

Proposing educative features of the curriculum materials that can enhance teachers' noticing

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The notion of noticing students' mathematical thinking supports one of the generic formative assessment strategies, eliciting evidence of students' learning, by emphasising the value of teachers' engagement with students' mathematical thinking beyond just identifying the procedure. In practice, most teachers will be expected to focus more on the answer presented than engaging with students' developing mathematical thinking due to limited resources such as knowledge and practical tools. The educative features of curriculum materials identified in this paper can potentially challenge teachers to review and enhance their practices. These features were proposed as a result of an analytic process that involved the analysis of five sets of teacher guides for multiplicative reasoning lessons, alongside a critique of the existing frameworks regarding formative assessment and noticing.

Keywords: Educative features, teacher guides, noticing, formative assessment, multiplicative reasoning

Introduction

This paper presents educative features developed as a part of the first author's PhD research aiming to contextualise formative assessment strategies suggested by Wiliam and Thompson (2007) in the secondary mathematics context and to explore educative features that can have the potential to facilitate the productive enactment of formative assessment. According to Wiliam and Thompson, these five strategies involve identifying learning intentions and sharing them with students, eliciting evidence of students' learning, providing feedback, supporting students to learn from each other, and encouraging students to be the owner of their learning. The assumption that underpins the arguments in this research is that while these generic strategies can be applied to various subjects, grasping the key ideas underlying these strategies and enacting them in specific subjects can be demanding for teachers (Bennett, 2011), due to various obstacles (e.g., limited teacher knowledge). Curriculum materials have the potential to encourage teachers to consider these obstacles and facilitate teachers' attempts to enhance their classroom practices.

In this paper, we focus on the second of the formative assessment strategies, the engineering of tasks to support eliciting evidence of students' learning and consider what features of teacher guides can facilitate teachers' enactment of this strategy. In a critical review of formative assessment, Bennett highlighted several potential teacher challenges to effectively enact formative assessment that can stem from the generic characteristic of formative assessment strategies. For the second strategy, teachers first need support to elicit evidence of how, and the extent to which, students understand the subject, rather than simply whether or not students can implement procedures correctly in class. Second, teachers then need help to make inferences about students' current and future learning based on this evidence.

Despite the growing body of research and recent policy acts that could encourage mathematics teachers to shift from identifying how students follow procedures to noticing and addressing how students understand mathematics, evident since the early 2000s, this shift in practice can take a long time to have an impact on classroom teaching. Recent evidence shows the persistence of a focus on procedures in mathematics education (Lithner, 2017).

Teacher guides are the elements of curriculum materials which can be accessible for teachers in planning and enacting their daily teaching practices and potentially set out (or at least refer to) most of the educative aspects of the curriculum materials. This study therefore initially focuses on teacher guides. More specifically, we explore the features that are integrated into existing teacher guides that can facilitate the enhancement of mathematics teachers' noticing practices and address this research question: *What educative features of existing teacher guides can enhance mathematics teachers' noticing practices?*

In order to address this research question, a series of analyses of five existing teacher guides, which are part of the curriculum materials that are acknowledged as well-designed either by researchers or practitioners, were conducted iteratively through a combination of a variety of sampling and data analysis techniques that involve use of telling cases (Mitchell, 1984) and deductive-oriented reflexive thematic analysis (Braun and Clarke, 2021).

Theoretical Background

Noticing students' mathematical thinking beyond eliciting evidence for learning

In his practical book, Wiliam (2018) elaborated on the strategy of eliciting students' learning by presenting example classroom practices that can help teachers of any discipline grasp the core ideas behind this strategy. Through these techniques, he highlighted teachers' responsibility for enabling students to think and gathering evidence about students' learning which will help teachers make decisions for the following teaching step. However, the example techniques provided seem generic and might require further consideration within specific subjects or even topics. For example, among these techniques, Wiliam advises teachers to listen to students to learn about their thinking, rather than focusing on the correctness of the responses. Although this advice can fit any subject, the specifics of the listening practice such as the content to concentrate on and the content-specific probes to provide students with will vary. In this study, in order to contextualise this generic strategy for secondary mathematics context and inspired by Prediger et al.'s (2008) approach of networking theoretical approaches, we expanded this strategy by complementing it with three aspects of noticing suggested by Van Es and Sherin (2021) and five strands of mathematical proficiency (National Research Council, 2001).

