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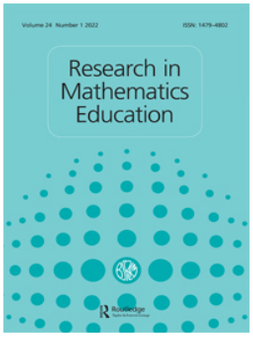

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Mathematics textbooks and self-regulated learning: responses from students in three Kenyan secondary schools

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ABSTRACT

The current moves by many African countries including Kenya to reform their mathematics education to adopt learner-centred pedagogies presents a need to fill the knowledge gap on learner-textbook relationships there. The mathematics textbook remains a key resource for teaching and learning and is increasingly being expected to play a pedagogical role in addition to making the national curriculums manifest to both teachers and students. In Kenya, the textbooks published by the state-owned company are regarded as core and occupy a central role in mathematics teaching. We present findings on the perceptions of students at three Kenyan public secondary schools on what they value in textbooks and what they find lacking in their core text in their efforts towards engagement with mathematics through self-regulated learning. Implications for practice are presented.

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Introduction

Across the African continent, there are moves to reform the teaching and learning of mathematics by adopting more learner-centred pedagogies than heretofore (Sifuna & Kaime, 2007). Schools and teachers are encouraged to adopt practices that demand more independence from school students with less emphasis on rote-learning and transmission models of teaching. A useful conceptual framework for coming to a better understanding of the impact of this on students is self-regulated learning: the more capable a student becomes in regulating their own learning, the more the student will be able to work independently and to develop understanding. This conceptual framework is employed in this article.

Internationally, textbooks are one of the most used artefacts in mathematics classrooms (Jukić Matić & Glasnović Gracin, 2021), having "a profound influence on the learning opportunities presented … [and] reflect[ing] cultural values" (Koljonen, Ryve, & Hemmi, 2018, p. 295). In many African countries, including Kenya, government-commissioned textbooks play a key role in mathematics education. The textbooks have typically been designed for teacher-mediation but are now being asked to play a different role in which students use them independently. Given the centrality of the textbook and the

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changes in its expected use alongside the reconceptualising of student learning, the need for research into textbook use in the African continent is manifest. This small-scale qualitative study is intended to contribute to this area of enquiry.[1]

We begin by reviewing the literature on mathematics textbooks including the role of textbooks in Kenya and the significance of the language of instruction. The larger study of which this was a part was designed to assess the impact of a range of intervention strategies on students' self-regulated learning in mathematics. A brief analysis of this concept follows and the larger study itself is then introduced. The study took place in three Kenyan secondary schools. These are described in some detail to provide what we hope is a vivid account of the Kenyan context: accounts of schools and mathematics classrooms from North America, other Anglophone countries, East Asia and Europe dominate mathematics education research and can easily play a hegemonic role in our assumptions about teaching and learning and in how we envision schooling.

Textbooks were not an original focus of the research but emerged as a theme during early stages of data collection. Two research questions resulted:

- What are the key characteristics of textbooks that students look for to support their self-regulated learning?
- How effective or otherwise do the students find the government-commissioned textbooks (KLB) in supporting their independent learning?

These questions then informed aspects of later data collection. Findings are presented and discussed and we conclude the article by considering the implications for practice.

Research on textbooks

In the past two decades, there have been increased efforts by mathematics education researchers to go beyond teacher-focused textbook research to explore student-textbook relationships (for example, Berger, 2019; Pepin & Haggarty, 2001; Törnroos, 2005), probably linked to preceding research on the shortcomings of the sole-mediator role of the teacher, with student use of textbooks being largely teacher-mediated (Haggarty & Pepin, 2002). Such a position has been found to be fairly limiting (MacIntyre & Hamilton, 2010; Weinberg & Wiesner, 2011) especially in the current mathematics education context across the globe which is characterised by a shift towards pedagogies in which learners are asked to take a more active part.

The adoption of such pedagogies in mathematics has resulted in an increased expectation for students, especially at secondary school, to "self-read" the textbooks including for self-instruction (Pepin & Haggarty, 2001; Törnroos, 2005). Accordingly, researchers are increasingly keen to understand the interaction between specific features of the textbooks and the students' ability to use them as core resources for independent learning. Some of the aspects that have been explored include: the pedagogical intentions of the textbook (Haggarty & Pepin, 2002); the influence of textbooks' content and presentation on students' engagement and participation in learning (Macintyre & Hamilton, 2010; Weinberg & Wiesner, 2011); how explicit textbooks are, through their examples, in supporting the development of the students' reasoning and verification strategies (Mesa, 2010a); and the influence of textbooks on students' achievement (Ham & Heinze,

2018). Other foci have been an interest in control structures (Lithner, 2004) which links to exploring how effective textbooks are for self-instruction by modelling the process of working out specific problems; the extent to which textbooks use elaborated sentences (Mesa, 2010a) or the rhetorical voice (Pepin & Haggarty, 2001) to show and justify the connections of ideas presented in the argumentation; and the potential of examples (Mesa, 2010b) for developing metacognition.

