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Malawian secondary mathematics teachers' take-up of language responsive teaching through lesson study

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In this paper we explore Malawian secondary mathematics teachers' take-up of language responsive teaching (LRT) during Lesson Study (LS) professional development (PD) on similar triangles. The findings presented here suggest that take-up of LRT through LS is complex. The teachers experienced and advocated engagement of learners in more mathematical talk and thinking during the PD workshops, lesson planning sessions and in lesson reflection. The limited, emergent enactment of some of these practices illuminates their complexity. We posit from this that developing LRT through LS, and particularly teachers' expanding their repertoires for enhancing students' language production, needs to be understood as a long-term goal with opportunities over time for planning, enacting and reflection.

Keywords: Language responsive teaching, lesson study, professional development.

Introduction

The teaching and learning of secondary level geometry is globally recognised as challenging (Seago et al., 2013). In Malawi there are calls for enhancing teaching quality of geometry through continuous professional development (PD) (Ministry of Education, Science and Technology, 2020). We responded to this call by initiating a Lesson Study (LS) PD project focused on geometry with Malawian secondary mathematics teachers in two schools to improve the teaching of geometry. After functioning for over 100 years in both Japan and China as systemic ongoing PD, LS has been adapted in many countries around the world because of its benefits including provision of opportunities for teachers to learn to improve their lessons through learning new teaching pedagogies, deepening their subject matter knowledge, working collaboratively, and becoming self-reflective (Huang et al., 2019). Very recently LS was introduced in Malawi in primary mathematics education, with evidence of improved teaching quality (see Fauskanger et al, 2022). This motivated our initiation of LS at the secondary level.

Recent calls related to adapting LS include promoting structuring discussions using theoretical resources, what has been referred to as theory-driven LS (Huang et al., 2019). We thus began the first cycle of LS by conducting a two-day workshop with experienced secondary mathematics teachers from two schools where we introduced them to: 1) activities for promoting geometric reasoning using a Mathematics Teaching Framework (MTF) and 2) the purpose and process of LS. MTF is a lesson planning, observation and evaluation tool developed and productively used with secondary teachers in some South African some schools serving low-income communities with educational contexts similar to most Malawian schools (Adler & Alshwaikh, 2019). It was thus considered an appropriate resource for promoting teachers' learning in our study. MTF brings into focus three key interacting mathematics teaching practices namely exemplification, learner participation and explanatory

communication (elaborated later). During the last session of PD, the teachers selected and discussed a problem and content area they would focus on, and the first cycle followed. We have reported teachers' take up of the exemplification elements of the MTF. They expanded their example sets, using additional and different dimensions of variation of geometry diagrams in their lesson plans and enactments (Mwadzaangati et al., 2022), confirming results reported on LS in South Africa that used the same framework: that LS can promote and support teachers' learning of exemplification practices (Adler & Alshwaikh, 2019). At the same time, however, the learner participation and explanatory communication elements of the MTF remained within the teachers' routine practices with teacher questioning inviting largely yes/no or single-word responses. This is not surprising; enabling learners' elaborative talk through language responsive teaching (LRT) is difficult (Prediger, 2019).

In cycle 2, we worked with the teachers on LRT through planning, enacting and reflecting on language use – on their and their students' talk - in their lessons. In line with the MTF, we focused on words used to communicate and justify mathematics, and on creating opportunities for learners to express their thinking. In the two-day workshop at the beginning of cycle 2, we engaged teachers in activities for promoting and responding to learners' mathematical talk and thinking. At the end of the workshop, teachers from one school chose to conduct LS on the topic of similar triangles, a concept research has shown as non-trivial to teach and to learn (e.g. Seago et al., 2013). The problem identified by the teachers was that learners face challenges in defining and applying properties of similar triangles. In this paper, we share our initial insights into the LRT practices that the teachers experienced and that were advocated during the workshops (e.g., probing learner thinking and talk to elaborate meanings of definitions and conditions supported by multiple representations) and those that were enacted in lessons. We pursue the following research questions: How were LRT practices interpreted by the teachers during (1) LS planning sessions and (2) lesson enactment?

Theorising language use in teaching: the MTF and LRT

The mathematics teaching framework (MTF) is rooted in sociocultural theory (Vygotsky, 1978) and thus with an orientation to mathematics as a network of interrelated and well-organized scientific concepts, and to mathematics teaching/learning as goal-directed and mediated (Adler & Alshwaikh, 2019). The MTF is a lesson planning, observation and reflection tool, and the 'teaching' version of the Mathematical Discourse in Instruction (MDI) analytical framework for describing and evaluating the quality of mathematics made available in teaching (Adler & Ronda, 2015). Its starting point is that teaching is always about something (the lesson goal), and the key teaching practices in meeting the goal include exemplification (examples, tasks, and their representational forms), explanatory communication (word use and justifying) and learner participation (what learners are invited to do, say and write). There is attention in the framework on the connections and coherence between these practices. Given the focus of this paper we zoom in here on explanatory communication (EC), the language practices in the MTF (see Adler, 2021, for detail), viz. how we use words to (1) name and mediate mathematical objects, processes and procedures – with attention to *movement between informal/everyday and technical/formal mathematical registers*, and (2) how these are justified – with attention to whether these are *statements and/or assertions or whether they are elaborated and then in what way*.