Van Es and Sherin (2021) contend that there are three components of noticing, which are 'attending', 'interpreting', and 'shaping'. They argue that, by engaging with students' learning, teachers are better placed to attend to, and begin to notice, the indications of students' learning. Teachers then need to interpret this evidence and shape interactions for further eliciting students' learning. This conceptualisation can be harnessed to contextualise the second formative assessment strategy and make it more easily applicable in classroom teaching.

The enactment of all three components of noticing requires well-defined learning goals that specify what constitutes learning that is worth noticing. In many educational systems, mathematics teachers often emphasise students' procedural skills rather than their conceptual understanding and mathematical reasoning skills for several reasons (e.g., teachers' beliefs about mathematics and mathematics learning, high-stakes testing and/or external accountability pressures). For more than three decades, educational researchers have described practices that push back against this tendency (e.g., Lampert, 1990). The framework offered by the National Research Council (2001) in the United States contributes to this by reframing the goal of mathematics education as five interrelated mathematical proficiencies: conceptual understanding, procedural fluency, strategic competence, adaptive reasoning and productive disposition. These five proficiencies are considered as the discipline-based learning intentions in this research that can guide teachers' noticing in mathematics classrooms.

The educative function of the curriculum materials

Considerable research has highlighted the role of curriculum materials in teachers' professional development (e.g., Remillard, 2005). In particular, Davis et al. (2017) conducted an extensive body of research in the elementary science context, which has been ongoing for almost two decades and has involved a variety of methods such as theoretical reviews, analysis of curriculum materials, observations and experiments. As a result, they offered the notion of educative curriculum materials and design principles that can help develop such materials. The educative curriculum materials refer to the materials that aim for teachers' learning alongside students' learning. In our research, inspired by the idea of addressing teachers' professional needs, the notion of educative features for the materials is used. It should be noted that the notion of educative features rather than educative curriculum materials is preferred, so as to highlight the educative function of the materials rather than the purpose of the designers as suggested originally.

Methods

In the wider PhD study, analyses were conducted iteratively to suggest educative features that can have the potential to facilitate enhancing teachers' formative assessment practices and to explore exemplifications of these features further in each iteration. This section of the paper focuses on the methods of this research that particularly led to the concluding arguments in relation to the educative features proposed. In the following sections, first, sampling strategies for the teacher guides will be presented. This will be followed by introducing the process of developing educative features.

Sampling teacher guides in the larger research

Five sets of mathematics curriculum materials that included teacher guides were chosen as a result of two stages that involved convenience and purposive sampling strategies. Table 1 presents the characteristics of these sets of materials. In the first stage of sampling, 12 sets of mathematics curriculum materials that are written in English and involve multiplicative reasoning lessons were chosen. In the second stage of sampling, 'telling' cases rather than typical cases were identified (Mitchell, 1984). That is, it was aimed to choose well-designed materials that have the potential to offer variety in terms of educative features and formative assessment practices. We considered materials as well-designed when they were either specifically research-based or preferred by a large

community of teachers. In Table 1, while sets A, C, D, and E are research-based materials set B is preferred by a large community of mathematics teachers in the United Kingdom. The variety amongst the materials was aimed to be provided in terms of the designers' stance, situating formative assessment within the materials, and the national curriculum with the materials was aligned.

Table 1: The characteristics of the sample set of curriculum materials

Materials	Designers	Situating formative assessment	Curriculum
A	Researchers	Main focus	National Curriculum in England
B	Practitioners	Part of pedagogy	National Curriculum in England
C	Researchers	Part of pedagogy	National Curriculum in England
D	Researchers	Main focus	Common Core Standards in the United States
E	Researchers and practitioners	Part of pedagogy	Common Core Standards in the United States

The process of developing educative features

Initially, the five sets of teacher guides were analysed using Braun and Clarke's (2021) deductive orientation for approaching reflexive thematic analysis. Deductive orientation allowed the use of Wiliam and Thompson's (2007) five formative assessment strategies as a guiding framework to direct coding and theme development. This was an explorative analysis that aimed to reveal the potential affordances in the materials that can help teachers' enactment of formative assessment. This was followed by an additional analysis that particularly focused on the potential affordances for feedback.

