Integrating Pupil Self-Assessment into Mathematics Classrooms: A Study in Singapore Primary Schools.
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Abstract
This study aimed to investigate how pupil self-assessment could be effectively integrated into teachers’ daily mathematics lessons in Singapore school settings. Four classes taught by different teachers in two primary schools collaborated in the study over three semesters. Data were collected through survey questionnaires, classroom observations, interviews with teachers and pupils, and pupils’ responses to teacher-designed self-assessment tasks. The study revealed that although teachers encountered initial challenges, over time they could overcome them and become quite comfortable in using pupil self-assessment tasks in their lessons. The results also showed that teachers developed positive views about integrating pupil self-assessment into their daily mathematics teaching. Implications for classroom practice and the challenges of teacher-led assessment change will be discussed.

Keywords: classroom assessment, self-assessment, teaching of primary mathematics
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Introduction
In Singapore, recent emphasis on the need to broaden the role of student assessment has led to an increasing interest in use of the so-called alternative assessment strategies in schools (Fan, 2003). Elsewhere (e.g., Niss, 1993; NCTM, 1986, 1995, 2000), it has been suggested these assessment modes in school mathematics instructions are more appropriate than the “traditional” assessment approaches in addressing new curricular emphases, such as fostering of favourable dispositions, inculcating desired habits of mind, and supporting the process of knowledge construction.

For the past few years, alternative assessment in Singapore has spread from the purview of a handful of passionate researchers (Fan & Yeo, 2000; Fan, 2002; Yazilah & Fan, 2002; Fan, 2003) and mathematics teachers on inservice programmes to reach the attention of schools. It received (in 2002) definitive support for its use when it was mentioned as an assessment mode in the draft guidelines for the assessment of mathematics in schools by the Curriculum Planning and Development Division of the Singapore Ministry of Education (MOE). The guidelines were later published as the Assessment Guides to Primary Mathematics (MOE, 2004a) and Assessment Guides to Secondary Mathematics (MOE, 2004b). These Guides offers a generous selection of alternative assessment methods. For an education system whose assessment practice is steeped in the so-called “traditional” methods, and in which tests and examinations are high-stake events to many parties (e.g., students, parents, schools), as much research-based evidence should be garnered as possible to support the use of these “newer” assessment modes.

Aim and Rationale of the Study
The Mathematics Assessment Project (MAP)* was undertaken in response to this challenge. MAP explored the use of four assessment strategies – project-based assessment, communication-based (journal writing and oral presentation), performance-based and student self-assessment. It asked:

- What are the effects of using “alternative” assessment approaches in mathematics on students’ achievement – cognitive and affective?
- How should the new (to Singapore schools) assessment strategies be effectively embedded in classroom practice?

This paper briefly presents an initial analysis of the self-assessment part of the MAP. The authors shall be happy to provide more details to readers who are interested to know further about the study.

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MAP identified several reasons for investigating student self-assessment. Firstly, pupil self-assessment would be the means to the curricular goals. The framework for the mathematics curriculum in Singapore (MOE, 2001) identified five interrelated components – Concepts, Skills, Processes, Attitudes, and Metacognition – as essential to meeting its primary aim of developing ability in mathematics problem solving. Whereas the traditional assessment modes might have catered well to the development of concepts (e.g., numerical, geometrical, algebraic, statistical) and skills (e.g., estimation, calculation, arithmetic and algebraic manipulations, communication), they might be inadequate in serving the development of the processes (e.g., thinking skills, heuristics), attitudes (e.g., appreciation, interest, confidence, perseverance) and metacognition. In inculcating the desired attitude, for example, reacting to mathematical work confidently, qualitative information from pupil self-assessment ought to be more relevant than a numerical written test score. Indeed, in the case of the development of metacognition, which was defined as awareness or conscious monitoring of one’s own thinking, the role of “self” in gathering information to guide one’s thoughts might be crucial to metacognitive growth in a pupil.

Secondly, at a time when the workload burden on Singapore teachers are being addressed at national level, it is a genuine concern that the use of alternative assessment strategies such as journal writing, performance assessment, portfolios or oral presentation, does not overburden the teacher. Depending on the school, a teacher would teach two or three subjects (English Language, Mathematics and Science). With three or four classes of 40 pupils (typical class size), it would be a daunting prospect to read and respond to pupils’ journals, review portfolios, or listen to oral presentations.

Thirdly, with the current emphases on developing thinking and creativity, came the press to expand the conception of assessment in the context of schooling in Singapore (Fan, 2003). The term assessment in common usage here refers to the written test or examination. Until recently, a school would typically schedule four assessment exercises (one a school term), in which pupils in the same year would take a common written paper. Fan (2003) characterises this mode of assessment as time-limited (i.e., to be completed in a block of time), tool-limited (i.e., to be restricted to paper-and-pencil) and venue-limited (i.e., to be held at a specified place like an examination hall). In his work with in-service teachers, Fan (2002) found a controlling effect of the written test on classroom practice. If an assessment strategy is to support the Singapore mathematics curriculum, it would need to go beyond a focus on end-product of learning and grading to serve the how, why and what of student learning (Fan, 2003). However, assessment as written tests and for grading is an idea entrenched and promulgated by the large number of “assessment” books readily available in local bookstores to parents, private tutors, as well as teachers, wanting to put their charges through intensive practice for the written test.