However, the interest in student-textbook relationships seems not to have extended to African contexts where the research, largely, remains teacher-focused (for example, Namukasa, 2018). This is significant for a number of reasons. First, mathematics textbooks and their use has been found to be different under different curriculum interpretations and these are generally influenced by different pedagogical intentions and different cultural and education traditions (Ham & Heinze, 2018). Second, it can be argued that, more often than in other regions, many African secondary school learners find themselves forced by circumstances, such as high teacher to student ratios, to rely more on textbooks as the second if not alternative teacher. Thus, there is a tendency for student self- rather than teacher-mediated use.

Added to this are the issues of the choice, publishing and distribution of textbooks. In most African countries, Kenya being an example, there is a designated, government-published textbook that is distributed to all schools as the key resource for mathematics. There is an urgent need for systematic exploration of the learning opportunities (Ham & Heinze, 2018) and constraints (Shield & Dole, 2013) that such textbooks, designed to be teacher-mediated, present to students engaged in independent study. Published textbooks are used as the main teaching and learning tool in Kenyan secondary schools and act as the key resource for making the national curriculum manifest to the students. Students spend most of their time, both in the classroom and outside it, working on textbook content.

In Kenya, of all the mathematics textbooks available in the market from both national and international publishers, the ones published by a state-owned publisher, the Kenya Literature Bureau (KLB), are recognised as the core textbook for secondary schools. They are published for each school year and are the *de-facto* curriculum for mathematics. They are accompanied by a teacher guide which, apart from offering answers for the exercises, offers guidance on structuring lessons and proposes the pedagogical practice to be adopted. In essence, the KLB is considered a government-approved blue-print for content coverage and instructional sequence, coming close to representing both the intended and implemented curriculum. That said, many schools also purchase other textbooks as an additional resource but the purchase and use of these varies across the schools: public schools in the higher tier and private ones have greater purchasing power while those in the lower tier mostly have to rely solely on the KLB. Similarly, the socio-economic backgrounds of students significantly affect their ability to purchase additional texts for themselves.

Mathematics textbooks in Kenya, including KLB, are written in English and this presents problems for many learners, an experience common in much of post-colonial Africa. (For Kenya-based research, see Essien, 2018; Oluoch, 2017; Wanjiku-Omollo, 2014). Language issues in multi-lingual classrooms are complex (Barwell, Barton, & Setati, 2007) and it is not our intention to oversimplify what is involved; we simply outline some of the issues to be considered. Kenya hosts over forty-two local languages (Oluoch, 2017) but the official languages and the languages of instruction are Kiswahili

(lower primary) and English (from upper primary onwards). English is valued as an international language and a language that "opens doors" (Wanjiku-Omollo, 2014): but this easily shifts into a neo-colonial downgrading of other languages with English as hegemonic (Nabea, 2009):

> Fluency in English is considered by many to have more benefits for the learners because it is spoken widely across many countries in the world. It is also seen as a symbol of power, status and prestige. (Setati, Chitera, & Essien, 2009, p. 67)

The language in which education is principally conducted, the language of instruction and assessment, is "one of the most far-reaching and significant features of any education system" (Wanjiku-Omollo, 2014, p. 16). Most secondary classrooms in Kenya are places of language diversity (Barwell et al., 2007) but, whilst code-switching (Adler, 2001) occurs, the formal medium of instruction, fully mirrored in the textbooks, is English. Many students are not proficient in English (Nabea, 2009) and there is a lack of teaching materials in other languages (Dubeck, Jukes, & Okello, 2012). The accessibility of the language of instruction has been the focus of attention of a number of researchers (Abedi & Lord, 2001; Opoku-Amankwa, 2009; Setati & Moschkovich, 2011). It has been found that "when a student is reading, pauses for unfamiliar words or constructions are likely to disrupt the flow of comprehension" (Abedi & Lord, 2001, p. 223). Oluoch (2017) found a positive relationship between the students' level of proficiency in the language of learning, in this case mother-tongue, and their mathematical performance. She notes:

> In instances where the language of instruction is appropriately chosen, learning outcomes are higher with greater access to learning, retention and continuity in school. (p. 18)

However, in the context of textbook use to support independent learning, it is important to note that, alone, improved language proficiency in the language of instruction will not in itself generate an increased capacity for reasoning, analysing and evaluating (Essien & Setati, 2007).