Figure 1 presents these analysis processes in the circular area in the middle of the figure. While the inputs of these analyses are presented on the left-hand side, the outputs of the analyses are presented on the right-hand side. The blue-printed text on the right-hand side highlights the findings that were the basis for the subsequent noticing analysis.

As a result of this process, two frameworks were developed. The first framework served to conceptualise classroom formative assessment by highlighting the key classroom formative assessment practices: identifying and sharing intentions of learning mathematics, noticing students' mathematics learning and providing feedback that can enhance students' learning of mathematics. These three practices are considered pillars of classroom formative assessment. Through the analysis, it was observed that while the first three formative assessment strategies highlight the key purposes of formative assessment, the last two strategies, which involve activating both students themselves and their peers for learning, refer to the classroom practices that can serve to achieve these purposes. As a result, the pillars of formative assessment feature the first three strategies. The second framework served as an analytic framework that guided identifying and comparing the educative features that have the potential to enhance teachers' classroom formative assessment practices. This framework

involves three educative features: alert, equip and guide. In the following section, the application of this analytic framework will be exemplified by using one teacher guide from set A. This teacher guide was chosen as an example as it involves rich examples of educative support for teachers' noticing students' learning of multiplicative reasoning.

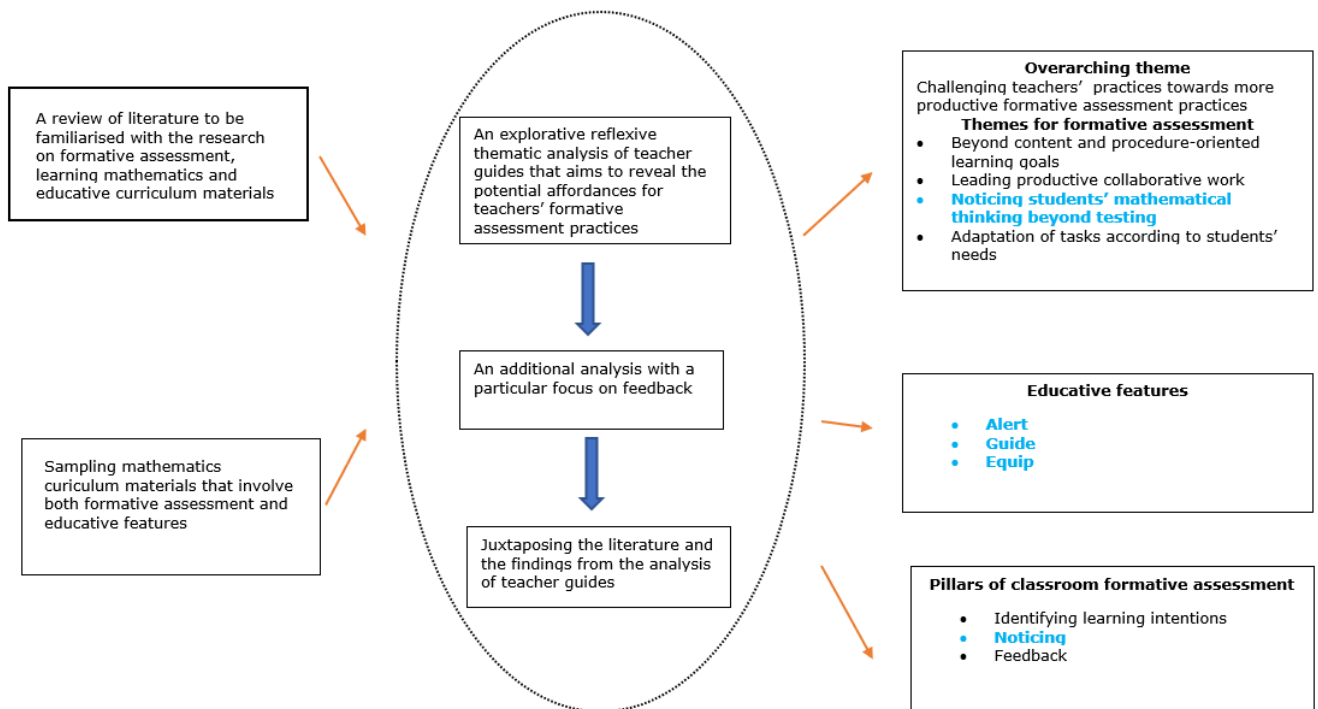


Figure 1: The initial analytic process that fed the noticing analysis

Expanding on three educative features through an example pedagogical message

The framework shown in Figure 2 was developed to clarify the relationship between three educative features, the components of noticing and five strands of mathematical proficiency. The curriculum materials could have the potential to facilitate teachers' enactment of the suggested pedagogy, which is noticing in this case. These educative features could support teachers in attending to, shaping and interpreting classroom interactions by centering the five strands of mathematical proficiency as learning intentions.

