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# Affordances of Systematic Shifting of Mediational Means When Introducing Whole-Number Addition: The Case of a Grade 2 Teacher in Malawi

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*This paper discusses mediational moves made by a Grade 2 teacher in Malawi while teaching the addition of whole numbers to learners for their first time at this level. The paper was guided by Vygotsky's sociocultural view of teaching as mediation, with the teacher as the main mediating agent in the classroom. The sociocultural tools of mediation used by the teacher in this paper were informed by the Mediating Primary Mathematics (MPM) framework, and include example spaces, artifacts, inscriptions, as well as the teacher's talk and gesture. The focus of this qualitative case study is on the shifts made by the teacher when working with the sociocultural tools of mediation within and across the first two introductory lessons on the addition of whole numbers with a sum of less than 20. The teacher helped learners progressively move from the physical representations of the concepts and processes associated with the addition of whole numbers to their equivalent written inscriptions. After a successful transition from the use of artifacts and inscriptions to mathematical talk, the findings suggest the need to move further to more efficient calculation strategies. Thus, the case study demonstrates the work of an early grade mathematics teacher in limited-resource settings; hence informs mathematics educators and researchers on the role of locally available cultural tools of mediation when introducing fundamental mathematical concepts.*

***Keywords****:* mediation, addition, early-grade mathematics

When introducing mathematical concepts during the early years of primary school, the teacher often faces the dilemma of determining the appropriate representations that will be meaningful to inexperienced young learners (Ball, 1993). Oftentimes, the teacher must work with multiple representations of new mathematical concepts and procedures. What adds to the challenge is that some of the represented mathematical concepts have multiple meanings. For example, the sum of 2 and 5, is both the process of adding the two numbers (symbolised as 2 + 5) as well as the concept represented by the result of that process (Gray & Tall, 1994). Similarly, the process of counting and the concept of number have dual meanings; and it is the role of the teacher to 'reify' (Sfard, 2008, p. 170) the process of counting into its corresponding object: number. The way a teacher handles the process-concept relationship can make some mathematical tasks easy or difficult for learners. Gray and Tall (1993) noted that success and failure in mathematics is closely related to a learner's ability to handle the dual nature of some mathematical processes and concepts.

As argued by Bartolini Bussi and Martignone (2013), mathematics teaching cannot be isolated from the cultural context in which it is taught. This is mainly due to many sociocultural factors that influence observable teaching practices. Cultural teaching practices are often inherited by teachers when they undergo their national education systems (Mosvold, 2008). For instance, in countries such as Malawi, mathematics is taught in multi-lingual societies where teachers are expected to teach in a language that they may not be familiar with, and as noted by Kazima (2008), some mathematical terms may not be rendered with the same conceptual meaning when translated from one language to another. In many educational systems, the difficulties that learners face when working with mathematical concepts are often revealed through their underachievement during national and international assessments in mathematics. The persistent failure of learners in mathematics has led some mathematics researchers and educators to look to success stories of East Asian countries that consistently outperform other countries in global assessments of numeracy and mathematics (Mhlolo, 2013). One observation made by Mhlolo (2013) is the consideration of variation theory as a promising approach to the teaching of mathematics; since the teaching attention shifts from just focusing on the visible classroom interactions between the teacher and the learners, but rather focus on what is made available to learn in a lesson.

As such, instead of focusing on general teacher-learner classroom interactions to understand how teachers teach the concept of addition, this paper draws attention to the need to understand the affordances brought about by a teacher's shifts in the orchestration of multiple representations of the concept of addition. The paper discusses how a Grade 2 teacher worked with various means of mediation identified by Venkat and Askew (2018) to represent the concept and process of addition within and across two lessons. This was done by answering the question: How does the Grade 2 teacher in this study make learning opportunities available through the systematic shifting of mediational means when introducing the addition of whole numbers to a large class at a rural school?

## Theoretical Framework

This paper is theoretically grounded on Vygotsky's sociocultural theory, which asserts that a scientific discipline is characterised by the interconnection between concepts (Kozulin, 2003). Hence, the teaching of mathematics, as a scientific discipline, is supposed to reflect the interconnected nature of the subject. One way of drawing attention to the relationships among mathematical concepts is through the application of variation theory (Kullberg et al., 2017; Marton & Booth, 1997). This is achieved through the systematic presentation of mathematical content to highlight the variant and invariant aspects of the concept being taught.

