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Research Article

Mathematics teachers' use of textbooks for instructional decision-making in lesson study

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This paper draws from a broad study that explored mathematics teachers' engagement with textbooks within the Lesson Study context. In the current paper, we report on teachers' use of mathematics textbook activities to inform their instructional decisions during collaborative lesson planning of numeric and geometric patterns. The study took place within the Lesson Study (LS) context – a teacher development practice that emphasises, inter alia, collaborative lesson planning. Data was collected by observing teachers during collaborative lesson planning and through interviews. Data analysis was informed by the Mathematics Knowledge for Teaching (MKT) framework and Modes of teacher engagement with the textbook. Findings suggest that teachers' instructional decisions are mainly stimulated by the textbooks, teachers use textbook activities with fidelity, and they seldom adapt the activities drawn from the textbooks. However, where adaptation occurs teachers do it superficially. We contend that the capacity to conduct in-depth interrogation of the text is a derivative of mathematics subject matter knowledge (SMK) as well as pedagogical content knowledge (PCK). Therefore, the widespread adoption of text without interrogation could be indicative of the lack of requisite content knowledge and pedagogical skills.

Keywords: Lesson planning; Lesson study; Mathematics textbook; Pedagogical content knowledge; Subject matter knowledge

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1. Introduction

The view that textbooks are the didactic tools that are mostly used by teachers cannot be contested (Kajander & Lovric, 2017). What makes textbooks to be the most frequently used resource could be attributed to the central role they (the textbooks) play in interpreting the curriculum. Hadar (2017, p. 154) puts it succinctly that "…textbooks influence the implemented curriculum, shaping the instruction in the classroom…". In other words, textbooks ought to be a bridge between curriculum policy and the implemented curriculum since their role is to decode the curriculum which is often nuanced in a truncated manner. Undoubtedly, textbooks and their contexts could have a bearing on teachers' instructional decisions (Davis et al., 2017) depending on how they are being utilised. For instance, Grouws et al. (2013) make a point that "…[teachers] may move through the textbook sequentially or not; they may teach differently than what the textbook

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recommends or not; …" (p. 419). In fact, the intentional or unintentional choices or modes of using textbooks validate Charalambous et al.'s (2010) assertion that textbooks offer teachers and learners possible teaching and learning opportunities and not prescriptive or conclusive teaching and learning opportunities. The coinage of the phrase potentially implemented curriculum as it relates to the role of textbooks (Valverde et al., 2002) captures the essence of Charalambous et al.'s assertion accurately. What this translates into is that although textbooks constitute important didactic tools, the ultimate instructional decision rests with teachers.

Teacher-textbook relationship begins when teachers plan lessons for enactment (Remillard, 2005). Therefore, the nature of teachers' engagement with textbooks and the decisions they make during collaborative lesson planning also impacts a great deal on the quality of a lesson developed. In addition, González et al. (2020) inform us that the quality of learners' learning experience is a derivative of their teachers' selection of activities, mainly from textbooks, during lesson planning. According to Fujii (2019), lesson planning is the fulcrum that determines the effectiveness of the lesson.

Since textbooks are the prominent resource teachers use in planning lessons, the more textbooks are educative for teachers in terms of both the pedagogy and content, the more beneficial they would be for teachers as they engage in kyozai-kenyu (Japanese term for the study of curriculum materials) during lesson planning. Vermunt et al. (2019) contend that teacher learning during lesson planning becomes more significant if teachers plan lessons collaboratively because, amongst other resources, they are able to learn from one another. Lesson Study, therefore, provides teachers with the platform to collaboratively study the curriculum and its instantiations such as textbook as they plan lessons.

Vincent and Stacey (2008) explored the depth and breadth of the kind of teaching that mathematics textbooks cultivated. Findings revealed that activities in the textbook were repeated and were of low procedural complexity. As a result, they concluded that such textbook activities may subject teachers to what they referred to as shallow teaching syndrome, since textbooks are the basic resource that teachers use. Hadar (2017) concurs that what the textbook offers can either enhance or limit learning. Textbooks that are not rich in content do not increase teachers' repertoire of their subject matter knowledge (SMK) or pedagogical content knowledge (PCK). Hence, curriculum materials, which textbooks are part of, should be educative in such a way that teacher knowledge is enhanced even beyond the grade that they teach (Davis & Krajcik, 2005).

Mathematical activities that are presented to learners during lesson are generally textbook-selected activities (Lepik, 2015). This means that textbooks assist teachers with activities to teach the concepts/topics. Therefore, for teachers to teach effectively, textbooks should be written in a manner that teacher engagement with them nurtures meaningful learning for both the teacher and the learners. Leshota (2020) asserts that teacher-text relationship that indicates the teacher's pedagogical design capacity (PDC) is in two- fold: teachers either omit or inject content. While omitted content is associated with content that was in the textbook but deliberately or unwittingly left out during lesson presentation, injection refers to the content that is added by the teacher during lesson presentation that was not in the textbook. Important to note is that, although Leshota (2020) focuses on the mediation of content during lesson presentation, lesson planning is implied because lesson planning is the stage that ought to precede lesson presentation.

The view of Krajcik and Delen (2017) is that quality tasks may be enacted by teachers who use textbooks that are rich in content knowledge and pedagogy. The quality of teachers' instruction is directly impacted by the kind of textbooks they use (Pratama & Retnawati, 2018). On the contrary, Mwadzaangati (2019) asserts that preparing and enacting quality tasks that are meaningful to learners does not only involve quality tasks from the textbook, but also the teacher's conceptualisation of the content to make effective use of the textbook content.