In what follows, the application of this framework will be demonstrated by analysing the noticing opportunities for students' conceptual understanding of multiplicative relations by using a specific teacher guide in set A. This teacher guide offers potential educative support that can facilitate teachers' noticing of students' developing conceptual understanding of multiplicative relationships. In order to maintain the focus on illustrative examples of educative features for noticing, our analysis identified the pedagogical messages in this teacher guide that can be associated with attending to, shaping, and interpreting students' developing conceptual understanding of multiplicative relations. This is followed by interrogating how teachers could be alerted, equipped and guided to enact these pedagogical messages.

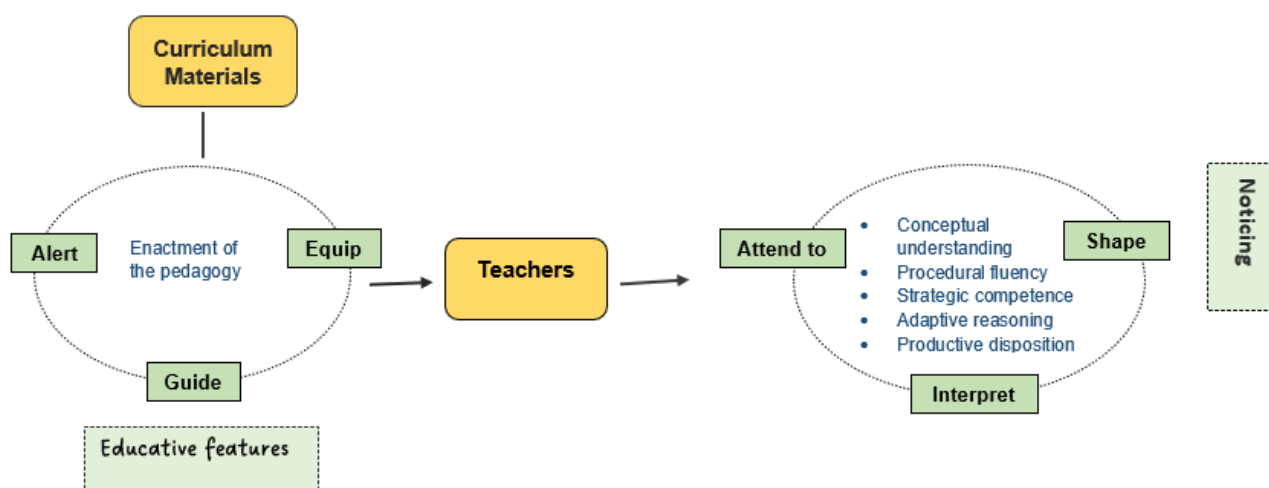


Figure 2: Relationship between educative features and the aspects of noticing

The pedagogical message we focus on in this section is that using variants of a multiplicative reasoning task can facilitate attending to students' potentially incorrect additive reasoning in multiplicative situations and shape classroom interactions that can facilitate teachers' attending to students' reasoning underlying their correct or incorrect responses. In this teacher guide, related references for alerting, equipping and guiding teachers were found. First of all, teachers were equipped with seven variants of the main task that could potentially reveal a broad spectrum of students' understanding. Due to space constraints, we present only two of these variants in this paper. On the left-hand side of Figure 3, the main task is presented. In this task, two posts and their shadows are represented. Students are expected to use the lengths of the posts and the length of the shadow of one post to find the length of the shadow of the other post. Providing teachers with this task could be considered as a reference for the educative support of equipping teachers to facilitate their attending to students' reasoning. More explicitly, when students give the answer 32, teachers could attend to students' incorrect additive reasoning, and when students give the correct answer 35, teachers could attend to students' correct multiplicative reasoning.

