	0	0	0	0	0	0	0	0	0	0	0	Y	0	0	1
32	Mohini	S3_T2	O5_A2	5.4.5		Practice tim	1	0	1	0	0	0	0	0	0	0	0	0	0	0	Y	0	0	1
33	Mohini	S3_T2	O5_A3	5.4.6		Practice tim	1	0	1	1	0	0	0	0	0	0	0	0	0	0	YN	0	0	0
34	Mohini	S3_T2	O5_A4	5.4.7		Practice tim	1	0	1	0	0	0	0	0	0	0	0	1	0	0	YN	0	0	0
35	Mohini	S3_T2	O5_A5	5.4.9		Greedy gate	1	0	1	0	0	0	0	0	0	0	0	0	0	0	Y	0	0	0
36	Mahesh	S4_T1	O1_A2	4.2.7		Race	1	0	1	0	1	0	0	0	0	0	0	0	1	1	Y	-race sports	0	1
37	Mahesh	S4_T1	O1_A3	4.2.8	Own procedure (non-formulaic, unlike S3_T3_	Long jump	1	1	1	0	0	1	0	1	0	0	0	0	1	0	Y		1	1
38	Mahesh	S4_T1	O2_A1	4.3.5	Own procedure (non-formulaic,student partici	Lunch time	1	0	1	0	0	0	0	0	0	0	1	0	0	1	Y		0	1
39	Mahesh	S4_T1	O2_A4	4.3.5		Lunch time																		
40	Mahesh	S4_T1	O3_A1	4.4.3	home work	Find out	1	1	1	0	0	1	1	1	0	0	0	1	0	0	YN	0	1	0
41	Mahesh	S4_T1	O3_A4	4.4.4		Activity time	1	1	1	0	0	0	0	1	0	0	1	1	0	0	YN	0	1	0
42	Mahesh	S4_T1	O4_A1	4.5.1		Gappu's air	1	0	1	1	0	0	0	0	1	1	1	0	0	0	Y	Gappu's	1	1
43	Sanchita	S4_T2	O1_A3	4.2.7	Own procedure (formulaic)	Race	1	0	1	0	1	0	0	0	0	0	0	0	1	0	Y	-race sports	0	1
44	Sanchita	S4_T2	O2_A1	4.4.2	No method needed - not sure what to say abo	Practice tim	1	1	1	0	0	1	0	0	0	0	0	1	0	0	YN	0	1	0

Stats | All list | DTU list | ATU list | Insertion list | Context coding | Bhumika | Afreen | Kanchan | Deepali | Sonali | Ganesh | Mohini | Neetu | Mahesh | Sanchita | +

Appendix K

Sample of attempted analysis of teacher discourse (counting occurrence of different type of teacher talk)