While the MTF identifies *what* teachers need to consider (colloquial and formal word use and different kinds of justifications), there is no explicit attention to the teaching moves that support learners' language use, particularly expressing their ideas. In the PD with the teachers, we expanded the MTF by drawing on some of the design principles of LRT (Prediger, 2019; 2022) which include moves such as identifying, demanding, supporting and developing language. We also worked on these with teachers in the PD. Elsewhere we have argued and elaborated the networked nature of MDI, including in relation to language practices (see Adler et al., 2022) and do not rehearse this here. To answer our research questions, we were interested in whether and how teachers did demand more learner talk, and the nature of this talk, and expand on this in the methodology following.

Methods

As in LS cycle 1, cycle 2 consisted of two initial planning sessions, followed by teaching 1, reflection 1 and lesson planning 2, then teaching 2, reflection 2 and lesson planning 3 (see Mwadzaangati et al., 2022 for detail). The first author of this paper participated in all stages of each cycle and video recorded the sessions which were later transcribed. To develop our arguments related to teachers' learning of LRT, given space constraints, we zoom in on episode 1 in the lesson. We trace its evolution from the teachers' planning discussion of whether and how to recall knowledge of congruency as a route into similarity, through to how they enact, reflect on and then reteach this; for it is in these different settings across a LS cycle that teachers are offered varied opportunities for learning through talking about and working on their practice. Our analysis of discussions in the lesson planning and reflection sessions was content based. We examined teacher utterances to identify whether and how they shared concerns about *word use and justifications* as well as *learners' expressing their thinking*, and so how they interpreted opportunities for explanatory communication and so LRT.

With regard to enactment in Episode 1, we first identified whether the talk (either the teacher or students) was in a *formal/technical or everyday/informal register*. In line with Prediger's (op cit) notion of the meaning-related register and following the MTF, we included what we refer to as school academic register, and so talk between informal and formal registers. To expand on the nature of the talk, we looked at the type of questions the teachers asked, and the responses following by students and the teacher – identifying *why questions (thus requiring justifications)* and whether the teacher reacted by *revoicing, elaborating or probing further*. Lastly, we also identified when and whether elaborations extended *beyond the verbal to include visual representations*. In MTF terms, as indicated earlier, this links with exemplification. Multiple representations are also emphasised in LRT and, as will be seen in the analysis, it was evident and needed to be included here.

Results

In the Malawi curriculum, congruent triangles are studied before similarity, and this link was promoted in a textbook the teachers examined. We note this because, and so understandably, the goal the teachers set for the lesson was to establish the meaning of similar triangles in relation to congruent triangles, and then the proportionality of corresponding sides. From the initial planning sessions that included textbook analysis and lesson plans data, as well as cycle 1 lessons, we noted that the teachers valued recalling knowledge and it was routine to begin a lesson recalling relevant 'pre-knowledge' -

in this case, of congruent triangles. We begin by discussing LRT issues discussed in extract 1 from textbook analysis session.

The initial planning session

The teachers discussed the abbreviations used to represent conditions of similar triangles, that these might confuse learners, as reflected in Extract 1. Note that T_n stands for teacher n.

- 241 T2: The second condition, if corresponding sides have lengths in the same ratio, this condition of proportionality that is given as Side Side Side. And the third condition, if two sides have lengths in the same ratio and the angle included between these sides have the same measure, this condition abbreviated as Side Angle Side. Are the conditions sufficient?
- 242 T1: Side, Side, Side?
- 243 T2: Yes, Side Side Side and Side Angle Side. Are they sufficient?
- 244 T1: Yes, the conditions are right, but the way they are now labelling them, Side Side Side, Side Angle Side. We use the same conditions and abbreviations for congruency, and here they are also using them for similarity. How do we look at that?
- 245 T3: It is ok but the only thing when it comes to congruency is that we will now be talking of two triangles that are exactly the same in terms of sides as well as angles while in similarity we are talking of two triangles that are exactly the same only in terms of shape. Yes, they have the same corresponding angle sizes, but their sides might be different. The ratios of their corresponding sides are the ones that will be equal.
- 255 T2: These conditions are lightly explained and what is confusing now is that the textbooks have only given conditions like Side Angle Side, Side Side Side which are the same as what we use when we are proving congruency. So, I think we need to check with the learners during introduction.
- 256 T3: Check what?
- 257 T2: If they understand the meanings of the conditions because this is where the problem lies, understanding the difference of SSS and SAS in congruency and similarity.