Self-regulated learning

We now offer a brief introduction to self-regulated learning, a construct that describes the regulation of one's cognitive process in an education setting (Pulkkinen & Puustinen, 2001). According to Perry (2002), students' self-regulation during learning entails independent metacognitively-led strategic action fuelled by the students' intrinsic motivation: there is an emphasis on the active involvement of the students in setting learning goals and their seeking to achieve them by monitoring, regulating and controlling their cognition, motivation and general learning behaviour – a fusion of skill and will. Accordingly, self-regulated learning has been widely considered as an individual characteristic involving a cyclic adaptation of thoughts, feelings and actions in the attainment of personal goals (Beishuizen, 2008). Its strategic and regulating aspects are taken to be dynamic and intrinsically driven and to be spurred on by enthusiasm, persistence and curiosity with both "hot" (motivational and affective) and "cold" (cognitive and metacognitive) components (Patrick & Middleton, 2002).

More recently, some researchers have reconsidered the emphasis on the individual. Calling for attention to "external co-regulatory elements in the self-regulation" (Volet,

Vauras, & Salonen, 2009, p. 217), they contend that students' regulation during learning should be considered more as an act of socially shared regulation or co-regulation (Hadwin & Oshige, 2011; McCaslin & Burross, 2011; Rogat & Adams-Wiggins, 2014). For example, Hadwin and Oshige (2011) claim that co-regulation plays an important role: it is "a transitional process in a learner's acquisition of self-regulated learning, within which learners and others share a common problem-solving plane, and self-regulated learning is gradually appropriated by the individual learner through interactions" (p. 247).

Both groups, whether identifying with the individual or the social, consider self-regulation in learning to be made up of three main components: goal setting, monitoring of the learning process and modification of learning strategies (Schloemer & Brenan, 2006), components directly linked to the preparatory or preliminary phase, task completion phase and appraisal or adaptation phase (Pulkkinen & Puustinen, 2001). Similarly, there is a general consensus that cognitive, motivational and social factors each play a key role in a dynamic and recursive process.

Various models of self-regulation exist, some of which provide a framework for making sense of superordinate contextual factors whilst others have a main focus on contextual factors within the students' immediate learning environment. For example, Ben-Eliyahu and Bernacki (2015) give space to macrosystems which include economic patterns, political philosophy and social conditions as well as more local exo- and mesosystems like neighbourhood and family, with the immediate learning environment as a microsystem. Others limit themselves to researching just these microsystems. For example, Zimmerman (1989) focuses on personal affective and cognitive self-regulation, on the observation and adjustment of the environmental conditions and on self-observation and strategic adjustment of behaviour whereas Perry, Phillips, and Hutchinson (2006) focus on deep understanding, the attribution of outcomes to factors the learner can control and the ability to choose from a repertoire of tactics and strategies in solving the problem at hand. What all have in common is an emphasis on the importance of individuals believing themselves capable of achieving their goals.

The study

The intervention study of which these findings are a part (Otieno, 2018) was an exploration of self-regulated learning in mathematics in Kenyan secondary schools. The fieldwork, both the intervention and the data collection, took place in three different schools, Ademba, Origa and Rayolah (pseudonyms), mostly in 2016. Ethical approval was obtained from both Sheffield Hallam University and Moi University Research Ethics Committees, as was ethical consent from the schools' principals, the focal classroom mathematics teachers and the parents of the students for the focal classes. Ethical assent from the wider community was also obtained by open meetings at which the projected research was described and comments invited and discussed.

Overview

The doctoral study from which this article is written was birthed from interest by the first author in making sense of small-scale interventions she had implemented in Kenya over

a period of eight years to improve students' relationship and engagement with mathematics. For her research, she implemented a number of such interventions in three secondary schools. Aware of the context- and value-laden nature of learning, unlike most mathematics interventions in Kenya which tended to focus on teacher attributes (Bett, 2016; Sifuna & Kaime, 2007), hers centred on the students themselves and the contextual factors they experienced. The choice of the theoretical framework of self-regulation was largely a result of resonance between her experience of, and approach, to learning mathematics during her schooling and her review of the literature which pointed to the potential for self-regulated learning to improve students' motivation, strategic efforts, achievement and skills for learning.