The paper also adopted Vygotsky's sociocultural notion of teaching as a set of mediated transactions—with the teacher as the main mediating agent in the classroom—who works with a set of sociocultural tools of mediation (Kozulin, 2003). The meaning assigned to cultural tools of mediation is only understood within a specified cultural context (Bartolini Bussi & Mariotti, 2008), and the didactic practices related to the tools of mediation also remain culture-specific, unless the teachers are exposed to didactic practices from another cultural context (Mellone et al., 2019). To understand the cultural tools of mediation used when teaching mathematics in the early years of primary school in Malawi, the study adopted the Mediating Primary Mathematics Framework (MPM) by Venkat and Askew (2018) shown in Figure 1. Theoretically grounded in Vygotsky's sociocultural theory, the MPM framework was empirically informed by studying the teaching that was done in historically disadvantaged schools in South Africa whose cultural context shares similarities with most public schools in Malawi.

### The Mediating Primary Mathematics Framework

The MPM framework was adopted both as the theoretical framework guiding the study, as well as the analytical tool for data analysis. The MPM framework identified four overarching means of mediation, called strands. The four strands are: Tasks and examples, artifacts, inscriptions, talk and gesture. The talk and gesture strand in the MPM framework is further subdivided into three sub-strands: Talk and gesture for generating solutions to problems, talk and gesture for making mathematical connections, as well as talk and gesture for building learning connections.

#### *Mediating Tasks and Examples*

The MPM framework considers the first strand (tasks and examples) as the foundation upon which mathematical instruction is overlaid. The framework examines how the tasks and examples strand is mediated by the remaining three strands and applies variation theory (Kullberg, Kempe, & Marton, 2017) to determine relationships among examples in example spaces. As discussed by Venkat and Askew (2018), an example space in this framework includes all the worked examples as well as the group tasks and individual exercises given to learners and marked by the teacher. As shown in Figure 1, examples and tasks are not coded independently in the MPM framework during data analysis. The assumption is that primary school children have not yet developed their abilities to discern the variant and invariant aspects of example spaces by themselves. Hence, in this paper, relationships among examples were mainly coded under the teacher's mediating talk and gesture for making mathematical connections.

**Figure 1**
*The Mediating Primary Mathematics (MPM) Framework (Venkat & Askew, 2018, p. 90).*

Appendix 1: The MPM framework — MEDIATING TASKS/EXAMPLES

**MEDIATING ARTIFACTS**

| | | | |
|---|---|---|---|
| No artifacts used or artifacts that are problematic/ inappropriate | Unstructured artifacts used in unstructured ways | Structured artifacts used in unstructured ways | Structured artifacts used in structured ways/unstructured artifacts used in structured ways |
| 0 | 1 | 2 | 3 |

**MEDIATING INSCRIPTIONS**

| | | | |
|---|---|---|---|
| No inscriptions or inscriptions that are problematic/ incorrect | Inscriptions that only record tasks or responses | Unstructured inscriptions | Structured inscriptions |
| 0 | 1 | 2 | 3 |

**MEDIATING TALK/GESTURES**

| | | | | |
|---|---|---|---|---|
| Method for generating/ validating solutions | No method or problematic generation/validation | Singular method/validation | Localized method/validation | Generalized method/validation |
| | 0 | 1 | 2 | 3 |
| Building mathematical connections | Disconnected and/or incoherent treatment of examples<br>OR<br>Oral recitation with no additional teacher talk | Every example treated from scratch | Talk connects between examples or artifacts/inscriptions or episodes | Talk makes vertical and horizontal (or multiple) connections between examples/ artifacts/inscriptions/episodes |
| | 0 | 1 | 2 | 3 |
| Building learning connections: explanations and evaluations - of errors/ for efficiency/ with rationales for choices | Pull back to naïve methods<br>OR<br>No evaluation of offers (correct or incorrect) | Accepts/evaluates offers<br>Accepts learner strategies or offers a strategy<br>OR<br>Notes or questions incorrect offer | Advances or verifies offers<br>Builds on, acknowledges or offers a more sophisticated strategy<br>OR<br>Addresses errors/misconceptions through some elaboration, e.g. 'Can it be ----?' 'Would – this be correct, or this?' Non-example offers | Advances **and** explains offers<br>Explains strategic choices for efficiency moves<br>OR<br>Provides rationales in response to learner offers related to common misconceptions<br>OR<br>Provides rationale in anticipation of a common misconception |
| | 0 | 1 | 2 | 3 |

