An analysis of teacher guides for formative assessment

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The teaching practices associated with formative assessment are widely accepted as improving students' learning. Wiliam and Thompson proposed a set of strategies that can enhance teachers' productive formative assessment practices. These strategies, however, give only limited guidance for implementation in specific contexts. My PhD research aims to identify examples of these strategies in the context of multiplicative reasoning in early secondary mathematics and interrogate ways to support teachers in enacting these strategies productively. As the first step, I analysed teacher guides for multiplicative reasoning lessons from five different sets of curriculum materials in the United Kingdom and the United States, adopting Braun and Clarke's reflexive thematic analysis approach. In this paper, I present the initial findings of this analysis in relation to the strategy of eliciting students' learning and introduce the future directions of this research.

Keywords: formative assessment; curriculum materials; teacher guides; noticing

Problematising enactment of formative assessment strategies

In order to enact formative assessment, it is necessary to first understand its meaning by taking into account its components including its actors, purposes and strategies for enactment. For over two decades formative assessment has been well-received but weakly conceptualised and exemplified among researchers and practitioners. Following Bennett's (2011) earlier critique on this issue, more recently, several attempts have been carried out to understand formative assessment better. Drawing on the existing definitions of formative assessment in the literature, in this research, formative assessment is conceptualised as a classroom practice where teachers, students and peers are involved; that is driven by disciplinary learning intentions, and that can encourage teachers and students to reflect on the learning and make productive decisions as a result (Black and Wiliam, 2009; Cizek et al., 2019). Even though this conceptualisation can raise hopes for the outcomes of formative assessment, it can still be challenging to achieve these outcomes without a well-thought-out action plan.

One of the most comprehensive frameworks that can enable the enactment of formative assessment is the five strategies of formative assessment proposed by Wiliam and Thompson (2007). These strategies are understanding and sharing learning intentions, eliciting students' learning, providing feedback that moves learners forward, and activating students and their peers while learning. However, these strategies need to be contextualised for certain contexts such as disciplinary aims and students' needs. The implementation of these strategies will undoubtedly vary in different disciplines. Understanding their value in particular disciplines, communicating the guiding principles, and exemplifying them will add to theory and practice.

The role of curriculum materials in enacting formative assessment

In this research, drawing on the socio-cultural approach, curriculum materials are considered as one of the artifacts to support teachers' productive formative assessment practices. This approach involves considering the affordances and constraints of curriculum materials for teachers' practices (Remillard, 2005). Alongside this conceptualisation of curriculum materials, a growing body of research has attempted to investigate the ways to design the materials in a way that can afford teachers' practices in an intended direction (e.g., Davis et al., 2017). Independent of this body of research, over the past decade, a number of researchers have developed curriculum materials that can help teachers' formative assessment practices (Burkhardt & Schoenfeld, 2019; Hodgen et al., 2014). In this research, I aim to harness all these theoretical and practical resources to feed the ultimate goal of recontextualising formative assessment and suggest design ideas for productive implementation.

The study

This paper presents a part of my PhD research. The overarching aim of this research is to identify the discipline-specific examples of formative assessment strategies and contextualise and reconceptualise formative assessment by analysing a set of curriculum materials. More specifically, I aim to identify the features that can afford teachers' productive formative assessment practices in the existing mathematics curriculum materials and to develop design principles that can guide future design. In the following pages, after introducing the methods used, I will present some initial findings.

Sampling and data analysis

In order to enable the observation of various features, the materials were chosen in a way that suggested variety as well as similarity. The materials were sampled in three stages. Resources that were written in English , involve multiplicative reasoning at the secondary school level and aim to support classroom formative assessment practices were identified in the first stage. 12 sets of materials were chosen at the end of this stage. In the following stage, these 12 materials were more closely examined to explore surface-level similarities and differences amongst them. As a result of this examination, three distinguishing categories emerged. First, the materials can be categorised by the designers' position and the purpose of the design. That is to say, while some materials were designed by researchers for research purposes (e.g. Corner Stone Maths, 2022), some were designed by practitioners for teachers' use (e.g. White Rose Maths, 2022). Second, materials can be categorised by the educational context they belong. That is to say, the materials are from either United Kingdom or United States which is expected to show variety. Finally, the third category is the way of including formative assessment. Three features were observed in this category: 1) materials include complete lessons that are particularly developed for formative assessment, 2) materials include lessons that acknowledge formative assessment as part of pedagogy and 3) formative assessment tools that can be used as supplementary tools in the lessons. At the end of this second stage of sampling, I identified six materials to be used in this research; namely, Corner Stone Maths , Increasing Competence and Confidence in Algebra and Multiplicative Structures (ICCAMS), Mathematics Assessment project (MAP), White Rose Maths, Connected Mathematics Project and Mathematics Formative Assessment System (MFAS). The analysis in this

paper involves 32 documents, including teacher guides for complete lessons and assessment tasks from five of these materials, excluding Connected Mathematics Project due to accesibility issue at the time of that analysis.