The decision to explore the adequacy of KLB in supporting self-regulated learning was occasioned by a response by one of the students midway through the implementation and collection of data: during an interview, he said he had done less self-study during the term because he had lost his preferred mathematics textbook (not KLB). The subsequent discussion suggested that interrogating the students' perception of the adequacy of KLB in supporting self-regulated learning of mathematics would contribute to the overall enquiry.

The field-work schools

We have included reasonably detailed sketches of the three participating schools, not because they are a central tool in the analysis, but because it is still relatively uncommon in mathematics education research for schools and classrooms from Kenya to be represented.

Ademba Secondary School is a faith-based community mixed boarding secondary school offering a values-based education with a focus on spiritual and character development. A significant proportion of the staff are either members of the founding church, which owns the school, or of affiliate churches. Other members of the church community play an active role in the school. There is a strong community feeling with warm relationships between the students and the teachers. Great emphasis is placed on student self-government and Ademba does not have external regulation tools like bells, explicitly outlined and publicly placed school rules and corporal punishment. The school does not rank students, places a high value on collaboration and has all attainment groups. Attainment is around the middle of the spectrum. A majority of the parents are middle class and the school has a fairly good infrastructure. Each student had an individual copy of KLB and at least one other mathematics textbook, kept for an academic year. The library is well stocked and most of the students have other books of their own.

Origa Secondary School is a fairly new, government-funded sub-county school and is amongst those from the very low tier. It has very basic infrastructure: the classrooms are crowded, with over 50 students in a class, many of whom do not have proper desks or chairs. Located in a metropolitan area, it has a very diverse group of students in terms of ethnicity, and even religion, making it difficult to unify the parents, teachers and students into a coherent school community. The neighbourhood is poor and lifestyles reflect its urban location: In contrast to rural communities where families live together in homesteads, here there are small and very basic rental houses. Rather than farming being the main economic activity, there is a proliferation of small businesses (many of which are

small "pubs"). Many parents spend a lot of time away from home trying to earn a living for their family either running small enterprises or labouring in construction sites in the capital city. The impact of poverty on the students' lives can be seen in their aging, patched-up uniforms and poor diet. Access to the school is difficult during the rainy season with most students walking barefoot through the sticky soil. Relationships are strongly top-down and the teachers often disapprove of the students' lifestyles, particularly those of the boys. Performance is poor and many students struggle with English, the main medium of instruction and assessment. Most students had their own copy of KLB, distributed at the start of each term but collected in during the holiday. Many students bought a revision[2] book.

Rayola Secondary School is a sub-county secondary mixed day school with a small boarding section for girls, largely attracting students from the wider district within which it is situated. A majority of the students and teachers belong to one local ethnic community. The school was founded by a local church but the running of it has been handed over to the government which decides on teacher recruitment and key school policies, though the church continues to have a significant influence and the school retains a faith orientation. It has a better infrastructure than Origa with basic school desks for each student but classrooms are over-crowded. Relationships are top-down and the cane is used, with student leaders (who have a special uniform) having a prominent role in discipline. Most of the students have been low attaining in primary school but a few opt for the school because of their inability to pay the fees demanded by the higher tier schools. Most parents work in farming and small related businesses. Famine is frequent and poverty levels are high with many students absent through inability to pay fees. Most students have to travel long distances to school. At least two students were expected to share a copy of the KLB. The books were distributed to the students at the beginning of each academic term and collected during the holiday. Most students, chiefly girls, who could afford to do so bought a revision textbook.

All three schools have concerns with their current academic performance especially in mathematics although Ademba is more heterogeneous with regard to previous attainment.

The study interventions and data collection process

Drawing on literature on self-regulated learning and on intervention studies, deliberative dialogues (Plamondon, Bottorff, & Cole, 2015) between the first author and students were used to arrive at locally-grounded, relevant and owned interventions. The specific interventions, which emerged at different stages of the deliberations, were progressively and flexibly implemented. They included: collective shaping of class norms to guide student engagement with learning in sessions; forming collaborative peer learning groups; voluntary daily working in a designated practice book of five problems chosen individually or through the peer learning groups as part of self-study; and implementation of an inter-school mathematics tournament. Metaphoric drawings (Ingebrethsen, 2016) about mathematics and reflective narratives were also used, doubling up as interventions with a potential for positively enhancing students' dispositions towards learning mathematics (McVarish, 2009) and as a data collection tool (Stuart, 2012). The data linked to exploring the adequacy of mathematics textbooks were

largely collected through qualitative interviews conducted before, during and at the end of the interventions.

