Two primary school teachers' pedagogical design capacity of using mathematics textbooks in Delhi, India

Meghna Nag Chowdhuri

University of Cambridge, Faculty of Education, Cambridge, UK; nc.meghna@gmail.com

India introduced a new National Curriculum framework in 2005, which included reformed goals for primary school mathematics in an attempt to make them more inclusive and student-centred. One of the efforts towards operationalizing the framework was to create new primary mathematics textbooks. In a context where textbooks are seen as the basis of all curricular activity – from sequencing, to teaching, to examination, it becomes important to understand how such reform-based textbooks are used by teachers. Drawing from a multiple case study in the context of government-run primary schools in Delhi, this paper reports that teachers seem to primarily reject these reform-based textbooks. Further it shows that while using the textbook, teachers have varied levels of design capacities to productively interpret the textbook tasks. The findings imply that curriculum and policy makers need to develop materials that teachers are firstly willing to engage with, and also provide space for teachers' design capacity to develop.

Keywords: Mathematics curriculum, primary teacher, pedagogic design capacity

Introduction

India, much like the rest of the world and especially the Global South, is attempting to improve teaching and learning practices in mathematics not just to increase learning outcomes, but also to ensure equity in its processes. In post-colonial India, quality and equity have remained fundamental to its Education system. These ideals are explicitly reflected in the National Curriculum Framework – 2005 (NCF 2005), which forefronts "processes" in mathematical activities as well as connecting mathematics to the lives of children (NCERT, 2005, p. 9). Another important feature of the Indian education system which is recurring in the literature is its 'textbook culture' (Kumar, 2005). The textbook continues to be the only resource in the classroom; and for state-run schools, prescribed and made available to students free. Kumar (2005) even claims that textbooks act as "de facto curriculum" (p. 67), despite an official curriculum framework and syllabus. Thus, it was not surprising that the textbook series (NCERT *Math-Magic*) was chosen as the first (and only) point of intervention to operationalize the visions of NCF 2005. Yet very little is known in India about how the textbook is navigated in classrooms. In this paper, which comes from a larger PhD study, I focus on the following research question:

In what ways do teachers use reform-based textbooks in their mathematics classrooms?

Theoretical framework

Keeping the context in mind, as we explore the Anglophone literature in Mathematics education on the relationship between the teacher and the textbook (or other curricular resources), we see various developments. Different frameworks are used by researchers to make sense of these aspects based on how they conceptualise the teacher-textbook relationship as well as textbook as a resource. In this paper, I use Brown's (2003) framework of "design capacity for enactment" (p. 4), to explore how

teachers in the Indian context use textbooks. Central to Brown's idea is that teachers design textbook use by *offloading-adapting-improvising* based on the degree of responsibility they share with the textbook and their own resources. Thus, while using the textbooks, teachers may place agency primarily on the textbook (*offloading*), or change the activity based on their own needs (*adapting*), or change the course of the work altogether, making it very different from the textbooks (*improvising*) (Brown, 2003). While there is no prescribed hierarchy to their choice of offloading-adapting-modifying (one is not better than the other), these indicate the relevance and priority given to the textbook as a resource in teaching. Furthermore, this use is a function of both textbook *affordance* (textbooks' own attributes) and teachers' *pedagogical design capacity*. The notion of *pedagogical design capacity* – "teacher's capacity to perceive and mobilize existing resources in order to craft instructional episodes" (Brown, 2011, p. 29) – is evaluative in nature signifying teachers' capacity to use the textbook in productive ways. More recently Pepin, et al. (2017) have further described 'teachers' design' as a "deliberate/conscious act" of "creating something new" (p. 801); thus, bringing dimensions of intentionality and genesis to the fore. They further distinguish between 'design' (during planning); and 'design-in-use' (during enactment). This exploratory paper, only focuses on teachers' 'design-in-use', as they mobilise textbooks' affordances and create lessons (without considering teachers' intentions). By doing so, I examine limited yet crucial facets of the notion of teachers' pedagogical design capacity.