Following the sampling, and using five formative assessment strategies as a guiding framework, reflexive thematic analysis (Braun and Clarke, 2021) was carried out to explore the instances that can afford teachers' productive formative assessment practices. Reflexive thematic analysis is only a method of data analysis. This allows theoretical flexibility to use the themes in the existing literature as well as creating a space for researchers' reflexivity. I conducted a deductively-oriented and explorative analysis. While a deductive orientation allowed me to use existing literature, the explorative approach allowed me to explore further themes.

In the pages that follow, one aspect of the results of this analysis is presented in relation to the formative assessment strategy of eliciting students' learning.

Findings in relation to the formative assessment strategy of eliciting students' learning

While eliciting students' learning, one of the teachers' tendencies can be to focus on the accuracy of students' responses rather than further investigating students' mathematical thinking. Identification of misconceptions can illuminate students' mathematical thinking (Smith III et al., 1994). That is to say, the mathematical tasks can be used to allow students to reveal their misconceptions and help teachers to notice students' gradual thinking.

Noticing refers to teachers' awareness of students' thinking which entails three aspects attending, interpreting and shaping (Van Es & Sherin, 2002; 2021). Teachers' skill to prioritise critical classroom incidents is referred to as attendance. Making connections between these circumstances and the local environment while considering the students' mathematical thinking is referred to as "interpreting." Shaping is the use of additional approaches to discover how students think.

The analysis identified two stages that support teachers' noticing by using misconceptions as a starting point to focus on students' certain ways of thinking. For the first stage, some instances were identified that have the potential to alert teachers to mathematical learning intentions and a variety of students' ways of thinking. Figure 1 and Figure 2 are two instances of the extracts that contributed to this result. Figure 1 illustrates students' typical mistakes and misconceptions when practising multiplicative reasoning tasks. Figure 2 shows a more focused student challenge with identifying functional relationships as opposed to scalar relationships. These extracts may encourage teachers to pay more attention to these subject-specific features and help them understand students' thinking, which will contribute to attending and interpreting aspects of noticing.

This lesson unit is intended to help you assess whether students recognize relationships of direct proportion and how well they solve problems that involve proportional reasoning. In particular, it is intended to help you identify those students who:

- Use inappropriate additive strategies in scaling problems, which have a multiplicative structure.
- Rely on piecemeal and inefficient strategies such as dobling, halving, and decomposition and have not developed a single multiplier strategy for solving proportionality problems.
- See multiplication as making numbers bigger and division as making numbers smaller.

Figure 1. Students' typical mistakes and misconceptions in multiplicative reasoning
Note. From *Comparing strategies for proportion problems*, by Mathematics Assessment Resource Service, 2015, p. T-1.

The items below are on the Mini Ratio Test. We gave the items to comparable samples of secondary school students (mostly Year 8, N=77 and N=74). Item A turned out to be much easier than item B (with facilities of 91% and 51% respectively). This supports the conjecture that students prefer scalar relations, since this relation is much simpler for item A than for item B.

A-Ant is making a spicy soup for 11 people. He uses 25 ml of tabasco sauce. Bea is making the same soup for 33 people. How much tabasco sauce should she use?

B-Ant is making a spicy soup for 11 people. He uses 33 ml of tabasco sauce. Bea is making the same soup for 25 people. How much tabasco sauce should she use?

Figure 2. Functional versus scalar relationship
Note. From *Post shadows*, by Küchemann et al., 2016, p. 122

For the second stage, some instances were shown to have the potential to guide teachers to notice students' thinking by interpreting and shaping. To put it another way, the materials analysed offered teachers questions that can enable them to interpret students' thinking as well as a number of probing discussion questions and additional mathematics tasks that could be used to understand students' thinking further. The following is an example of probing questions for a task in the MFAS.

A task in MFAS

When making a coffee, Amanda uses three tablespoons of ground coffee for every 12 ounces of water. Complete the table by displaying this ratio as well as four other equivalent ratios. Then explain how you calculated the equivalent ratios you wrote.

Probing questions

How is the number of ounces of water related to the number of tablespoons of coffee?
Can you use multiplication to generate equivalent ratios?
Can you use division to generate equivalent ratios?
Can you determine how many ounces of water are needed for 25 tablespoons of coffee?
Can you write the given ratio as a unit rate?

Figure 3. Probing questions
Note. Adapted from *Making coffee*, by CPALMS (n.d.)

These examples are acknowledged as an opportunity to help teachers expand beyond merely pointing out students' mistakes or misconceptions by noticing the reasons for these mistakes and misconceptions and students' gradual thinking. This can help teachers to realise disciplinary goals of mathematics such as conceptual understanding, problem-solving and reasoning beyond embracing procedural knowledge.

Conclusions and future direction

In this paper, I brought attention to the need for contextualising formative assessment strategies and communicating these contextualised strategies to teachers. The existing curriculum materials provide this to some extent, as the examples presented above for the strategy of eliciting students' learning demonstrate.

In the following stages of this research, I will conduct further analysis of the same curriculum materials by juxtaposing the results of the initial analysis with the literature to pinpoint any gaps in the materials as well as the affordances for teachers to engage in productive practices. For example, the initial analysis did not offer examples to support some elements of learning mathematics, such as a productive disposition (National Research Council, 2001). Additionally, a complete investigation is required to provide instances for other critical formative assessment components, including feedback. At the end of that analysis, I intend to produce design principles that can guide future design.

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