Title	Factors affecting primary science teachers' enactment of formative assessment: Reality and professional decision making
Author(s)	Poh Hiang Tan and Aik Ling Tan
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The problem

Assessment is an important part of education and it often shapes classroom practices. In recent years, there has been a call to move attention away from assessment *of* learning or summative assessment to assessment *for* learning or formative assessment. Formative assessment, or "instructionally oriented classroom assessment" (Popham, 2008) is a process that aims to improve students' learning through embedding assessment in instructions so as to create a "learning culture" where both students and teachers view formative assessment as a source of information and help to improve teaching and learning (Shepard, 2000). Black and Wiliam (1998b) describe formative assessment as an activity "*when the evidence is actually used to adapt the teaching work to meet the needs.*" (p.2). In their review of 250 research papers, Black and Wiliam concluded that formative assessment is a powerful force that could greatly improve students' learning when properly implemented. Despite the potential benefits of formative assessment, doubts about the effectiveness and more fundamentally what constitute orthodoxy formative assessment practices in the classrooms remains elusive (Bennett, 2010). In fact, Bennett (2010) raised issues about the claim made in the review by Black and Wiliam (1998), citing that the studies in the review were too disparate for meaningful conclusion to be drawn based on effect sizes. The studies cited in the review reflect varied results of formative assessment when implemented in different contexts. Bennett (2010) thus urged for a well-conceptualized approach such that the process and methodology of assessment are rooted in specific domain. An approach suggested by Pellingrino, Chudowsky, and Glaser (2001), was to conceptualize assessment as a process that is based on triad relations of cognition, observation and inferences. This triad relation requires that assessment be based on good understanding of what accounts for learning (or the knowledge and skills) within the specific domain. Teachers or task developers could then design appropriate situation or task so that students have the opportunity to display what they have learnt and the evidence of which can be appropriately interpreted and used. While the three elements are important in formative assessment, the development or selection of task will impact students' performance directly and also how teachers could go about collecting relevant information about their students.

Cognizant of the issues and questions relating to formative assessment, this research aims to answer the following research questions:

(1) What are the factors affecting primary science teachers' decision making in selecting activities for formative assessment?
(2) How do teachers perceive their role to be in enacting formative assessment in the primary science classroom?

Research Design

Research Context

This study is largely qualitative in nature with data obtained from questionnaires with 39 elementary science teachers from six schools scattered in various parts of Singapore. Singapore is a country that has traditionally performed well in international comparative studies such as TIMSS and PISA. Culturally and socially, education and national examinations are viewed as important and hence high stakes. As such, schools placed emphasis on summative assessments

and used them to emplace students into different ability groups and for policy and curriculum planning.

Research participants and Data collection

The 39 teachers in this study are randomly selected and they have teaching experiences from 1-40 years. Their educational backgrounds are also varied (from A-levels to Masters degree) and they are from six primary schools. These teachers have all taught elementary science and the topic of electricity. They were all given a probe (in the form of a questionnaire) with three activities based on topic of electricity and were asked to select a suitable formative assessment activity for their students and their reasons for the selection.

The probe

The probe consists of three tasks (labeled T1, T2 and T3) on electricity that would at least assess the following three learning outcomes as found in the primary science syllabus:

1. Recognise that an electric circuit consisting of an energy source (battery) and other circuit components (wire, bulb, switch) forms an electrical system.
2. Show an understanding that a current can only flow through a closed circuit.
3. Identify electrical conductors and insulators.

At the end of the primary school education, all students sit for a placement examination known as Primary School Leaving Examination (PSLE). The PSLE comprises assessment of four core subjects, namely, English, Mother Tongue (mainly Chinese or Malay or Tamil or other Non-Tamil Indian Language), Mathematics and Science.

Task T1 was set in the format similar to the science questions in PSLE Science requiring individual student to give a written response. Task T2 was similar to the activities found in science resource books requiring the students to work in pairs. It follows the Predict-Observe-Explain sequence commonly used in science teaching in Singapore classrooms. The apparatus need in this activity would be commonly found in the science lab. Task T3 was a group activity that required each group of four to five students to create a puzzle for another group of students to solve. At the end of the activity, the students were required to share with the owner of the puzzle how they arrive at the answers. The set-up for activity was unusual and required teachers to source for shoebox and to mount a switch, two light bulbs and a set of batteries on the box cover.

Data Analysis

The responses from the teachers form the data corpus for this research. We adopted a modified process of coding (open coding, axial coding, and selected coding) as suggested by Glaser and Strauss (as cited in Flick, 2006). In the first instance, we carried out open coding whereby we examined all the responses to search for frequent ideas expressed by teachers. Subsequently, we carried out axial coding where we looked into the relationships among the frequent ideas expressed by the teachers and developed four themes (implementability; learning outcomes; nature of task; and students) based on the responses of the teachers. Finally, for selective coding, we examine the details and context of the responses to finalize the integrated themes among the responses so that we could understand the factors guiding the teachers' decision making for selecting tasks for formative assessment. Coding was carried out by two

researchers using NVivo 9 and inter-rater agreement was set at kappa value of at least 0.5, indicative of fair to good agreement among the two coders.

Findings

The factors that affect teachers' decision making in task selection for formative assessment are (1) nature of task; (2) students; (3) learning outcomes; and (4) implementability of task. As can be seen from table 1, the nature of the task is most important when teachers select tasks for formative assessment. Teachers also relate the nature of the tasks to students' ability when they are selecting the task as can be seen by the similar percentage coverage of the codes.