When teachers plan lessons, they use textbooks in conjunction with teacher guides. Teachers' guides are also one form of curriculum resource that supports the teacher in the planning and presentation of lessons (Remillard, Harris et al., 2014). Remillard, Van Steenbrugge et al. (2014)

conducted a study investigating how the authors of mathematics teachers' guides communicate with teachers. Their findings revealed that teachers' guide offer different guidance to teachers. Davis and Krajcik (2005) discriminate between educative guidance and directive guidance. The former refers to the content in the teachers' guides that guides the teachers' practice, while the latter refers to the direction that the teacher's guide gives in terms of what the teacher or the learner is supposed to do or say. In their study on mathematics teachers' guides in US, Belgium and Sweden, Remillard, Van Steenbrugge et al. (2014) noted differing guidance offered by the teacher's guide. For instance, Belgian teacher's guide was more directive than educative, the US teachers' guides had a balance between the educative and the directive feature of the teachers' guides, while the Swedish teacher's guides were different, some were more educative than directive and some contained a balance between the two features. Koljonen et al. (2018) attest that the teachers' guides can be used as the analytic tool for tacit norms of the classroom. A teacher's guide is a resource that is used regularly by the teacher to plan and present lessons (Ljerka, & Dubravka, 2021).

Our study explored how teachers' use of mathematics textbook activities informs their instructional decision-making during collaborative lesson planning in the context of Lesson Study (LS). LS is a teacher professional development model that originated in Japan (Fernandez, & Yoshida, 2012). Before being translated into English by the anglophone scholars, LS was known as jugyo-kenkyu for Japanese teachers – where jugyo means lesson and kenkyu means study or research (Fernandez, & Yoshida, 2004). Duez (2018) noted that although LS had been practiced in Japan for over a century, it was formalised in the early twentieth century. According to Fujii (2013), LS involves a group of teachers that collaboratively study the curriculum materials (kyozai-kenkyu) and formulate aims and goals of the lesson they want to teach, collaboratively plan lessons, one teacher presents lessons while some observe the lesson presentation and record the learning and teaching taking place; and lastly, analytically reflect on the lesson with the aim of strengthening it. As a result, these lessons are referred to as research lessons because of their research nature.

Lesson Study is a fairly new practice in South Africa. Sekao and Engelbrecht (2022) presented a five-stage Lesson Study cycle adapted for the South African context. The five stages include diagnostic assessment/analysis, lesson planning, lesson presentation and observation, post lesson reflection, and lesson improvement. Diagnostic assessment/analysis is a unique feature of the South African version of Lesson Study. During the diagnostic analysis process, teachers intentionally identify a problematic topic/concept for learners by analysing the learners' responses to the diagnostic assessment which would culminate into the goal of the research lesson (Sekao & Engelbrecht, 2022). Although in the current study teachers from whom data was collected implemented the entire LS cycle, data was collected on two stages namely, the 2nd stage (collaborative lesson planning) because it is the stage where teachers directly interact with the textbook(s) through *kyozai-kenkyu* when planning the lesson, and the 3rd stage (lesson presentation/observation) because teachers and learners use textbooks during lesson presentation. The study addressed the research question: How do teachers use mathematics textbook activities to inform instructional decision-making?

2. Theoretical Framework

We used two theoretical lenses to gain insights into how textbooks contribute to teachers' instructional decision-making: Mathematics Knowledge for Teaching (MKT) advocated by Ball et al. (2008) and modes of teacher engagement with the textbooks espoused by Remillard (2005). Ball et al. (2008) argue that the knowledge base that mathematics teachers need to have within the MKT framework comprises two domains: the subject matter knowledge (SMK) and the pedagogical content knowledge (PCK) each constituted by three sub-domains. The three sub-domains of SMK are the common content knowledge (CCK), specialised content knowledge (SCK) and horizon content knowledge (HCK); while those constituting PCK are knowledge of the content, and the

student (KCS), knowledge of the content and teaching (KCT) and knowledge of the content and the curriculum (KCC).

Under the SMK domain, Ball et al. (2008) attest that the mathematics knowledge that any layperson could have, for example, counting, is referred to as CCK. SCK refers to the knowledge of mathematics that only mathematics teachers possess over and above the CCK. Ball et al. (2008) define HCK as the knowledge of the integration of topics/concepts within or outside the current grades' mathematics content as well as the integration of mathematics with other disciplines. The SMK domain in this paper serves as a content tool that teachers need to tacitly have for the concepts/skills to be taught to make sense to learners. Under the PCK domain, KCS includes teachers' consideration of the learners' thinking as they plan lessons, KCT refers to the consideration of learners' learning styles and pace during lesson planning and KCC refers to the appropriateness of the concepts being taught to the respective grade (Ball et al., 2008). Regarding PCK in this paper, the teacher needs to know among other things, his/her learners well in terms of learner's learning styles, content knowledge that learners already have on the concept and misconceptions if any as well as the content that is supposed to be taught as per policy in the respective grade for meaningful learning to take place.