28 students (14 female and 14 male) were interviewed; 12 from Rayolah, six from Origa and 10 from Ademba including both day scholars and boarders. Using theoretical sampling (Creswell, 2013), the selection of interviewees was done progressively, based on emerging theoretical interests from data collected at different stages of the enquiry. For example, at the pre-intervention stage, students were selected based on their participation in the deliberative dialogues and/or their expression of negative or positive academic emotions (Pekrun, Goetz, Titz, & Perry, 2002) towards mathematics through the texts explaining the metaphoric diagrams. Similarly, during the intervention stage, additional interviewees were selected in response to insights in their reflective narratives and/or their consistency in completing in their practice books the work previously agreed.

Data collection was an intense process involving, amongst other things, historical analysis, intuitive judgment, cross-case comparisons and continuous reference to theoretical knowledge. This supported a "bottom-up" approach to designing interviews, allowing for the emergence of data (Renganathan, 2009). The number of interviewees was progressively increased until data and theoretical saturation had been attained (Robinson, 2014). Data trustworthiness was sought by building adequate rapport (Lechuga, 2012) and paying keen attention during interviews to emotional feedback and both verbal and non-verbal cues (Voldnes, Grønhaug, & Sogn-Grundvåg, 2014).

The interviews were principally conducted in English but some code-switching occurred. In transcription, the original was kept with an English translation in brackets. A conversational manner was adopted with minimal steerage (Pawson, 1996). The students were asked open-ended questions about their use of KLB for their self-study with additional probing if needed to elicit comparisons between KLB and other textbooks.

Data analysis

In analysing the data, the first step was to use the theoretical models of self-regulated learning found in the literature (for example, Ben-Eliyahu & Bernacki, 2015; Perry et al., 2006; Zimmerman, 1989) to make deductive inferences from the students' responses. This led to the identification of some initial attributes of the core and other textbooks in supporting the students' independent learning. But the world being "theory laden but not theory determined" (Fletcher, 2016, p. 4), alongside this deductive inference, abductive inference was also used, starting with the data and then seeking to find plausible and "most likely" conclusions, continuing to explore both the students' subjective experiences of self-regulated learning and the mechanisms that underlay those experiences; this allowed for findings that did not fit with the pre-determined theoretical frame. This was particularly important in remaining sensitive to aspects specific to the cultural contexts of the participants and in ensuring that western-based theoretical frameworks of self-regulated learning were not forced onto the Kenyan context. Where aspects of the data did not tally with the theoretical lens, relevant research literature was brought into play. This three-way dialectical process between using theoretical analysis, looking for plausibility and "most likely" and returning to the research

literature continued iteratively until what was emerging about the students' textbook use and self-regulation seemed settled between iterations.

Findings

The data generated by the larger study had identified the influence on self-regulated learning of some wider contextual factors, for example, family relationships and background, cultural factors and religion – the macro-, exo- and mesosystems. But the data which related to the adequacy of Kenyan secondary schools' mathematics textbook were almost entirely restricted to factors within the more immediate learning environment – the microsystems. Nevertheless, from other aspects of the study, the first author was able to bring knowledge of some of these wider contextual factors to her understanding of what the interviewees said.

Three interconnected factors that emerged from the analysis as contributing to self-regulated learning were: the extent to which students' self-monitoring and self-evaluation were supported by KLB and other textbooks; whether or not the textbooks helped them to have a repertoire of strategies and tactics available to use; and the extent to which they were able to use the textbooks to develop understanding and deepen their learning. A fourth factor concerned the level of challenge provided, with responses varying from seeking to avoid it to welcoming it. Finally, the accessibility or otherwise of the English language used could undermine attempts at self-regulation. We now consider each of these features more fully.