Table 1: Factors affecting teachers' decision making for formative assessment task selection

Categories	Sub-category	Percentage Coverage (%)
Nature of task (18.9%)	- Purpose of task	5.6
	- Challenging	4.8
	- Simple	3.6
	- Intent of assessment	3.4
	- Diagnostic	1.5
Students (18.2%)	- Students' ability	10.2
	- Motivation of students	5.3
	- Collaboration	2.8
Learning outcomes (14.7%)	- Content	8.9
	- Skills	5.8
Implementability (12.7%)	- Manageable	4.4
	- Able to complete	3.8
	- Teachers' involvement/help	2.5
	- Resource availability	2.1

The data also showed that teachers pay a lot of attention to students' abilities when they are considering tasks for formative assessment (10.2% coverage). In their responses, the teachers mention alignment of level of difficulty of tasks to students of different ability levels. Responses such as:

"*Weaker pupils will be able to handle it well.*" (Tr7)
"*Task 2 may be given to middle and low ability groups.*" (Tr9)
"*The middle ability should be able to tackle this.*" (Tr15)

The teachers in this study also privileged the science content (8.9% coverage) that the students' will learn when they select tasks for formative assessment. They are concerned whether the intended learning outcomes as spelt out in the national curriculum documents will be fulfilled when they carry out the task. While this is expected of teaching and learning in the reality of classroom life, it suggests a dilemma that teachers face in trying to enact formative assessment. They have to find a balance between focusing on students' learning as opposed to trying to ensure that the relevant content is taught in class. Responses pertaining to science content are as follows:

"… pupils need good knowledge of electricity before being able to carry out this task" (Tr 6)

"… I will be able to monitor if the pupils have fully comprehend the whole idea of what electricity, conductors and circuits mean. …I will be able to guide pupils who have misconceptions along the way." (Tr 14)
"It provides feedback on pupils understanding of the various component of a simple circuit, such as the battery, wire, bulb, switch etc." (Tr 18)
"The lighting up of the bulb will also tell me that they have understood that it means their circuit is closed." (Tr 23)
"*Teacher can check on pupils understanding based on their design of closed circuit and use of conductors of electricity."* (Tr 39)

Task T3 was an unfamiliar task that required the teachers to create the shoebox set-up. A number of the participants did focus on its novelty and made similar observations like *"T3 is for higher ability pupils"* (Tr 2) and *"It is too time-consuming to be done in class"* (Tr 26). However, contrary to our initial hypothesis that teachers will focus on the implementability of the task in their decision-making, we found that while this is a concern, it is not a major issue with most teachers (12.7%).

Within the probe, there were two tasks that required student collaboration. In the findings, we were surprised at the relatively little attention given to the effects of group activities who have increasingly become a common feature in the primary science classroom (2.8%). This could be an indication of teachers prioritizing the different criteria of selection of tasks.

The teachers in the study dichotomize the ideas of summative-formative assessments and assessment-classroom activity. As one participant pointed out, "*But if it is for summative assessment purposes solely then T1 is more suitable. T2 and T3 provide more for formative assessments - to inform teacher and pupil about child's progress and readiness*" (Tr 1). While Task T1 was intentionally set in the same style as PSLE science question, the explanation given by students in the question could still reveal students' learning of electricity. As Bennett (2010) pointed out, there tends to be an oversimplification of summative assessment for the purpose of assessment *of* learning and formative assessment for assessment *for* learning. While the primary purpose of summative assessment could be for documentation purpose, it could still fulfill a secondary purpose of assessing students' learning. The same argument would go for a formative assessment. When used appropriately, it could provide documentation of students' learning journey. Based on the definition by Black, Harrison, Lee, and Wiliam (2003), the purpose could be formative if the task could provide information on the students' learning for teacher to make an informed decision on the next course of action.

Another significant finding from this study is that a number of teachers tend to draw a distinction between assessment and the classroom activity per se (5.6%) with a number of participants seeing the task as an "*enrichment activity*" (Tr 3, Tr 18, Tr 38) or *"extension activity"* (Tr 19, Tr 36, Tr 37). As a teacher (Tr 16) pointed out, *"The other 2 tasks are more direct and can be used immediately after the basic lessons are taught. I think they are not very suitable for formative assessments"*. This finding is similar to what Kind (2009) expressed in her review of nine models on pedagogical content knowledge (PCK) arising from different studies. Kind found that only two models by Magnusson, Krajcik, and Borko (1999) and Veal and MaKinster (1999) considered assessment as part of PCK that teachers need to be equipped with (as cited in Kind, 2009).Our findings show that there are teachers who perceived that formative assessment are often associated to hands-on activities while many others see tasks with a distinct

summative or formative purpose. In our interaction with many teachers, there seems a perception among teachers that all forms of assessments carried out in class are formative in nature with less attention paid to the interpretation of the elicited evidences from students.

Contribution to the teaching and learning of science

The significance of this paper lies in understanding teachers' ideas about assessment and their classroom practices. Our results show that teachers take students' abilities into consideration in selecting classroom tasks. Further, our results also show that some participant teachers risk making disparate distinction between assessment and classroom instruction. These analyses of the results have the potential to inform teacher professional development and reform curriculum and assessment changes.

Interest to NARST members

Science educators and curriculum developers who are interested in understanding teachers' professional decision making would benefit from the knowledge of what guide teachers' practices. Assessment shapes classroom practices and teachers actions and understanding how teachers' perceive assessment and make decisions relating to assessment will impact classroom practices.

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