The prerequisite for teachers to be able to decide on an instructional approach to embark on in presenting a lesson is content knowledge and pedagogy knowledge. That is, no lay person would be able to plan and present a mathematics lesson other than the mathematics teacher who has a repertoire of some knowledge and skill needed in the teaching of mathematics. The MKT framework by Ball et al. (2008) consists of both the SMK and the PCK domains and the sub-domains that will only be possessed by the mathematics teacher. However, the research question investigates how textbooks contribute to teachers' instructional decision making. To complement the MKT framework, we also used Remillard's (2005) modes of teacher-text engagement as a second theoretical lens to view data in order to respond to the research question. Remillard (2005) assert that teacher-text engagement is through offloading (using textbook activities as they are from the textbook), adapting (altering textbook activities to suit the teaching methodology and learners' level of understanding), and improvising (teachers designing their own activities). So, while the MKT framework (Ball et al., 2008) assisted us identify the potential SMK and PCK repertoire that teachers may possess and use to interact with textbooks, the modes of teacher-text engagement by Remillard (2005) revealed the type of teacher-text engagement.

3. Methodology

This qualitative case study involving grade 6 teachers is undergirded by interpretivist paradigm (Creswell, 2017) which enabled us to gain a deep understanding of mathematics teachers' instructional decisions when they engaged with mathematics textbooks within the LS context. Since LS is a practice-embedded process, the utility of the interpretivist paradigm for our study afforded us an opportunity to immerse ourselves in the teachers' natural environment, the classroom, to collect data when they (the mathematics teachers) engaged with textbooks.

3.1. Research Approach

This study adopted a deductive-inductive approach. While deductive approach associates itself with the researcher's preconceived assertions on the phenomenon, inductive approach relies on the presented data to understand the phenomenon (Alase, 2017). In addition, Lune and Berg (2017) assert that inductive approach preempts the researcher to immerse himself/ herself to the data with the aim of identifying themes that are in turn explained by the study's theoretical framework. Whereas, in deductive, the researcher uses the study's theoretical framework to explain cases under investigation influenced by his/her experience of the phenomenon (Lune & Berg, 2017). Analysing data deductively and inductively in qualitative research contributes to a much more comprehensive approach (Azungah, 2018).

3.2. Research Design

This study adopted a case study as its research design and explores mathematics teacher engagement with textbooks in the context of Lesson Study. While case studies subject the researcher to an in-depth enquiry and understanding of the phenomenon, it fosters socially constructed knowledge (Yin, 2012). This study took place under natural settings because there is no special arrangement that was made to enable data collection for this study. Teachers collaboratively planned lessons at the venue that they often use for research lesson design in the context of LS and lessons were presented to the respective teacher's classes. The data collected in this study was triangulated because data was drawn from lesson planning and lesson presentation observation as well as transcripts of individual and group interviews.

3.3. Research Procedure

The provincial department of education where the study was conducted granted permission to conduct research at the sample schools in the district after which the district director and circuit managers were given consent forms to populate on their awareness of the study being conducted I their respective schools. Eight grade 6 mathematics teachers from different schools who were already familiar with Lesson Study constituted the sample for this study. As per the prescripts of LS, they worked collaboratively as a team to plan three lessons focusing on numeric and geometric patterns. Specifically, the following mathematics concepts were covered in the three lessons: determining input values, output values and rules of numeric patterns using tables; investigate and extend geometric patterns; and, determining input values, output values and rules of patterns using flow diagrams and tables (Department of Basic Education [DBE], 2011). Participating teachers also signed the consent forms. Parents of learners that were going to be used for lesson presentation were made to sign the assent forms assuring them that the focus of the study is on the teachers and not the learners and therefore, their learners will not in any way be used in the study.

3.4. Data Collection Techniques

Data was collected through observation and unstructured interviews. Teachers were observed as they planned the lessons and, interviewed to gain insight into their actions while they were planning the lessons. Unstructured Interviews were also conducted for corroboration after the lesson planning session when necessary. All data collected was video-recorded and transcribed. Patterns formed were grouped into categories and codes from which themes emerged.

4. Findings

Lesson objectives, teaching methodology and selection of activities were the three themes that emerged from the data. These themes informed teachers' instructional decision-making during collaborative lesson planning as they engage with the textbooks.

4.1. Lesson Objectives

The effectiveness of a lesson is normally determined by the extent to which lesson objectives are achieved. Lesson objectives are a common feature in the lesson plan template. Teachers need to state what learners must be able to achieve by the end of the lesson. more often than not, lesson objectives are constituted by learners' prerequisite knowledge of the concept and what learners are to learn in the current lesson. Therefore, while a certain level of SMK in order to merge the lesson objectives constitutes is critical, teacher's pedagogical design capacity on how best to present the content to learners for objectives to be achieved is also vital. As teachers were selecting activities from the textbook during lesson planning, they kept on reminding one another of the objectives they needed to achieve in the lesson. In other words, the already-stated lesson objectives guided the selection of textbook activities throughout the lesson planning session. This was evident when teachers had the following discussion as they were selecting activities:

T1: Ok let us go back to objectives. What are the objectives of this lesson? Learners should know … [silence for a while]. I am waiting people …
T7: … should determine…
T2 and
T7: … output and input values using flow diagrams and tables

So, lesson objectives guided teachers on the type of activities they needed to select from the textbook. However, teachers also felt that activities that they altered were better suited for them to achieve the lesson objectives than the activities used as they were in the textbooks. What was interesting though is, the altering of activities was superficial as mentioned in ……. When teachers were asked to rate activities that they alter as compared to the ones that they use unaltered, T8 commented : … just more or less, what she has…eh… said. Uhm… the ones we create ourselves are, they look more into…eh… making sure we achieve the objectives that we have set for ourselves

The teachers' believed that the activities they created help them achieve objectives in a significant way compared to the activities that are taken directly as they are from the textbook. Directly taking activities from textbooks that may not help them to achieve the lesson objectively may imply weak KCC.