### *Mediating Artifacts*

Artifacts refer to the tangible resources prepared by the teacher before the lesson and may remain in existence after the lesson. The MPM framework does not just focus on the availability of artifacts in a particular lesson, but how the teacher works with the artifacts, shifting from their physical form to their ideal form where they represent a particular mathematical concept or process and leading learners to appropriate mathematical generalisations, and eventually be able to work in the absence of the arteficts. Venkat and Askew

(2018) refer to this shift as *fading* of artifacts. As shown in Figure 1, the framework examines the types of artifacts used during a lesson and categorises them as either structured or unstructured artifacts. Structured artifacts refer to those that explicitly show mathematical properties of the concepts being represented by the artifact even if the teacher does not give much emphasis on the properties. An example of a structured artifact is an abacus. Unstructured artifacts, on the other hand, do not show mathematical properties of the concepts being represented but only rely on the teacher's explanation to make these properties noticed by the learners.

When analysing the lesson videos for the teacher's use of mediating artifacts in this paper, the first step was checking the *nature* of the artifacts used, to determine whether they were structured or unstructured and thereafter examined whether *the use* of the artifacts was structured or unstructured. Structured use of artifacts would lead learners to appropriate mathematical generalisations, and eventually be able to work in the absence of the artifacts.

### *Mediating Inscriptions*

Inscriptions refer to what the teacher writes during the flow of the lesson and are temporary in nature (Venkat & Askew, 2018). Venkat and Askew (2018) as well as Askew (2019) differentiate artifacts and inscriptions based on whether they are pre-made and brought into the classroom and their permanence. Hence, charts and cards that are prepared before the lesson, though containing inscriptions, are regarded as artifacts in the MPM framework. This indicates that inscriptions perform a supportive mediational role during a lesson. During data analysis, the MPM framework only provides the coding for the type of inscriptions and not their use (see Figure 1). Structured inscriptions bring attention to the structural connections among the represented concepts whereas unstructured inscriptions are randomly written by the teacher and fail to show mathematical connections among the concepts being represented as compared to.

### *Mediating Talk and Gesture*

The three types of talk and gesture presented in the MPM framework refer to the explanatory communication made by the teacher during a lesson. Mediating talk and gesture for generating solutions to problems examines the teachers' explanations for the procedures used to find the solutions to the given problems. This also includes the teacher's talk for validating the offers given by the learners.

Being a scientific discipline, mathematical concepts are interconnected (Kozulin, 2003). As such, the teacher's mediating talk and gesture for making mathematical connections is expected to make these connections visible during a lesson. These can be connections between parts of a lesson, horizontal connections between examples used during a lesson, or vertical connections with concepts learnt before a lesson or after a lesson.

Mediating talk and gesture for building learning connections focuses on the way the teacher deals with learners' offers. The teacher examines the learners' errors in their responses and determines the appropriate action or "responsive move" (Venkat & Askew, 2018, p. 80) to remediate the errors or misconceptions. Muir (2008) noted that learners' responses provide unexpected ideal moments or "teachable moments" to address a misconception that would not have been much clearer before or after this moment.

When analysing the teacher's talk and gesture for generating or validating solutions to problems during the study, the focus was on whether the methods were generalisable, enabling learners to apply problem-solving techniques to arrive at the required solution or validate the offers given by fellow learners during the lesson. The teacher's talk for making mathematical connections was analysed by applying variation theory (Kullberg et al., 2017) to understand the teacher's use of systematic variation to provide opportunities for learners to notice structural "similarities" (or invariant aspects) and "contrasts" (variant aspects) within and across examples used (Venkat & Askew, 2018, p. 78). The analysis for the teacher's talk for building learning connections involved checking whether the teacher verified learners' offers or build on them, considering these as eliciting "teachable moments" (Muir, 2008). Ultimately, the teacher may explain strategic choices, providing the rationale for each option considering the common misconceptions.