We saw the first three characteristics at play in various interconnected ways. One of the things the students valued was being able to work independently to come to understand things. In this context, they spoke of the need for comprehensive and clear explanations. For example, Nyagonyango (female, Ademba) said that a number of times she found the summary notes in KLB not comprehensive enough and had to look for other books to support her self-instruction and self-monitoring. Ambonya (male, Ademba) said that he preferred the clarity of another textbook rather than KLB whose exposition he said tended to "mix him up" and Kish preferred the more extended explanations in one of the revision books:

> It has … explanations I can understand; KLB - the explanations don't explain in depth like the other one - I prefer the revision book. (Kish, female, Origa)

They were aware that detailed and logical explanations without sudden leaps or gaps supported their learning and they criticised textbooks that did not provide full, step-by-step explanations. For example, Ogello (male, Ademba) said that "KLB is shallow … it kind of jumps to the answer and does not give the explanations". Sudden leaps or gaps in the text were unhelpful and inhibited understanding:

> You will find I am using KLB and sometimes … totally I don't understand; there are some gaps … for example, you will find that there is a number 12 and you are not sure where it has come from. But in these others, they will explain step by step, they will tell you 'for example' … 'therefore' … (Hellena, female, Rayolah)

Here we see the students monitoring and evaluating the extent of their understanding and seeking to deepen it.

They had other ideas about how to deepen their understanding. For example, Ogello (male, Ademba), who spoke of using most of his private study time to concentrate on "internalising the concept", reported the usefulness of real-life examples. He had monitored his progress and also recognised the need for the textbooks to connect new concepts with concepts he had learnt earlier to make "the understanding of the normal syllabus to flow better", to help with the new concept "going inside". For Adie, the use of drawings helped understanding:

> That [alternative] book is gold … to me … You are also given a drawing to explain that particular thing. The other books just give a formula. It is like you only have the formula. And you do not have anything on what is being talked about. (Adie, male, Ademba)

The students also noted that their understanding was deepened when they were presented with a variety of ways to approach the problems they tackled in their independent study:

> Coz it [an alternative textbook] has many methods, explains better than KLB … it has methods … more than one method which you didn't know. (Adhis, female, Rayolah)

> [The preferred] book shows you that is not the only way that you can do it. It gives you another way to do. Another formula … KLB teaches you one method. (Adie, male, Ademba)

Being able to see the relationships between different approaches helped enhance their conceptual fluency.

They needed textbooks that helped them monitor and evaluate their learning and again had some useful ideas about how this might be achieved. Some students developed their understanding of concepts by studying examples and wanted a good variety. Kyla (female, Ademba), for example, said "these books ask questions differently … So I use the other book when discussing with my friend". Having a good number of examples was also important in coming to understand more challenging ideas. For example, having monitored her learning, Ado said:

> some of the textbooks have many examples, so based on how much I have not understood that is what I use … KLB should give more examples as the current number sometimes is not enough to understand a concept that is more complicated. (Ado, female, Rayolah)

Ado also voiced a concern of several students: she was aware of how helpful answers and clear worked-out solutions were in supporting independent learning and self-monitoring and evaluation because they allow one to check understanding and see "if what you have done is right". The students missed the feedback which answers and worked-out solutions can provide and this affected their ability to exercise self-judgement.

These three interconnected aspects of the students' responses, which all seemed to call for greater interaction between student and text, may be linked to the wider social context within which the teachers worked. The teachers were often under immense pressure to complete the assigned syllabus content (which they considered too packed) within a given time; and, as a result of the large number of lessons each had to teach and, for Rayolah and Origa, the large class sizes, teacher workload was very heavy. As a result, in all three schools, most resorted to instructional practices that allowed for very limited student participation and little focus on understanding.

> the teacher gives long explanation, he just dwells on one question for long, about 20 min and yet the teacher does not ask us "do you know?" or "how can you explain the question?" (Odeny, male, Rayolah)

> Learning mathematics this week was challenging. A lot was not being understood [by me] especially during the lessons … What I didn't like was that our maths teacher's aim is not for us to understand but to finish the syllabus. He also doesn't want to be asked questions or any opinion. (anonymous, Ademba, text accompanying metaphoric drawing)

It seems likely that the students, lacking both participation and the development of understanding in class, were valuing books that provided these instead.

The issue of the level of challenge was one where the responses of the students varied; both responses seemed connected to the possibilities for self-regulation. Some preferred straightforward questions and others responded positively to a more complex cognitive challenge. The responses suggested that the cognitive demand of the questions had some influence on different aspects of their self-regulation. One group of students, mainly boys from Rayolah and Origa, indicated that they used KLB during their study because the questions in the exercise section were not complicated or very difficult.

> KLB has not given complicated things, the sums are just of moderate difficulty … It is not a must for one to be a fast learner, for one to understand, because it doesn't have many things/ demands. You will just pass through them slowly and you will come to understand things … (Achuku, male, Origa)

Odeny (male, Rayolah) welcomed the familiarity of the KLB questions "because it is what we have done in school". These students also liked clear links between questions and the topics to which they related, finding mixed exercises in KLB confusing.