4.2. Teaching Methodology

By the teaching methodology we refer to the strategies and approach that teachers adopted during the lesson planning session for the lesson presentation. In some cases, teachers adopted the activities as they were; consequently, the teaching approaches used in the textbook were adopted as they were. Figure 1 shows the activity that was taken as it was from the textbook, not only in terms of concepts to be taught but also in terms of pedagogy as reflected in Figure 2. Implicitly, textbook activities assisted teachers with the list of resources needed to present the lesson.

Figure 1
Example of a teaching approach taken as it is from the textbook

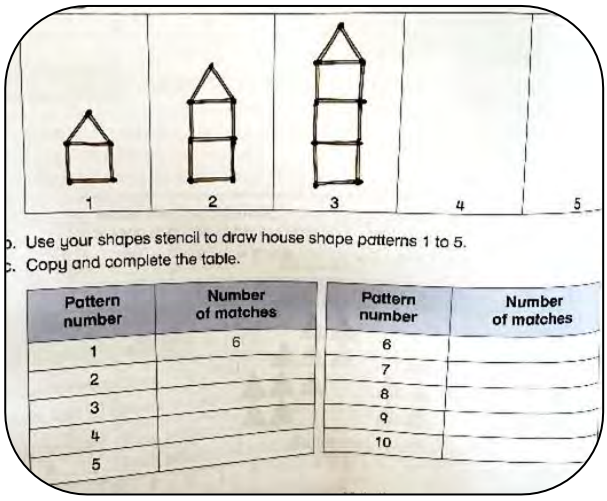
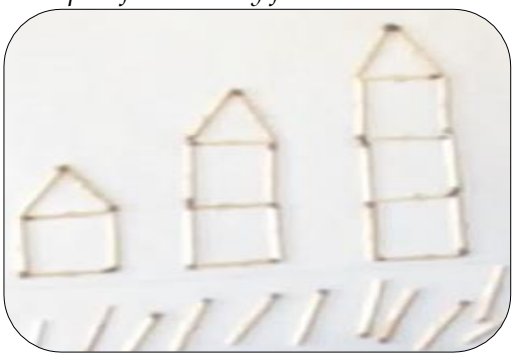


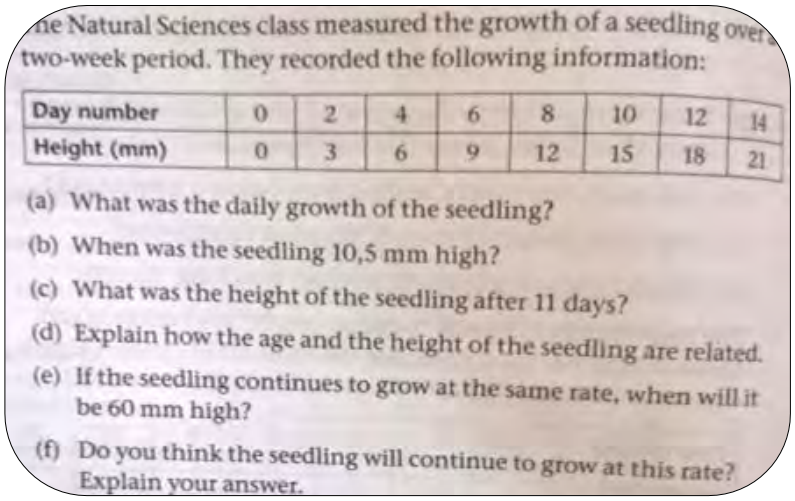
Figure 2
Example of an activity from the textbook



During lesson preparation/presentation, teachers used five series of textbooks and, learners in the respective three schools have one copy of one series of the textbooks used by teachers. As a result, textbook selected activities during lesson planning were presented in the form of worksheets. As teachers were selecting activities, they were also very conscious of the 1-hour teaching period that they were to present the lesson. While the textbook suggests that learners use the matchsticks to build houses from house number 1 (Figure 2), teachers decided to come to class with the illustrations of the first three houses and asked learners to extend the pattern by building the next two houses to save time. This they did because they agreed that learner pace could delay the lesson. This was evidenced by T3's utterances when he said: …learners can be slow.

For all textbook selected activities, teachers worked out expected responses. This conscientised teachers of the possible errors that learners make. For example, in Figure 3, teachers suggested that they provide a hint for learners which was not provided in the textbook because they felt that learners will not realise that there are skipped input values (day number). This means while the textbook assisted teachers with the methodology to use to achieve the lesson objectives, teachers also used their PCK and specifically KCS and KCT to lead learners to attain the lesson objective.

Figure 3
Source: DBE textbook, p. 280


ne Natural Sciences class measured the growth of a seedling over a two-week period. They recorded the following information:

Day number	0	2	4	6	8	10	12	14
Height (mm)	0	3	6	9	12	15	18	21

(a) What was the daily growth of the seedling?
(b) When was the seedling 10,5 mm high?
(c) What was the height of the seedling after 11 days?
(d) Explain how the age and the height of the seedling are related.
(e) If the seedling continues to grow at the same rate, when will it be 60 mm high?
(f) Do you think the seedling will continue to grow at this rate? Explain your answer.