## Methodology

The study was conducted at a rural primary school in Malawi where most learners are exposed to mathematical instruction mainly in the classroom. A qualitative case study design (Creswell, 2014; Yin, 2016) was adopted to gain a deeper understanding of teachers' mediation of mathematics in the classroom (Bartolini Bussi & Mariotti, 2008).

### The Study Context

Malawi uses an 8-4-4 system of education, with eight years of primary school, four years of secondary school, and four years of university education. Children start the first grade of primary school at age six. Pre-school education in Malawi is not regulated. As such, the majority of learners (about 60 percent) start their first grade of primary school without undergoing any form of pre-school education (Robertson et al., 2017). Teaching in the first four grades is done in vernacular, and switches to English from Grades 5 to 8. Pupil/teacher ratios are generally high, averaging 100:1 in the first two grades of primary school (Brombacher, 2011). Primary school teachers are prepared through a two-year teacher education program in specialized teacher training colleges whereas secondary school teacher preparation is done through fouryear university programs. Unlike secondary teachers who are trained to teach specific subjects, primary school teacher training colleges produce generalist teachers who can teach any primary school subject at any grade level. Although teaching in the first four grades is done in vernacular, the language of instruction in teacher training colleges is English (Chitera, 2012; Kaphesi, 2003). Across the Malawi education system, a teacher is mainly assigned a grade-level and not necessarily a group of learners. This is different from other countries where a teacher may move with a particular group of learners across grade levels for several years (Bartolini Bussi & Martignone, 2013).

**Case Selection**

The primary school was purposively selected as a paradigmatic case (Palyst, 2008) with exemplar higher learner achievement during the national Primary School Leaving Certificate Examinations compared to other schools in the same geographical area. Considering the spiral nature of mathematical knowledge, the assumption made was that learner achievement at higher levels of primary school is associated with a good lower primary school background. The main participant was a Grade 2 teacher who was identified based on work performance according to recommendations from the school's administration, and voluntarily accepted to participate in the study.

**Data Collection**

Five lessons were observed from one Grade 2 teacher when teaching the addition of whole numbers, but this paper focuses on the first two lessons to gain insights on the mediational moves from the introduction of the concept of addition to its application. The lessons were video recorded and field notes were taken on observations that could not be captured by the camera. Unstructured post-lesson interviews were conducted with the teacher to get clarification on outstanding observations which were made during the lessons.

The observed lessons focused on the addition of numbers with a sum of not more than 20. The learners had done single-digit addition at Grade 1 more than three months before the lesson. Prior to the first observed lesson, the learners had been on a two-month end-of-academic-year recess, and during their first month in Grade 2, they were first introduced to counting and writing new numbers (from 10 to 20) before they could do operations such as addition and subtraction on these numbers. The current mathematics and numeracy curriculum in Malawi restricts learners to work with only 0 to 9 in Grade 1, and 10 to 99 in Grade 2. After that, they encounter three-digit numbers in Grade 3, and work with larger numbers from Grade 4 onwards.

## Data Analysis and Results

As mentioned above, the MPM framework also acted as the analytical framework for this study. This framework made it possible to see the teacher's mediational shifts to a "fine-grain level" (Venkat & Askew, 2018, p. 73). The unit of analysis in the MPM framework is an instructional episode. As such, the recorded videos for the two lessons were segmented into episodes that were marked by a change in the flow of the lesson, such as the change from whole-class tasks to group work, or a change in the example sets being worked on. The MPM framework was used to determine the extent to which the teacher worked with artifacts, inscriptions, as well as talk and gesture during lesson enactment.  Since the paper's focus was not on evaluating the quality of teaching, only the descriptive indicators for each means of mediation were used during the analysis, but not the numerical levels shown in Figure 1.

After giving summaries of the observed lessons, the analysis presented in this paper have been structured following the way the teacher worked with each of the four means of mediation shown in Figure 1, noting the shifts made by the teacher when working with each means of mediation.