The educative support in this teacher guide goes beyond equipping teachers to attend to these two commonly anticipated student responses; it also provides variants of this task that could equip teachers to shape classroom interactions to obtain further information about students' reasoning. The task in the middle of Figure 3 could equip teachers to shape interactions that can reveal whether students use incorrect additive reasoning when one length is the multiple of the other length (the length of P is a multiple of the length R). The task on the right could equip teachers to shape interactions that can reveal whether students who give correct responses could use incorrect additive reasoning when identifying the scale factor, which is $2\frac{7}{12}$ in that example, which might be relatively challenging.

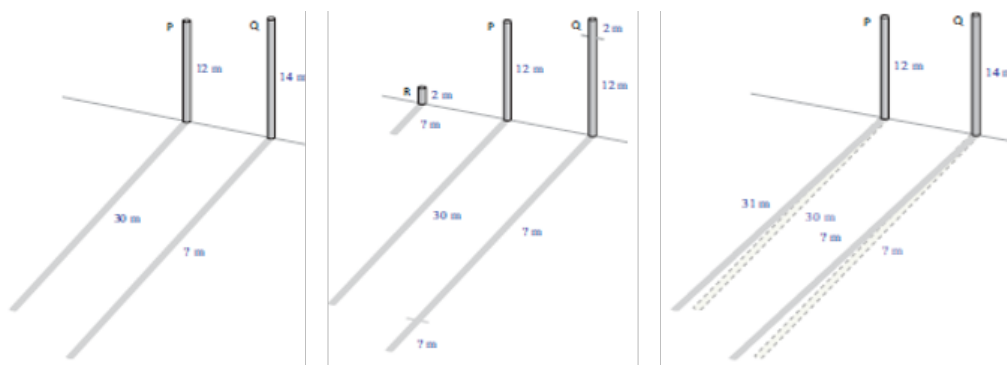


Figure 3: Three variants of the task for multiplicative relations (from Post shadows, by Küchemann et al., 2016, p. 123)

Alongside being equipped with these tasks, teachers are guided through instructions that could facilitate making better use of the main task. More explicitly, teachers are guided to record students' immediate responses, encourage students to discuss their reasoning with their peers and record students' responses after these discussions. This guidance could help teachers obtain sufficient information about students' developing reasoning while completing this task, and this information could help them make better judgments regarding the variant of this main task to be given as the next task.

Finally, in this teacher guide, a reference to alerting teachers to the rationale of using variants of the main task was found: it was explicitly stated that these variants could encourage students to engage in additive or multiplicative thinking. Teachers were also alerted to the rationale behind selecting a multiplicative relationship involving a fractional scale factor: this choice of numbers may pose a challenge for some students, which can lead to an incorrect additive response. This educative support could have the potential to encourage teachers to utilise the variants of the main task and select fractional scale factors.

Conclusion

This paper introduced a framework that involves three educative features of curriculum materials that hold the potential to facilitate teachers' pedagogical practices. These features include: *alerting* teachers to the function of the practice in order to encourage them to enact the practice; *equipping* teachers with the tools and knowledge that can afford enactment; and *guiding* teachers by providing instructions to facilitate the enactment. We contend that to employ these educative features to evaluate the educative potential of designed curriculum materials, the initial step should be identifying the pedagogical message intended to be conveyed to teachers. The authentic characteristic of this framework is its focus on facilitating teachers' in-the-moment classroom practices beyond providing them with passive knowledge.

While in this paper this framework is exemplified with a narrow context, which is facilitating teachers' noticing of students' conceptual understanding of multiplicative relations through teacher guides, we contend that this framework can have wider implications. More importantly, we argue that these three educative features can be integrated into various curriculum resources in various contexts (e.g., digital resources) with the purpose of enhancing teachers' certain pedagogical practices.

Furthermore, the framework developed in this study and its suggested application can inform future research on developing curriculum resources to enhance teachers' practices. The next stage of this research could be to employ, craft and theorise these features in a design-based research study.

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