The teachers realised that in the textbooks, the abbreviations widely used for conditions of congruency (e.g., SSS and SAS) were also used in similarity, and thus stating conditions would not necessarily mean students ‘understood’ them (245, 255). Indeed, this was a potential source of confusion considering that understanding of the meanings of the conditions is the learners’ main challenge (257). They agreed to ‘check’ learners’ meanings of the conditions (255-257). This suggested that the teachers interpreted LRT as including both naming (e.g., SSS) and explaining meanings of geometric concepts (e.g., meaning of SAS). From the teachers’ discussion in Extract 1, we anticipated that in the lesson, learners would be asked to recall and then explain the meanings of conditions of congruent triangles. We were also interested to see whether and how this talk moved between informal and formal registers towards the formal language.

Working with LRT practices in teaching 1 and 2

During teaching 1 the teacher started by writing the topic ‘similar triangles’ on the board and stated that the day’s lesson was on similar triangles, but that first, they would talk about congruent triangles. The lesson proceeded as in Table 1 below. Note that T stands for teacher, S for student.

In teaching 1, the teacher asked recall questions, for example, what do you know about congruent triangles and what are the tests for congruency (1, 8), and he revoiced learners’ responses (2, 10, 12).

He inquired ‘what is wrong’ the first definition (5), and elaborated the difference between angles and triangle (7), all in either the formal or meaning-related register. Students’ responses included stating definitions and naming conditions in school academic register (e.g., triangles of the same shape and size, and in formal register (e.g., Side, Side, Side and Side, Angle, Side) (2, 9-12). This reflects well-oiled teaching routines, and where some elaboration is offered, this is done by the teacher (7). Elaboration of meanings by students was not in focus notwithstanding agreement in the planning discussion that students’ understanding of the meanings of conditions of congruent triangles needed to be ‘checked’.

Table 1: Lesson Episode 1 recalling congruent triangles

Teaching 1	Teaching 2
<p>E 1.1 Recall of definition of congruent triangles</p> <ol style="list-style-type: none"> 1. T: What do you know about congruent triangles? 2. S1: These are angles of the same shapes and size. 3. T: Congruent triangles are angles of the same shapes and size? 4. S2: Are triangles of the same shape and size. 5. T: What is wrong in the first definition? 6. MS: angles! 7. T: angles, because when we are talking about congruent triangles, we cannot say they are angles of the same shape and size. We talk about angles as amount of turn which is in degrees. So, triangles are said to be congruent if they have same shape and size. 	<p>E 1.1 Recall of definition of congruent triangles</p> <ol style="list-style-type: none"> 1. T:... How do you define congruent triangles? 2. S1: Congruent triangles are triangles which have exactly the same shape and size. 3. T: Congruent triangles are triangles with same shape and size.
<p>E1.2 Recall of conditions of congruency</p> <ol style="list-style-type: none"> 8. T: What are the tests for congruency? 9. S3: Side, Side, Side. 10. T: Side, Side, Side, yes what else? 11. S4: Side, Angle, Side 12. T: Side, Angle, Side, yes what else? 	<p>E1.2 Recall of conditions of congruency</p> <ol style="list-style-type: none"> 4. T: What are the conditions for congruency, anybody who remembers? 5. S2: By using Side Side Side. 6. T: By using Side Side Side, what does Side Side Side mean? 7. S3: All corresponding sides are equal to each another. 8. T: Yes, Side Side Side means that we have two triangles in which this side equal to that side... <i>(draws on two triangles on the board and indicate 3 pairs of corresponding equal sides)</i> 9. T: Another condition? 10. S4: Side, Angle, Side 11. T: We can have two triangles where this side is equal to that side, this angle equal to that angle and this side equal to that side. <i>(again referring to triangles drawn on the board)</i> 12. T: Another condition? <p>....</p>
<p>Episode 2 T: anyone who can define or explain what you know about the word similar?</p> <p><i>The interaction patterns continue in the same form as above.</i></p>	<p>Episode 2 T: Can we have two triangles where corresponding angles are equal but the sizes of the triangles are different? Can that be possible? <i>Some students say yes, others no, and T then proceeds to illustrate the possibility of this using two similar chalkboard triangles, with a drawing of these on the board.</i></p>

After teaching 1, the teachers met to discuss the lesson. They expressed satisfaction with students’ involvement in defining congruent triangles and naming their conditions. Their interest was focused on the connection between congruency and the definition of similar triangles. In Extract 2 below, the

teachers explain their views on their routine practices on teaching congruent and similar triangles and what they learnt during LS.