**Summary of Lesson 1**

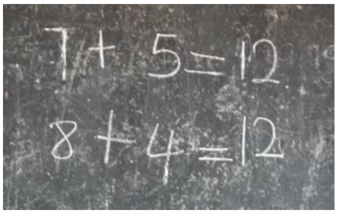
The first lesson was an introduction to the addition of whole numbers at the Grade 2 l. The first episode of Lesson 1 started with learners singing a number song from 1 to 20. After the song, the learners were placed in groups of 10 to 15 learners in which they were assigned physical objects to use as a team during calculations. During the second episode, learners were asked to work out the sum of 3 and 2 through group work using mango leaves. This was followed by asking the same groups to work out 9 + 6 using beans. In episode 3 of Lesson 1, the teacher wrote "7 + 5 =" on the chalkboard and worked out the solution using framed counters (see Figure 2). After finding the sum, the teacher appended 12 at the end of the written statement. The process of finding 7 + 5 was also done for "8 + 4 =" written on the chalkboard (see Figure 3). In all the examples, the sum was found using the combine-and-count-all strategy for the addition of whole numbers. During the counting, the whole class chanted together as they counted each summand or addend and counted all the counters representing the sum. For instance, 7 + 5 was found by counting seven items, followed by counting five items, then combining all the items and counting them to obtain the sum.

**Figure 2**

*Handmade Framed Counters*

Episode 4 focused on reviewing the meaning of the plus and equal signs. One learner gave the name “answers” to the equal sign, but the teacher emphasized the conventional mathematical term “equals”. During the last episode (episode 5) the teacher erased the solutions for 7 + 5, 8 + 4, and 9 + 6 and asked the class to give the solutions; and emphasized that 7 + 5 and 8 + 4 had the same answer 12. The recorded attendance for the first day was 87 learners (42 boys and 45 girls) against an overall class enrolment of 130.

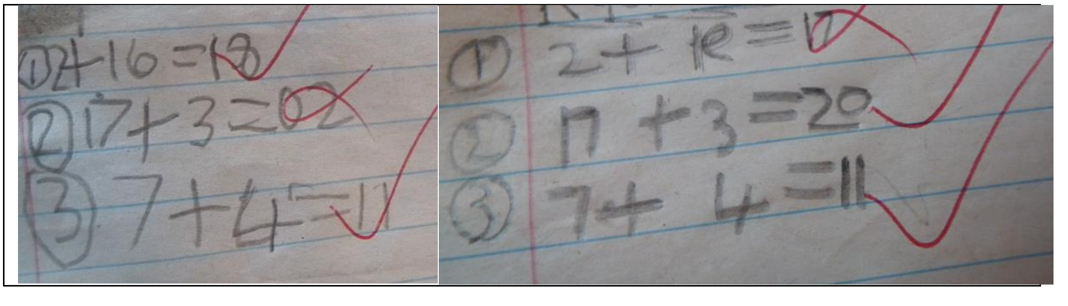
**Figure 3**
*Chalkboard Inscriptions of 7 + 5 = 12 and 8 + 4 = 12*




**Summary of Lesson 2**

The second lesson was taught the following day. The recorded attendance was still reflecting the figures for the first day, implying that the teacher had not updated the information. The first episode of the second lesson focused on a review of Lesson 1. During the second episode, learners were given cards with pre-written problems (9 + 6, 16 + 4, and 4 + 15) to be worked out in their randomly assigned groups. In episode 3, the teacher gave three problems (2 + 16, 17 + 3, and 7 + 4) to be worked out by the learners individually in their notebooks and marked by the teacher (see Figure 4). As the teacher was marking, additional emphasis was put on proper notations for the signs, indicating what is a plus sign (+) and what is not (*X*). The teacher ended the episode, and the lesson, by verifying the solutions to the three given problems with the whole class.