Furthermore, one selected activity required learners to express their answers in rands (South African currency). Teachers knew that many learners would have a problem converting rands to cents and therefore decided to accept an answer in cents and in rands. This was evident when they had this discussion:

> T1: …our answers there. If we are gonna say it's one rand fifty cents, so we don't have to…
> T7: …to say money in rands because learners will be confused…
> T1: We must have both answers in our memo. That I am expecting that one and this one …
> T7: …that money made in rands or in cents slash cent…because now we know, they will be confused when writing the numbers, I know because they will say one rand fifty, they won't put the commas.

This showed that teachers understood their learners' thinking. Although the learners' thinking seemed to be accommodated in the above activity, emphasis on decimals as a topic was tacitly implied, which is a concept that is introduced at grade 6 level. The selection of activities from the textbook was also impacted by whether the assurance that the answers were correct. In instances where teachers found themselves unsure of the answer, they consulted the teachers' guides however, they asserted that teachers' guides do not really help them because they provide answers only.

Teachers' integration of other concepts into patterns within the mathematics discipline (within the current grade and outside) was superficial. Although concept calculations are well explained in the textbooks using worked examples, integration of the concepts is not explicit. As a result, teachers could not meaningfully relate patterns to any other mathematics topic within and outside the grade 6 mathematics content. When asked if patterns integrated with any other topic within and outside the grade 6 curriculum, T3 responded:

Yes, with lots of sections like uhm… addition, subtraction of… maybe I should just say all the operations, it does depending on the nature of uhm…the pattern but it does because one must be able to count, to add or subtract even multiply so it does link

When teachers were asked if they teach decreasing patterns, they confirmed that they mostly teach increasing patterns. This was evident in the following discussion:

> T4: Yah, it's decreasing that one. We don't have to take that will be difficult.

T7: No, …, we can take that decreasing one
T4: Decreasing!
T7: Yah
T4: Oh! it's easy
T1: It's easy!
T4: Yah.
T1: Ok. Is it dividing by two? Yah.

Although teachers felt that the decreasing pattern would be difficult for learners, the textbook provided worked examples that showed the calculations in some instances enabling the teacher to see the trend. The calculation method used in the textbook fostered the selection of the activity. Some teachers felt that textbook selected activities exposed them to different questioning styles. They felt that if they were not using textbooks, their questioning style would be more of a lower order question. This was evident when T7 and T2 responded as follows when asked how the textbooks have assisted them prepare their lesson.

> T7: The way we ask questions. What I learnt is the way we ask questions to the learners, we relate to the textbooks, the way we ask questions…
> T2: I wanted to say uhm… textbooks has helped us a lot because activities, some of the activities were taken from the textbook as they are and those activities helped us to create our own and the activities in the textbooks cater for all learners, according to my knowledge. So, that even helped us how to ask the questions to the learners instead of maybe asking "what", we were able to even ask "how" so they helped us.

Textbooks, therefore assisted teachers cater for the different levels of cognitive demand using their KCS and KCT. Furthermore, since patterns involved both the numeric and the geometric patterns, teachers tended to convert a geometric pattern to a numeric pattern and solve as if it was a numeric pattern. Of the five different textbooks that were used during lesson planning, only one textbook outlined the investigative calculation plan to extend a geometric pattern. Other series converted geometric patterns to numeric patterns. This means textbooks had a direct effect on the meaningfulness, appropriateness and relevance of the teaching method used by teachers in their practice.

4.3. Selection of Activities

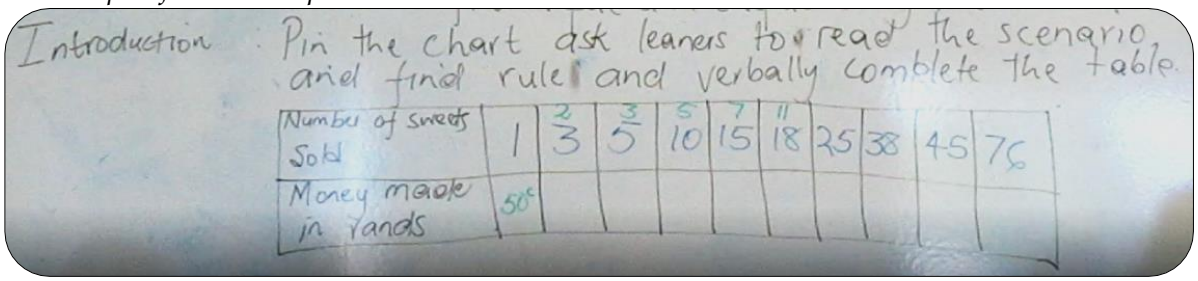
Regarding the selection of activities, textbook activities were predominantly selected as they were from the textbook. Features of teacher reliance on the textbook were also very prominent as teachers would debate on whether the activity should be taken as it is from the textbook or altered. In one instance where the activity involved building a pattern with matchsticks, some teachers felt that it would be time consuming for learners to build patterns with matchsticks in class, others felt that if they come to class with the three stages of the pattern built as in Figure 1 and Figure 2 above, it would not take that long to extend the pattern and they finally opted to take the activity as it was from the textbook. When teachers were asked why they felt that they had to take activities as they were from the textbook, we got the following response from:

> T4: … I think this work has been checked … has been checked and assessed so we cannot edit the work that is in the textbook. We must take all of it … When teachers were selecting activities from the textbook, they would have discussions like
> T1: What if we take the same one and use it as the first one for presentation. This one [pointing at the original activity from the textbook]
> T6: Mhh T1: … exactly as it is on the book. Number of sweets sold… money made in rands.