- 52 T3: Normally of course minus this training that we have been doing, because like in most cases when you are teaching about similarity you do not plan that learners are going to talk about congruency, that is rare you just start from defining similar triangles.
- 53 T4: Yes, very rare.
- 55 T3: So, we would say this is the best way of introducing the topic.
- 56 T2: Yes, sure I think we have learnt that students should learn congruency first so that when we are teaching similarity, we should start from congruency then link with similarity then they understand their differences better.

In Extract 2, the teachers explain that linking congruency with similarity is a new practice they learnt during the LS (52,56). They agree that the practice of connecting congruency and similarity could enhance learners' understanding of both concepts (56). However, they did not discuss that this comparison was not done during the lesson. We learn from Extract 2 that recognising and conducting LRT practices and so moving from their routine practice of asking students to define congruent triangles and state their conditions without elaborating meanings was not a straightforward task for the teachers. During the second workshop where the teachers also started planning for teaching 2, we discussed with the teachers why naming only does not enable the teacher to see what learners understand, and that it is important for learners to explain their meanings, and why the link between congruent and similar triangles needed to be more explicit.

In teaching 2 which took place about two months after teaching 1, the lesson began in the formal register, supported by a concrete visual representation of two identical triangles. The teacher held up two identical wooden board chalkboard triangles and asked students to name the objects and the type of triangles they represented. When students named the triangles as congruent, the lesson proceeded as shown in Table 1, and while in a similar way to teaching 1, this was supported by a visual representation. The language register also starts and moves between the formal and school academic register. Teacher talk included asking recall questions or example, how do you define congruent triangles (1), revoicing students' responses for example congruent triangles are triangles with same shape and size (3). Students' talk included stating definitions and conditions in school academic language register (e.g., are triangles with exactly the same shape and size) and in formal language registers (e.g., Side, Side, Side) (2, 5). In episode 1.2, the teacher moves and asks students to express what side side side 'means' (6). What is interesting here is that the teacher recognises that the student's response requires further elaboration, yet proceeds to do this himself, in more colloquial or informal language supported by a visual representation of triangles he drew on the board (8 and then again 11). This suggests that the teachers interpret LRT as including the need for elaborating meanings, this did not extend in enactment to the move of 'demanding' this of students.

We have included in Table 1, the introduction in the two lessons to similarity, as this reinforces our analysis of a shift, as in teaching 2, the teacher explicitly connects congruency to similarity, asking students a thinking question. There is disagreement, and he follows by leading the elaboration, supported again by visual representations.

Discussion

In the initial planning and lesson reflection for teaching 1, the teachers themselves articulated the importance of connecting similar and congruent triangles and the importance of naming and elaborating meanings for conditions of both congruent and similar triangles. Making connections between concepts is both a LRT and mathematics teaching and learning issue (Prediger 2019; Vygotsky, 1978). Teaching congruent and similar triangles beyond only naming conditions and ensuring elaboration of meanings and making links between the conditions is also a geometry teaching issue (Seago et al., 2013). We therefore notice that during planning and lesson reflection sessions, the teachers interpreted LRT practices as including both making connections among mathematical concepts, naming and elaborating meanings.

However, there was generally little talk by students in both lessons. During teaching 1 learner talk was limited to naming as elaboration of meanings was done by the teacher with a focus on defining congruent triangles only but not on the conditions. In teaching 2, there was an elaboration on meanings of conditions of congruent triangles using visuals, with these largely expressed by the teacher, and the registers in use more formalised. While naming geometric concepts is something that the teachers do well it is not straightforward for them to build conceptual understanding by linking naming and justifying. The MTF helps in two ways; by focusing on how things are named and elaborated (justified). Prediger (2019) describe elaborating meanings as a higher discursive level of LRT practice and that designing tasks for engaging learners in this practice is challenging for teachers. We thus worked on some open tasks with the teachers and encouraged them to include them in their plans, but they selected not to do so – a function of our LS process where teachers' selections led them to start from what they know. At the same time, this enabled a realisation that they initially thought that naming is understanding.

These findings lead us to reflect on learning LRT through our approach to LS. What might be enabled if teachers initially explored a pre-designed and more open task that would elicit student talk? As this is distant from what they routinely do, exploring this first could be a route in? But it begs the question of how these might become meaningful in their actual day-to-day teaching and so connect with them? On the other hand, if you start as we did, with their planning from current resources, and so in sync with routine practices, what follows is shaped by that? This is a deep tension between having teachers design their own tasks in lesson plans that they want to use and building these towards more demanding tasks that elicit student thinking and reasoning. All these point to further work and the time and investment needed for LS that works from where teachers are and with their responsibilities.

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