**Figure 4**
*Learners’ Notebook Inscriptions*



**Mediational Shifts in the Use of Examples**

During the two lessons, there seemed to be an upward shift in both the complexity and range of examples used. The teacher gave fewer single-digit examples (3 + 2, 9 + 6, 7 + 5, and 8 + 4) during the first lesson and more two-digit examples (9 + 6, 16 + 4, 4 + 15, 2 + 16, 17 + 3, 7 + 4 and 12 + 8) in the second lesson. The affordances and constraints related to the teacher's selection and sequencing of these examples have been discussed under the mediational shifts in the teacher's talk and gesture for making mathematical connections.

**Mediational Shifts in the Use of Artifacts**

By the end of the first lesson, the teacher had worked with mango leaves, counters, beans, and learners' fingers, which are all classified as unstructured artifacts in the MPM framework. Some shifts in the use of physical manipulatives were noticed across the episodes within Lesson 1. The teacher presented the first two examples using heaps of objects from which the learners were asked to count the summands and find their sum. Thereafter, the examples were only given as written statements; thus accomplishing what Askew calls the "fading away" of artifacts (2019, p. 218). The expectation is that the teacher should gradually make the learners able to work in the absence of the artifacts. However, despite this positive shift, the usage of the artifacts was not structured, due to the combine-and-count-all strategy that was used, hence some learners made errors during counting.

During the second lesson, the teacher mainly worked with framed counters (see Figure 2). Learners who did not bring their counters were asked to use their fingers and toes. The notable shift was that the diversity of physical manipulatives was greatly reduced in the second lesson compared to the first, which could be considered a slight move towards the fading of artifacts.

**Mediational Shifts in the Use of Inscriptions**

The inscriptions observed during the study were mainly written by the teacher on the chalkboard. In the MPM framework, good use of inscriptions enables the transition from the physical presence of artifacts to the abstract representation of mathematical ideas. During the first lesson, the teacher initially posed the tasks as word problems mentioning mango leaves and beans. After finding the solutions using the given objects, the teacher thereafter wrote the structured chalkboard inscriptions 3 + 2 = 5 for mango leaves; this was followed by 9 + 6 = 15 for beans. Thus, the teacher used inscriptions to achieve the desired shift from the physical presence of the mango leaves and beans to their numerical representations.

After introducing the learners to the formal mathematical notations for addition, the last two examples were now introduced using the written representations "7 + 5 =", and "8 + 4 =". The notable shift was that the last two problems were no longer associated with the physical presence of specific objects which were referred to during the outset of the lesson. Thus, it can be said that the teacher used the structured inscriptions to ‘reify’ (Sfard, 2008, p. 270) the tangible objects into their corresponding structured mathematical notations. As shown in Figure 3, the examples “7 + 5 = 12” and “8 + 4 = 12” were written one on top of the other, making them structured. However, the connections between these two written examples could have been made much stronger if the learners' attention was drawn to them through the teacher’s talk.

The teacher also employed contrast to highlight the meaning and proper usage of inscriptions. During the second lesson the teacher compared “+” and “×” which some learners wrote in their notebooks. During the first lesson, the teacher deliberately sided with learners who erroneously named “+” as a subtraction sign, and later greatly commended the learners who maintained their stand that “+” means addition.

**Mediational Shifts in the Teacher’s Talk and Gesture**

During the two lessons, there were notable shifts in the three types of teacher talk; that is, talk and gesture for generating solutions to problems, making mathematical connections, and building learning connections. Regarding the use of gesture, the teacher mostly pointed to the statements written on the chalkboard when mentioning them. This made it possible for learners to associate the teacher’s mathematical utterances with their corresponding inscriptions. This association was necessary especially when dealing with number names for the numerals written on the chalkboard as shown in the following excerpt of the first lesson:

| | |
|---|---|
| 53. Teacher**:** | Chifundo had three[1] mango leaves. What do we call “*zitatu*”? *[Three is “atatu” or “zitatu” in Chichewa]* |
| 54. Class**:** | **Three**! *[Respond in English]* |
| … | |
| 57. Teacher: | **“***Atatu*” means how many? |
| 58. Class**:** | **Three**! |
| 59. Teacher**:** | It is **Three**. Alright? |

As shown in the above excerpt, the teacher familiarised the learners with English number names for all numerals. All numerals written on the chalkboard were referred to using their equivalent English number names.

[1] The transcripts were originally in Chichewa, the national language in Malawi. Where English was used, the word(s) have been indicated in bold.