Figure 1 and Figure 2 illustrate both an example of the activity taken from the textbook as it is as well as the textbook nature of affording teachers an idea of the methodology to use when presenting the content. Taking activities as they were from the textbook ensures that the skills which the intended curriculum intends to transmit through the partially implemented curriculum (textbook) are indeed transmitted if the textbook is aligned to policy.

However, teachers occasionally altered and fragmented activities so that learners' learning becomes meaningful. Teachers occasionally changed the context of the activity if they felt that the context would not be easily understood by learners but in all instances when they change the context, they also lower the cognitive demand of the activity. For example, when the teachers felt that the numbers in a table from a textbook were too large and too many for the introduction they changed the numbers to smaller numbers as shown in Figure 4.

Figure 4
An example of an altered question



Teachers used their KCT by considering the length of the activity for the introduction and KCS by reducing the numbers so that learners are able to calculate the output values within the stipulated time for the introduction.

In other instances, teachers would fragment the activity – take part of the question to the introduction and the rest of the questions to the presentation. In this case, teachers' altering of textbook activities was very superficial.

5. Discussion

The study showed that the teachers predominantly selected textbook activities with fidelity. Remillard (2005) refers to the selection of activities as they are from the textbook as offloading. Remillard (2005) asserts that fluency in mathematics is a prerequisite for teachers to be able to design their activities independent of the textbook. Moreover, Stein et al. (2007) assert that textbook-bound teachers are likely teachers with significant content gaps. However, teachers also superficially adapted activities by lowering the cognitive demand of the activity, which is what Leshota (2020) referred to as critical omission. This could imply that teachers have some gaps in content and methodology as a result, associate themselves with the entry mode (fidelity) of teacher engagement with the textbook.

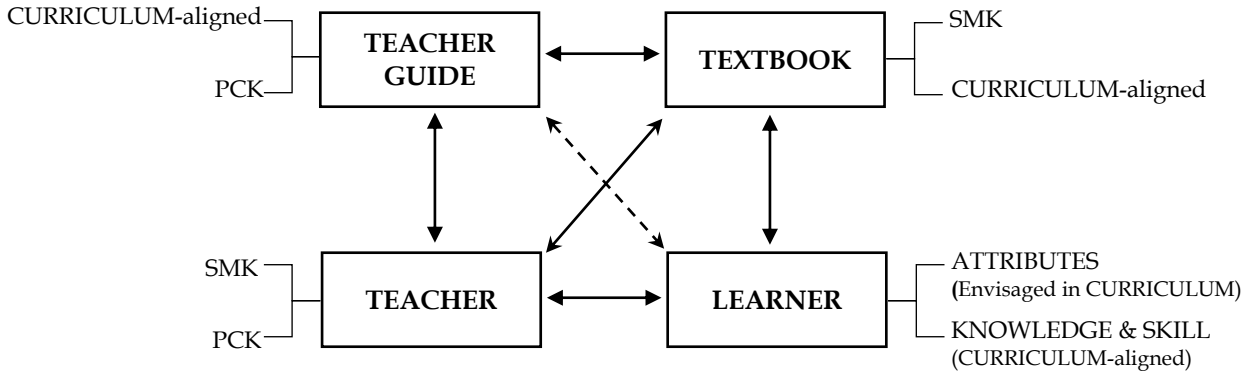
Ball et al.'s (2008) sub-domains of PCK were prominent during lesson planning as teachers consistently thought about learners' thinking and pace but, if the curriculum materials (teachers' guides) was educative enough for teacher in terms of pedagogy, more impact regarding teacher instructional decision-making would have been prominent. Teachers demonstrated awareness of KCC as they were always mindful of the objectives that each lesson was to achieve. Aligning lesson objectives to curriculum policy, is an essential feature of the lesson plan (Sekao & Engelbrecht, 2022). Textbooks, therefore, enabled teachers to select activities that would foster the achievement of objectives. As teachers selected activities during lesson planning, they had their learners' thinking in mind (KCS), as well as the possible errors that learners make (KCT). As a result, they altered the content accordingly (KCT). However, teachers' pedagogical content knowledge (PCK) espoused by Ball et al. (2008) would have been greatly improved if the s teachers used contained both the educative and the directive feature of teachers' guides as espoused by Davis and Krajcik (2005). But rather, teachers' guide provided just the answers to the textbook activities. It takes a certain level of SMK to engage meaningfully with the textbook. As teachers worked out answers, they were able to see if the activity was suitable for their learners or not. This is what Ball et al. (2008) refer to as SCK. Teachers' inability to meaningfully integrate patterns to other mathematical concepts within and outside the grade 6 curriculum indicated that their level of the horizon content knowledge (HCK) was low. An educative teachers' guides in this regard

would have assisted teachers make informed links between patterns and other related concepts in mathematics.