Methodology

Sample: The larger study (a part of which is presented in this paper) is a multiple case study of ten teachers in four government-run municipality schools using *Math-Magic* textbooks. Delhi government schools, mandated to use these textbooks, were the site for the study. Importantly, these schools are low resourced both in terms of infrastructural resources, as well as teaching and learning resources. Getting permission to conduct my field work in these under-studied sites was particularly difficult. The ten primary school teachers were thus chosen based on convenience sampling, in schools which allowed me to conduct my study. However, I ensured that all the teachers had more than eight years of experience, including experience of using the textbook from the time of its introduction. Also, I focused on grades 4 and 5 teachers, where these textbooks were being used.

Data collection: Keeping the theoretical framing in mind, I focused on the three parts of the design capacity framework, and collected data on textbook affordances (the textbooks themselves), teachers' textbook use and thinking (through classroom observation and teacher interviews). While collecting *classroom observation data* (which is the data that I am analysing in this paper), I was given permission only to audio-record the classrooms, which was sufficient to capture the textbook use dimensions of teachers' teaching. The audio-recording was supplemented by observation notes, where I noted how the textbook was treated in the classroom (were the teachers reading it before starting the lesson, were they showing the textbook to students, did they provide time for students to read the text etc). In total, for each of ten teachers, I observed 3-4 lessons.

Data analysis: After transcribing and translating the audio recordings, the lessons were categorised into episodes which were defined on the basis of the tasks that teachers chose, so that an equivalent unit of analysis could be used to compare the textbook tasks with the teachers' chosen tasks. A total

of 34 lesson observations from the ten teachers, were categorised into 152 episodes (each episode corresponding to a task from the textbook analysis). These episodes were coded based on Brown's 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) which were completely unrelated to tasks in the textbook. Thus, a notion of 'insertion' was necessary which accounted for such episodes, as done 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) (e.g. 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-inserted use' which closely supported my data.

Overall findings

Teacher acceptance or rejection of the textbook: Figure 1 below shows details of the textbook use of each of the ten teachers. There are two notable results from this analysis. Firstly, we can see that four teachers are using the textbook directly for majority of their teaching, and the remaining six teachers are using their own insertions for more than half of their episodes. This is a clear indication that the textbook is not being used most of the teachers in my sample, who are *rejecting* them.

Direct use of textbook tasks: While analysing the episodes of 'direct textbook use', there were two ways in which teachers used tasks. One was by following each sentence in the book, (often teachers would read the text, or ask students to read it out), thus addressing every aspect of the book as a script. The second way of using which seemed more flexible was to pick and choose tasks (or elements of them) as the teacher felt suitable. These two kinds of approaches to directly using the tasks were especially exemplified by teachers Jagdeesh and Kamala, discussed in the next section.

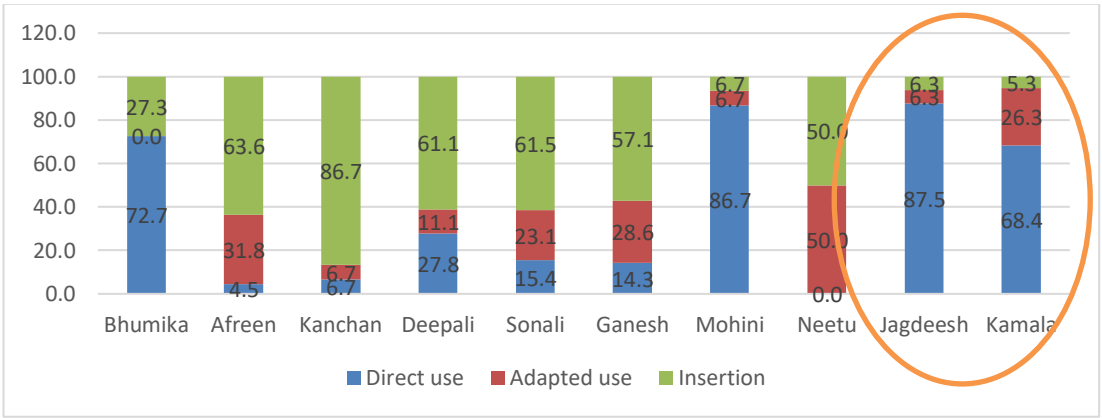


Figure 1: Per cent of episodes observed categorised as direct, adapted or inserted textbook use