### *Shifts for Generating Solutions to Problems*

As mentioned earlier, the solutions for all the problems solved during the two lessons were found using the "combine and count-all" strategy for addition, using various types of physical manipulatives that acted as counters. This can be referred to as the use of a singular method for generating solutions as indicated in the MPM framework (Venkat & Askew, 2018). The count-all strategy appeared to be less efficient. For instance, it took an interchange of nearly 100 utterances between the teacher and learners just to find 7 + 5. The process had to be repeated several times due to learners' counting errors. These errors would have been reduced if the teacher used the count-on strategy where counting would have been done up to 7, then continue with 5 more steps and reach the answer 12.

### *Shifts for Making Mathematical Connections*

Variation theorists posit that the selection and sequencing of examples can either enhance or constrain what is made available to learn in a lesson (Kullberg et al., 2017). The teacher attempted to make a learning connection between the examples 7 + 5 and 8 + 4 when summarising the lesson by mentioning that both of them had the same result of 12. This connection would have been made much stronger if the relationship was emphasised at the earliest opportunity than mentioning it once at the end of the lesson.

During the second lesson, three out of the seven examples (16 + 4, 17 + 3, and 12 + 8) had the same sum of 20, but this was not highlighted in the teacher's talk and gesture. In addition, the sequencing of 16 + 4 and 15 + 4 was another learning opportunity—because one summand was kept invariant and the other two differed by 1—but this connection was missing in the teacher's talk. Since young learners may not have fully developed the capability of deducing the variant and invariant aspects of example spaces by themselves, Venkat and Askew (2018) indicate that more learning opportunities are realized when the teaching draws attention such aspects to through talk and gesture.

### *Shifts for Building Learning Connections*

The handling of learners' errors is another critical aspect of mediating talk in the MPM framework, thereby building on learners' misconceptions to enable making learning connections. During the second lesson, the teacher emphasized the proper syntax for reading the addition statements that were written on the chalkboard or cards. As indicated in utterances 175 to 179 of the excerpt that follows, the teacher emphasized the need for learners to state the entire mathematical statement when giving the results of the addition tasks instead of just giving the final answer.

175. Teacher: *[Focuses attention to another group]* Yes, this group. What have you found?

176. Group: *[The whole group shouts the answer]* **Fifteen**!
177. Teacher: Which numbers did you calculate? What were the numbers? One person! One person! *[Asks one learner]* Begin!
178. Learner 17: **Nine** plus **six** equals **fifteen**.
179. Teacher: That one says **nine** plus **six** equals **fifteen**. Let us give them stars. Let's do it! *[Teacher and other learners flash their fingers towards the group]*

If the teacher had just accepted the final answers given by the individual learners, as in utterance 176 of the preceding excerpt, some learners would not have managed to connect them with the original summands. By insisting that the learners should mention the resulting sum together with the original summands, the teacher enabled the building of mathematical connections for that task.

### Possible Factors Influencing the Teacher's Use of Mediational Means

The observed shifts in the teacher's use of mediational means seemed to be influenced by other factors such as curriculum materials, ease of use, as well as class size. It was found that the teacher's lessons were based on the guidelines and suggestions as presented in the Grade 2 curriculum documents on numeracy and mathematics. There were also some indications during the observed lessons that the teacher's selection of artifacts for a particular task was also influenced by the ease of use. For instance, the teacher might have found it easier to use mango leaves for finding 3 + 2 but probably felt that leaves could not be easy to handle when working with 9 + 6 and 8 + 4; hence, the teacher opted for the use of beans as counters.

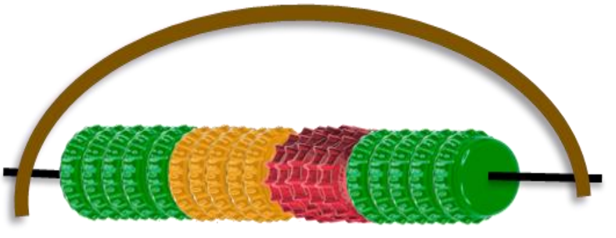
As mentioned in the summary of Lesson 1, the class, which had 87 learners present during the first lesson, influenced the teacher's design of the lesson, with most tasks done in groups. This enrolment was not unusual considering the large pupil/teacher ratios averaging 100:1 in the early years of primary schools in the Malawian context (Brombacher, 2011). When solving the problems, the teacher did the counting with the whole class using physical manipulatives, probably to make learners' actions observable for easy monitoring of their active engagement during the lesson.