Furthermore, textbooks afforded teachers teaching methodology and resources. However, due to the lack of a framework that guides the writing of mathematics textbooks, strategies outlined in the five textbook series used were different. Only one series followed what the policy states that learners should: "Investigate and extend geometric patterns looking for relationships or rules of patterns." (DBE, 2011, p. 19). The other four textbook series converted a geometric pattern to a numeric pattern and extended the pattern as if it was a numeric pattern. In this way, the intended curriculum goals are flawed by the methodologies communicated in the textbook. These flaws possibly result from the lack of a framework that guides the writing of textbooks.

We conclude this discussion by suggesting a framework that could be used by authors for textbook conceptualisation so as to strike a balance between the teachers' guides, the textbook, the teacher, and the learner (TTTL), see Figure 5.

Figure 5
Proposed framework for textbook conceptualisation



We argue that textbook authors need to conceptualise teachers' guide not only to be curriculum-aligned, but to assist the teacher teach and the textbook to assist both the teacher and the learner learn. The teachers' guides need to be fleshed with pedagogy so that the teacher improves both the PCK and the SMK respectively. Learners would then individually benefit content from the textbook after it has been clearly and meaningfully mediated by teacher. In this way, the knowledge, and skills that the policy intends to impart on learners would be realised and thereby producing the learner it envisaged. In this case, we argue that teacher interaction with the textbook during lesson planning could escalate from fidelity (basic entry level) to adapting (Remillard, 2005).

6. Recommendations

Findings depicted that teachers could not make informed links to patterns in Grade 6 and beyond. We recommend that teachers' guides be bolstered with aspects of pedagogy and not just answers only to the textbook activity. While such recommended teachers' guide assist teachers with pedagogy and enable them to view patterns and any other topic in relation to others and not in isolation, they will also assist them make informed connections within mathematics to patterns and in turn, assist them make informed instructional decisions. In addition, we recommend that the suggested TTTL framework be used for textbook conceptualisation in order to improve teachers SMK and PCK and thereby shift the mode of teacher-text interaction from fidelity to adapting the curriculum. We believe that the methodology gap caused by different interpretation of the concepts for example, teaching geometric patterns as if they were numeric patterns, would be narrowed tremendously. Since the level of teachers' understanding of the content and pedagogy would have been improved, teacher could also shift from critical omission of concepts as they select activities for lesson presentation to what Leshota (2020) referred to as productive

injection (having valuable input to selected activities). Lastly, we recommend that LS be practised extensively and consistently for teachers to be professionally developed meaningfully in terms of content.

7. Conclusion

The study showed that during collaborative lesson planning, textbooks informed the teachers' decisions on the lesson objectives, teaching methodology, and selection of activities. Notwithstanding the important role that textbooks play in providing possible opportunities to learn, the ultimate discretion to decide on what could work for effective teaching and learning rests with teachers. Teacher knowledge of content and pedagogy plays an important role in instructional decisions teachers make during lesson planning. Working collaboratively to plan mathematics lessons gives teachers a window to have multiple pedagogical perspectives of the concept/topics, thereby aiding teachers' instructional decisions. Of course, the mode of teachers' engagement with textbooks cannot be ignored in the overall scheme of things. For instance, if teacher engagement with textbooks is done like following a script, innovative instructional decisions are likely to be stifled.

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References

Alase, A. (2017). The interpretative phenomenological analysis (IPA): A guide to a good qualitative research approach. *International Journal of Education and Literacy Studies, 5*(2), 9-19. https://doi.org/10.7575/aiac.ijels.v.5n.2p.9

Azungah, T. (2018). Qualitative research: deductive and inductive approaches to data analysis. *Qualitative research journal, 18*(4), 383-400. https://doi.org/10.1108/QRJ-D-18-00035

Ball, D. L., Thames, M. H., & Phelps, G. (2008). Content knowledge for teaching. What makes it special. *Journal of teacher education, 59*(5), 389 – 407. https://doi.org/10.1177/0022487108324554

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. https://doi.org/10.1080/10986060903460070

Creswell, J.W., & Poth, C. N. (2017). *Qualitative inquiry and research design: Choosing among five approaches*. Sage.

Davis, E. A., & Krajcik, J. S. (2005). Designing educative curriculum materials to promote teacher learning. *Educational researcher, 34*(3), 3-14. https://doi.org/10.3102/0013189X034003003

Davis, J. D., Choppin, J., Roth McDuffie, A., & Drake, C. (2017). Middle school mathematics teachers' perceptions of the common core state standards for mathematics and its impact on the instructional environment. School Science and Mathematics, 117(6), 239-249.

Department of Basic Education [DBE]. (2011). *Curriculum and Assessment Policy Statement Mathematics: Intermediate Phase (Grades 4-6)*. Department of Basic Education.

Duez, E. (2018). Global applications of the Japanese lesson study teacher education and training model. *International Dialogues on Education: Past and Present, 5*(1), 65–73. https://doi.org/10.53308/ide.v5i1.83

Fernandez, C., & Yoshida, M. (2004). *Lesson study: A Japanese approach to improving mathematics teaching and learning (Ser. Studies in mathematical thinking and learning)*. Lawrence Erlbaum Associates. https://doi.org/10.4324/9781410610867

Fernandez, C., & Yoshida, M. (2012). *Lesson study: A Japanese approach to improving mathematics teaching and learning*. Routledge.

Fujii, T. (2019). Designing and adapting tasks in lesson planning: A critical process of Lesson Study. In R. Huang, A. Takahashi & J. P. DePonte (Eds.), *Theory and practice of lesson study in mathematics* (pp. 681- 704). Springer.