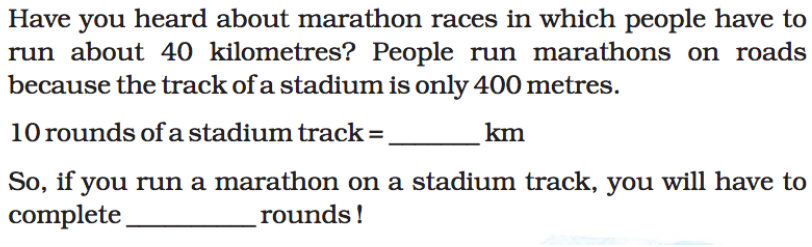
Contrasting cases of teacher design capacity

As discussed in my theoretical framework, the use patterns analysed above do not indicate the evaluative aspect of use; i.e teachers' pedagogical design capacities. Design capacities can be

explored within each of these three types of textbook engagements. For this paper, I look at two frequent direct users and their contrasting interpretations and mobilisations of the textbook affordances; i.e. their design-in-use. Jagdeesh and Kamala, both have eight years of teaching experience and both teach grade 4 in the same school. Jagdeesh tended to follow every task given in the textbook, while Kamala was pickier in terms of what she chose to include in her class. In the following section, I analyse how two focus tasks (Figure 2, 3) were used by Jagdeesh and Kamala; as they *designed* two very different lessons. While Jagdeesh used the textbooks' affordances in productive ways (as afforded by the textbook), Kamala does not do so.

Focus tasks chosen for analysis and its affordances

The task in Figure 2 has two kinds of questions – 'Have you heard about marathon races?' invites students to engage with the context of the problem which follows. Such questions which were posed to students encouraging them to talk about their thinking, life experiences and feelings were coded as *expression tasks*. The following two questions are *specified tasks* (fill the blanks) where students are expected to answer the pre-formulated question. It is crucial to note that the text breaks down (possibly for support) the specified tasks into two stages, first asking students to find distance covered in 10 rounds (laps), and indicate its use to find the number of rounds for the 40 km.


Have you heard about marathon races in which people have to run about 40 kilometres? People run marathons on roads because the track of a stadium is only 400 metres.

10 rounds of a stadium track = _____ km

So, if you run a marathon on a stadium track, you will have to complete _____ rounds!

Figure 2: Expression task and Specified task within Book 4 chapter 2

In the second task shown below (Figure 3), we see another typical problem from the textbook which I refer to *generation tasks*. Here, the task is not pre-formulated, and to answer all these questions students have to bring in information from their own experiences or surrounding to answer the question. These particular aspects are viewed as task 'affordances', which are also aligned with the NCF reforms aiming to make mathematics process oriented and linked with everyday life.

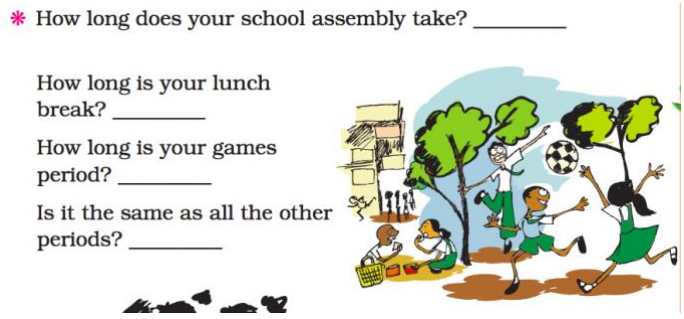


Figure 3: Generation task within Book 4 chapter 4

Comparison of teacher use of focus tasks:

Table 1 below, shows the different approaches taken by Jagdeesh and Kamala, while attempting these tasks. To provide some context, these teachers teach all the subjects for their class and are free to allot any time for each of the subjects, including for mathematics. Thus, the amount of time for each task or subject depends on the teachers' own goals for the lesson (there are institutional time limitations due to administrative work which are not discussed in this paper).