## Discussion

The teacher demonstrated shifts in the usage of mediating means within each lesson and across the two lessons. During the first lesson, the teacher focused on moving from artifacts to inscriptions, while in the second lesson the teacher shifted from inscriptions to mathematical talk. Despite the positive shift in the fading of artifacts across the two lessons, all the observed artifacts were unstructured (Askew, 2019; Venkat & Askew, 2018). Saka and Roberts (2018) suggested one improvement that can be introduced to the handmade framed counters observed in this study. As it can be seen in Figure 2, the counters had different colours but were not sorted in any order, making them unstructured. If the counters in Figure 2 could be sorted and arranged in a recognisable pattern (such as coloured groups of 5 shown in Figure 5), then the framed counters could have been considered structured artifacts. The structuring of the framed counters shown in Figure 5 could make it easier when working with number bonds, thereby reducing the need for unit counting.

**Figure 5**

*Restructuring the Framed Counters Shown in Figure 2*



It was also noted that in all the two lessons, the teacher used the count-all strategy when performing the addition of two numbers. During the first day, the process looked manageable because the example space included single-digit numbers (such as 3 + 2), but as the numbers grew bigger in the second lesson (such as 17 + 3) the process of addition looked cumbersome. This shows what is constrained by the count-all strategy for addition when handling higher-order tasks involving the addition of whole numbers, hence indicates the need for using other more efficient strategies that promote number sense among learners.

The findings demonstrate the opportunities of learning afforded by the systematic structuring of artifacts and inscriptions coupled with appropriate teacher talk when introducing concepts in limited resource settings. Such structuring would ensure a smooth transition from the use of concrete manipulatives to written representations of the concepts during the initial stages, followed by a further shift from the written inscriptions to mathematical talk during subsequent stages.

The findings from this study also highlight the argument by Bartolini Bussi and Mariotti (2008) that the negotiation of meaning for tools of mediation is culture-specific. For instance, whereas teachers in developed countries may work with commercially available artifacts, that may not be the case with most developing countries (Ng et al., 2012). The teacher in this study only worked with locally available manipulatives. Teachers in Malawi generally consider the production of home-made artifacts for their lessons as part of their work of mathematics teaching. In their study of mathematical tasks of teaching, Kazima et al. (2016) found that all the teachers who participated in the study (n = 14) agreed that preparation of artifacts is one of the tasks of a mathematics teacher. In this study, the teacher also had to be conscious of the language-related issues when working with numbers. During the first lesson, learners were familiarised with the English number names for all the written numerals although most of the communication was done in vernacular. This could be considered one way of preparing the learners for the upper primary school classes where they would eventually be using English for learning mathematics. Considering that, the teacher had worked with different sets of learners at the second-grade level (not a cohort of learners), the teacher was more familiar with the grade 2 content. However, the teacher could probably lack the aptitude to look for the future needs of learners as is the case in countries where teachers move with one group of learners across a number of grade levels (Bartolini Bussi & Martignone, 2013).

These findings inform those interested in classroom discourse in limited resource settings—such as mathematics teacher educators and mathematics education researchers—regarding what can be accomplished by the systematic shifting of mediational means as the learners progress from introductory concepts to more complex ways of working. The findings also inform the umbrella project that supported this study (Strengthening Numeracy in Early Years of Primary Education through Professional Development of Teachers Project) on empirically proven strategies for introducing whole-number addition when building the capacity of practising primary school teachers in Malawi through in-service training. Malawian teachers can adapt to mathematics teaching practices from other cultures, such as variation theory, if they are given adequate exposure (Goldsmith & Seago, 2011; Mellone et al., 2019). Teacher education programmes may also need to incorporate language-responsive pedagogical strategies for teaching fundamental concepts, such as addition, in multillingual classrooms that are common in some countries.

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