> … from mixed questions you have difficulty to interpret, you don't know which topic it has come from … I like the questions, after I remind myself which topic has the questions. (Owino, male, Rayolah)

Conversely, however, some of the girls, especially those from Rayolah, seemed to prefer the exercise section of other books because they found them cognitively challenging. Maria (female, Rayolah) said that the other textbook she used "has sums that are fairly difficult that makes you think" whilst Adhis (female, Rayolah) appreciated having more difficult questions because they prompted her to discuss her mathematics with others in her group or with the teacher.

At Rayolah and Origa, the out-of-school lives of the boys and the girls were very different. The girls were kept at home, not allowed to do outside jobs and were much more closely supervised. They had to work hard within the family but in ways that would not directly affect or undermine their studies. The boys, however, were, in many cases, already living separate, independent and largely adult lives. (This was not the case at the relatively prosperous and middle class Ademba.) Owino was not untypical:

> … during weekend a boy can get a job in the neighbourhood then gets his say, Ksh100-200, that is what you save to buy phones and buy [internet] bundles … and then I am in my house there is nothing the parent will do to me; I will come when the parent is asleep. Food I will buy for myself. Boys in most cases don't ask for food from the parents, they fend for themselves. They buy food for themselves from the shops or market. (Owino, male, Rayolah)

It seems likely that this independent and adult-orientated lifestyle would lead to less engagement with a schooling agenda and therefore to a more instrumental relationship with learning. In addition, this lifestyle led to both limited time for self-study and to competing interests in non-academic activities. These factors too would be likely to lead to a preference for straightforward questions and quick answers.

> One of the things that takes many boys away from their books is movies … there are places in the neighbourhood that they can go to watch movie. Then there are those who have screens and DVD in their houses … those who don't have may also come to your place … they end up making you to abandon reading … (Achuku, male, Origa)

Finally, as expected, a concern raised by some students was the accessibility of the English used in the textbooks. As with most mathematics classrooms in Kenya, the ones in which the study was conducted were places of language diversity but, whilst code-switching occurred in spoken communications, with Kiswahili, Sheng and English all being used, the formal medium of instruction, fully mirrored in the textbooks, was English. This caused problems throughout – in the exposition, in the examples and in the exercises – but students found the level of difficulty experienced depended on the text being used. In this respect, KLB fell short of the other textbooks, with students finding "the English is easier to understand than that of KLB … it is easy to understand" (Ado, female, Rayolah). Atie said:

> [the alternative textbook] is easier to understand, I mean the words; when you read, you feel like you understand [better] than KLB which has English inanichanganyisha [mixes me up, confuses]. Sometimes you have to use a dictionary … and I also don't use the KLB questions in the exercise section because sometimes I find the questions [language] difficult to understand. (Atie, female, Origa)

Thus it seemed that language accessibility had a direct impact on students' efforts at self-instruction.

We note that the concern about the accessibility of the English used in KLB emerged largely from the students from the two public schools, Origa and Rayolah. The students from the private Ademba school were mostly from middle class families where the parents were proficient in English and encouraged its use; they also were educated in English from pre-primary onwards. In contrast, few students from the two public schools used English as a medium of communication outside school and, in most of their education, they relied on their native language, versions of Kiswahili and moments of code switching by the teacher. Attempts at self-instruction through textbooks was therefore unique in that it was almost the only learning opportunity that was strictly through English.

Discussion

The use of qualitative methods in this study allowed the student voice to contribute to researched understanding of the effectiveness or otherwise of mathematics textbooks in supporting independent learning and to suggest ways in which the textbooks could be improved. The approach was culturally sensitive and allowed a distinct, non-western voice to come through.

The study was small-scale, only involving three schools and, within them, a fairly limited number of students. Nevertheless, the findings provide pointers to ways in which textbooks need to be redesigned to offer better support for self-regulated independent learning. We draw on these to address our two interconnected research questions:

- What are the key characteristics of textbooks that students look for to support their self-regulated learning?
- How effective or otherwise do the students find KLB in supporting their independent learning?