Teacher	Expression task	Specified task	Generation task
Jagdeesh (productive design)	*Expanded discussion*	*Explanatory approach*	*Opening the task*
Kamala (unproductive design)	*Omitted*	*Direct approach*	*Closing the task*

Table 1: Comparison of teacher use of focus tasks

Omitting versus expanding the expression task: Jagdeesh, instead of approaching the first *expression task* as a yes or no response, spends 10 minutes discussing different aspects of the context – what is a marathon, how a stadium looks like, what sports can be played in a stadium. He even encourages students to bring forth their own understandings, by listing the different sports they have heard being played in a stadium. He thus expands this expression task further creating his own probing questions supporting the task. On the other hand, Kamala omits this question all together, and only focuses on the specified tasks.

Direct versus explanatory approach to specified task: In his approach to the specified tasks, as possibly intended by the task, Jagdeesh uses the first question as the first step to the solution of the second question. That is, first finding distance travelled in 10 rounds and then discussing how many 10 rounds would be needed for 40 km. Throughout these stages he focuses on a detailed explanation of the solution procedure (spending 20 minutes), by breaking down the bigger question into smaller parts, which are more easily answered by the students. For example:

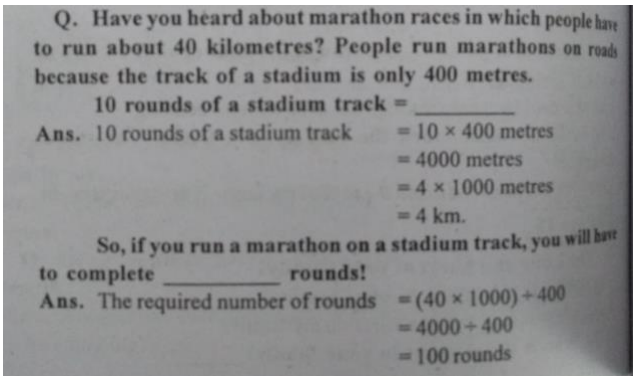
> T: [We have to run] 40 kilometres. Now in 10 rounds, [we covered] 4000 meters that is 4 kilometres. In the next 10 rounds, how much will it be? In the next 10, if we add more, then how much is it adding 4 and 4? 8 km. After that another 10 rounds if we add?

Thus, Jagdeesh focuses more on the process of the solution (with some support from the structure of the specified task) rather than presenting formal operations for solutions – such as multiplication.

Kamala on the other hand only spends 10 minutes in total on the task. She introduces the stadium with circumference 400 m at the beginning of the lesson and draws it on the blackboard to help model the stadium. Consequently, she only focuses on the first questions of the given task unlike Jagdeesh's use of the both the questions to explain the process of the solution. Instead of an elaborate explanation, we see Kamala giving direct procedures.

T: Now, this is given in your book. If you take 10 rounds of this stadium, then what will you get? [] If you take one round of this stadium, then how much will it be? 400. You will multiply 400 with 10 rounds, then we will get how many metres we have run.

As we can see above, she directly tells the students that 400 needs to be 'multiplied' by 10 and consequently she writes the solution on the blackboard using the standard column algorithm form of multiplication. It is also important to note here, that Kamala was using an unofficial privately published guidebook while discussing this chapter alongside the textbook. The guidebook (see Figure 4) which acts like an answer book, provides a solution to each task in the textbook which just like her approach are also direct and formalised rather than process oriented (interestingly the guidebook even has a calculation error). Thus, instead of using the affordance within the textbook task (two questions as support for process explanation), Kamala takes a direct approach as given in the guidebook.



Q. Have you heard about marathon races in which people have to run about 40 kilometres? People run marathons on roads because the track of a stadium is only 400 metres.

10 rounds of a stadium track = _____

Ans. 10 rounds of a stadium track = 10 × 400 metres
= 4000 metres
= 4 × 1000 metres
= 4 km.

So, if you run a marathon on a stadium track, you will have to complete _____ rounds!

Ans. The required number of rounds = (40 × 1000) ÷ 400
= 4000 ÷ 400
= 100 rounds

Figure 4: Page C-10, Apollo guidebook

Opening versus closing the generation task: While attempting the generation task (shown in Figure 3), we again see two very different approaches by Jagdeesh and Kamala. Jagdeesh while addressing this question (See Figure 3: How long does your assembly take?), tries to bring to fore the fact that the answer will vary based on the activity conducted during the assembly:

T: Hmm. Sometimes it is 15 minutes and sometimes it is 30 minutes. Sometimes, when there is a children's meeting, it may take longer, otherwise the time for prayer meeting is about 20 minutes which includes the national song.