González, M. J., Gómez, P., & Pinzón, A. (2020). Characterising lesson planning: A case study with mathematics teachers. *Teaching Education, 31*(3), 260-278. https://doi.org/10.1080/10476210.2018.1539071

Grouws, D. A., Tarr, J. E., Chávez, Ó., Sears, R., Soria, V. M., & Taylan, R. D. (2013). Curriculum and implementation effects on high school students' mathematics learning from curricula representing subject-specific and integrated content organizations. *Journal for Research in Mathematics Education, 44*(2), 416-463. https://doi.org/10.5951/jresematheduc.44.2.0416

Hadar, L. L. (2017). Opportunities to learn Mathematics textbooks and students' achievement. *Studies* in *Educational Evaluation, 55*, 153 – 166.

Kajander, A., & Lovric, M. (2017). Understanding and supporting teacher horizon knowledge around limits: A framework for evaluating textbooks for teachers. *International Journal of Mathematical Education in Science and Technology, 48*(7), 1023 – 1042. https://doi.org/10.1080/0020739X.2017.1301583

Koljonen, T., Ryve, A., & Hemmi, K. (2018). Analysing the nature of potentially constructed mathematics classrooms in Finnish teacher guides-the case of Finland. *Research in Mathematics Education, 20*(3), 295–311. http://dx.doi.org/10.1080/14794802.2018.1542338

Krajcik, J., & Delen, I. (2017). The benefits and limitations of educative curriculum materials. Journal of Science Teacher Education, 28(1), 1-10.

Lepik, M. (2015). Analysing the use of textbook in mathematics education: the case of Estonia. *Acta Paedagogica Vilnensia, 35*, 90-102. http://dx.doi.org/10.15388/ActPaed.2015.35.9193

Leshota, M. (2020). Teacher–textbook relationships in mathematics in contexts of limited resources. *African Journal of Research in Mathematics, Science and Technology Education, 24*(3), 375-386. https://doi.org/10.1080/18117295.2020.1847833

Ljerka, J. M. & Dubravka, G. G. (2021). How do teacher guides give support to mathematics teachers? analysis of a teacher guide and exploration of its use in teachers' practices. *Research in Mathematics Education, 23*(1), 1–20. https://doi.org/10.1080/14794802.2019.1710554

Lune, H., & Berg, B. L. (2017). *Qualitative research methods for the social sciences*. Pearson.

Mwadzaangati, L. (2019). Comparison of geometric proof development tasks as set up in the textbook and as implemented by teachers in the classroom. *Pythagoras, 40(*1), 1–14. https://doi.org/10.4102/pythagoras.v40i1.458

Pratama, G. S., & Retnawati, H. (2018). Urgency of higher order thinking skills (HOTS) content analysis in mathematics textbook. *Journal of Physics: Conference Se*ries, *1097*(1), 012147. https://doi.org/10.1088/1742-6596/1097/1/012147

Remillard, J. T, (2005). Examining key concepts in research on teachers' use of mathematics curricula. *Review of educational research, 75*(2), 211-246. https://doi.org/10.3102/00346543075002211

Remillard, J. T., Harris, B., & Agodini, R. (2014). The influence of curriculum material design on opportunities for student learnings. *The International Journal on Mathematics Education, 46*(5), 736–749. https://doi.org/10.1007/s11858-014-0585-z

Remillard, J. T., Van Steenbrugge, H., & Berquist, T. (2014). A cross-cultural analysis of the voice of curriculum materials. In K. Jones, C. Bokhove, G. Howson & L. Fan (Eds.), *Proceedings of the research in mathematics education: 19th international Conference on mathematics textbook research and development* (pp.395–400). University of Southampton.

Sekao, D., & Engelbrecht, J. (2022). South African Primary Mathematics Teachers' Experiences and Perspectives About Lesson Study. *International Journal of Science and Mathematics Education*, *20*(7), 1431-1453. https://doi.org/10.1007/s10763-021-10214-w

Stein, M. K., Remillard, J., & Smith, M. S. (2007). How curriculum influences student learning. *Second handbook of research on mathematics teaching and learning, 1(*1), 319-370.

Valverde, G. A., Bianchi, L. J., Wolfe, R. G., Schmidt, W. H., & Houang, R. T. (2002). According to the book: Using TIMSS to investigate the translation of policy into practice through the world of textbooks. Springer Science & Business Media.

Vermunt, J.D.., Vrikki, M., van Halem, N., Warwick, P., & Mercer, N. (2019). The impact of Lesson Study professional development on the quality of teacher learning. *Teaching and Teacher Education, 81*, 61-73. https://doi.org/10.1016/j.tate.2019.02.009

Vincent, J., & Stacey, K. (2008). Do mathematics textbooks cultivate shallow teaching? Applying the TIMSS video study criteria to Australian eighth-grade mathematics textbooks. *Mathematics Education Research Journal, 20*(1), 82-107. https://doi.org/10.1007/BF03217470

Yin, R. K. (2012). Case study methods. In H. Cooper, P. M. Camic, D. L. Long, A. T. Panter, D. Rindskopf, & K. J. Sher (Eds.), *APA handbook of research methods in psychology, Vol. 2. Research designs: Quantitative, qualitative, neuropsychological, and biological* (pp. 141–155). American Psychological Association. https://doi.org/10.1037/13620-009