The study identified several key textbook characteristics that the students looked for to support their self-regulated learning. We consider each of these in turn and, for each, assess how effective or otherwise the students found KLB. In line with previous research in other cultural contexts (Fan, Zhu, & Miao, 2013; Pepin & Haggarty, 2001), explicit explanations and some rhetorical presence in the text emerged as key for self-regulated learning. As one of the students remarked, KLB was written for the teacher and so the text was often experienced as not full enough and as unclear and incomplete. For example, they drew attention to inadequate comprehensiveness and comprehensibility in the exposition, the limited presentation of different methods, the failure to connect new concepts to those learnt earlier and the limited use of explanatory devices such as real-world examples or drawings. The failure of KLB to provide sufficient number and variety of examples (known to be important for developing procedural and conceptual fluency (Mesa, 2010b)), answers or worked out solutions to the questions significantly affected the capacity for self-judgment and self-evaluation and thus metacognitive planning. In addition, many participants found that the English of KLB presented a challenge to their cognitive self-regulation with the anticipated disruptions in comprehension occurring.

The question of the students' response to the cognitive demand of the exercises was less clear. The literature suggests that cognitive challenge may support aspects of self-monitoring and self-evaluation (Mesa, 2010b) because cognitive complexity leads some students into paying more attention to what (and how) knowledge and resources need to be deployed to solve successfully the problem at hand. A number of students said they preferred trying out questions from other textbooks instead of KLB precisely because the former were more cognitively complex and, as such, pushed them into deeper cognitive engagement, thus allowing them to identify areas of difficulty where they needed further help from friends or teachers.

Conscious reaching out for difficult questions was seen to lead to working with peers or initiating dialogue with the teacher. Both of these are likely to support co-regulation which appears to work as a key transitional process in students' acquisition of self-regulation (Hadwin & Oshige, 2011). It is known that when students work together on problems, the development of mathematical thinking is supported across the attainment range (Boaler, 2008) and the practice impacts positively on learners' metacognition (Smith & Mancy, 2018). It is possible that, if frequent opportunities for peer interaction and sharing of problem-solving strategies, approaches and findings were to be built into the text, this might lead to more students being willing to attempt more cognitively challenging tasks. We recognise the likelihood that this might not extend to all students.

We recommend these pointers be explored further and that revised approaches to textbook writing be tested out with a more comprehensive sample.

Implications

In Kenya, as in many other countries on the African continent, the core mathematics textbook provides by far the most significant resource used in teacher teaching and student learning. As such, the textbook tends to have a central influence in developing teacher pedagogy and, as investigated here, in supporting or otherwise student self-regulated learning. It is important to note that, given this significant role of textbooks, equity concerns arise. In many schools, especially lower tier ones, there is a persistent problem of not having either enough textbooks or a sufficient variety leading to less than full access for some students.

The research reported here offers clear indications of what needs to be done to make Kenyan mathematics textbooks more accessible to students for their independent use and better able to support self-regulated learning. We recognise that KLB is currently designed to be teacher-mediated and therefore it is unsurprising that it had deficiencies in supporting independent student use. Nevertheless, by considering the students' response to these deficiencies, with the current changes in mathematics education and therefore in the use of textbooks, our findings have useful implications for the mathematics teachers; textbook authors and publishers; and the Kenya Institute of Curriculum Development (KICD) and other such bodies that play a key role in vetting and approving textbooks for use in schools.

For the teachers, the findings suggest that they may have to develop strategies to compensate for some of the identified deficiencies in the core textbooks. For example, the concerns raised by some of the students on the comprehensiveness of the explanations in the exposition section and accessibility of the English used should push the teachers towards strategies for scaffolding the students' use of the textbooks and ensuring that they create learning environments that allow for students to ask questions and seek clarifications. Similarly, setting group tasks as part of students' homework – where students are relatively isolated geographically, most still have access to mobile technology – will help provide an environment for co-regulated and self-regulated engagement.

The findings also provide valuable information for mathematics textbook authors and publishers on aspects to which they need to pay attention if the textbooks are to afford better opportunities for self-regulated learning. The findings provide pointers to attributes that should be considered when vetting textbooks to ensure that the texts not only support the teaching of mathematics by teachers in classrooms but also the students' self-regulation during learning. In addition, taking steps based on the findings to improve the core mathematics textbooks' adequacy in supporting self-regulated learning will, in the short term, enhance the student-textbook relationship. In the long term, by modelling a different pedagogical approach, it may provide a significant contribution to current efforts by countries to make learning mathematics in secondary schools more student-centred, reforms intended to put the learner at the centre of the teaching/learning process, reforms which rely for their effectiveness on student capacity for self-regulated learning.

Notes

1. The article is based on the first author's doctoral thesis (Otieno, 2018). All of the data extracts presented are copied verbatim from the thesis and some sections of the text also first appeared there.
2. The use of the word "revision" is not the same throughout Anglophone countries. Here, as in the UK, the term means examination preparation.

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