This shows that the Jagdeesh is open to the possibility that generation tasks can have many answers and the aim is to keep that in mind while answering. In contrast, Kamala gives definite answers which the students have to write down.

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

As we can see above, in Kamala's approach to the generation tasks, no openness is accommodated. Instead she renders the answer '30 minutes' given by a student wrong and goes on to give a 'correct' answer to the student. Thus, despite the question being open (depending on the student's perspective), she closes the kind of answers it can have.

If we look back at Table 1, along with the description of these episodes, we can see that while Jagdeesh seemed to interpret the key affordances within the tasks in alignment with the task's rationale; Kamala's interpretations contradict them. We can thus say that Jagdeesh seems to have a

higher pedagogical design capacity with respect to these textbooks; compared to Kamala. It is important to note that here I have not included evidence from teachers' own thinking which will enhance our understanding of the dimension of 'intentionality' motivating these designs-in-use. Furthermore, this does not imply that Jagdeesh and Kamala will always teach in these ways, and thus these are not fixed labels for teachers rather helpful indicators to help situate teachers' work in relation to the textbooks.

Conclusion

In this paper, I have discussed primary school teachers' relationship with mathematics textbooks, in the context of Delhi, a city where there is hardly any research in understanding how teachers interact with textbooks. Especially the perspective of viewing teachers as designers (and not just 'implementers'), actively participating while using the textbooks, is completely missing from the Indian policy discourse. Although the need for reforming curriculum and textbook has been articulated strongly in the last 15 years, there is a need to now put teachers at the centre of the discussion. In such a context, using this approach to study Indian teachers is a novel idea (even though in other parts of the world this idea has been developed in innovative ways). By focusing on such a framework, with some adaptation in terms of categories and unit of analysis, this paper reports two findings.

Firstly, the finding that majority of the teachers in my sample are rejecting the textbooks, is a common finding across the globe when teachers encounter reforms. Yet this finding has severe consequences in a context where officially, this is the only textbook provided to teachers, and the schools are not resourced to provide supplementary materials. As we have seen, this might mean that teachers rely on unofficial privately published guidebooks which often have contradictory pedagogical suggestions. Or teachers might rely on their own traditional notions of teaching, thus reforms miss the opportunity of using the textbook's potential of becoming 'educative material' (Davis & Krajkic, 2005).

Secondly, within the group of teachers who were primarily accepting and directly using textbook tasks, by focusing on two teachers we were able to more closely investigate teachers' design capacities as they engaged with the textbook's affordances. In case of the two teachers we clearly see two different ways of perceiving and mobilizing the resource around the tasks; ie their pedagogical design capacity. Jagdeesh is attempting to approach the tasks more openly, attempting to engage students with the contexts integrated in the text and also giving more explanatory solutions. On the other hand, Kamala does not pick up the opportunity of engaging children with the context, and tends to give direct formulaic solutions and closes tasks which are more open. While Jagdeesh seemed to interpret the key affordance within the textbook productively, Kamala does not. Recognising that teachers' design capacities are not homogenous is important in terms of not just curriculum designing but also the accompanying teacher support. Small scale initiatives are starting in science education, such as Ramadas (2017) – where teachers' varied experiences with curriculum feeds back into curriculum design. Yet, these are almost absent in primary Mathematics. Developing partnerships of designing needs to be the next step for the Indian curricular context; which extends the view of teachers as designers and integrates that into curriculum designing (at national, state, school or

classroom level) (Jones & Pepin, 2017). After more than 10 years of introduction of reform-based textbooks such as *Math-magic*, conceptualising ways of developing design capacities needs to become central.

In this paper, I have explored different designs-in-use of the teachers, yet not discussed notions of intentionality: Are teachers consciously making these design choices? What are their intentions and goals behind them? By exploring designs-in-use across the three levels of textbook use: direct use-adapted use-inserted use, along with teachers' rationales for those choices, my larger study aims to develop this notion of 'pedagogical design capacity' further.

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