Lastly, the local knowledge-base for pupil self-assessment is relatively limited. How should self-assessment be conceptualised and operationalised for a young child (Nisbet & Shucksmith, 1984)? Are they able to “reflect” on their thoughts or “self-evaluate” their mathematics performance? For MAP, pupil self-assessment is said to start when the
pupils undertake to reflect, judge and then report (spoken or written) on their own behaviour or performance. Pupil responses to questions on their experience of learning mathematics are assumed to be able to tap the attitudinal, dispositional, or metacognitive dimensions of their learning. This assumption is investigated in the study.

Method
Two primary schools were selected using stratified random sampling from the list of all primary schools based on the information provided by the Ministry of Education (MOE, 2003). One was drawn from nine high-level performance primary schools as identified by the MOE, and the other from the rest of the primary schools. Each selected school was to nominate two high-performing and two non-performing Primary 3 classes (pupil performance at primary 2 being the criterion), as well as a comparison class. However, MAP was unable, because of situational factors (e.g., nature of schools selected), to obtain non-high-performing classes from the high-level performance school and high-performing classes from the other school (see Table 1 below). The final selection of classes was with two high-performing classes from a high-level performing school and two non-performing classes from a “typical” regular school. The same mathematics teacher taught the two non-high-performing classes, whereas different teachers took the rest of the participating classes (intervention and comparison).

<table>
<thead>
<tr>
<th>Table 1: No. of participating students by schools and classes</th>
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<tbody>
<tr>
<td>High-performing school</td>
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<tr>
<td>Non-high-performing school</td>
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<tr>
<td>Total number of pupils</td>
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Data was collected from survey questionnaires administered to the pupils, the pupils’ responses to the “new” assessment tasks, classroom observations when the assessment activities were being used, field notes from discussions with the teacher-collaborators throughout the intervention period, and end of project interviews with these teachers and about five pupils per class at the end of the project.

The survey questionnaire was completed by the pupils at the start (pre-questionnaire) and at the end (post-questionnaire) of the project. There are two parts to the survey questionnaire. The first part (Part A) of the survey questionnaire consisted of 14 items asking pupils for their views towards mathematics and mathematics learning, feelings when learning mathematics, perceptions of their own performance in mathematics, and beliefs about the usefulness of mathematics. The items are generic ones, for example: “I enjoy doing mathematics,” “I can get good grades in mathematics,” “I dislike mathematics,” and “Knowing mathematics will help me get a good job next time.”

The second part (Part B) has 6 items to find out the extent of pupils’ familiarity with new assessment strategies in their previous mathematics learning. More specifically, the pupils were asked about their experience with writing and talking about mathematics, reflecting on their mathematics learning, making up mathematics problems, relating
mathematics to real-life situations, and solving problems in a variety of ways. Some of the items used are: “My maths teacher asked me to write down reasons for my maths answer,” “My maths teacher asked me to make up maths questions by myself,” and “My maths teacher encouraged me to solve maths problems in different ways.”

A nine-point scale (“disagree totally” to “agree totally”) was chosen, based on the results of pilot-testing a two-point and a 9-point version of the questionnaire a pilot with 79 primary 3 pupils not participating in the main study.

The post-questionnaire completed by the intervention classes used the same items as the pre-questionnaire for Part A. It differed from the pre-questionnaire only in Part B for intervention class, where it now asked pupils for their views and experiences with using the self-assessment activities. Sixteen items were used. Examples are: “I like to do more self-evaluation questions,” “Doing self-reflection helps me to learn mathematics better,” and “I enjoy creating my own mathematics questions.” For the comparison classes, the pre- and post-questionnaire had the same items.

In collaboration with the researchers, the teachers designed three types of activities aimed at encouraging pupil self-assessment. These activities (examples shown below) would be embedded within the daily mathematics lesson. They were:

A. Pupil self-evaluation activity, which focused on pupils assessing their learning at the end of a topic.

B. Pupil self-reflection activity, which focused on pupils monitoring their problem solving efforts (see the appendix for a sample).

C. Pupil constructing mathematics questions, which focused on pupils making up problems or designing tasks at the end of a learning segment (e.g., as revision).

After introducing the activities to the pupils in the above order, the teachers were to use any of them as they saw fit over three semesters.

Before the start of the project proper, all teacher collaborators attended a briefing-cum-workshop session on the new assessment modes, aim and design of the project, and logistical requirements. Thereafter, the researchers met the teachers twice a term to discuss implementation matters or to assist in the design of the assessment tasks.

Some findings and discussions
What were some challenges the teachers faced in introducing the self-assessment activities? How did the pupils view the self-assessment activities? Did they get to like learning mathematics more? Did their mathematics performance in the end of term assessment suffer? These questions were addressed below.

Teacher interviews and discussions
Overall, all the participating teachers were very receptive to trying out the self-assessment activities. They saw no pedagogic conflicts in embedding any of the activities with a daily lesson. In the case of the pupil self-evaluation activities, the teachers were seldom surprised in that the pupil responses mostly agreed with the teachers’ “personal” assessment of the pupils’ learning. The teachers viewed the self-reflection activities and
the pupil problem-construction activities initially as a welcomed variation to their instructional approaches. They expressed confidence in using them after the first round. Their challenge was to find class time (discuss later) to include the self-assessment activities.

Although the participating teachers all acknowledged the usefulness of the self-assessment activities, as when there was mismatch between their personal assessment and the pupils’ self-assessment of their learning (typified by the remark “I didn’t think they would have difficulty here”), they would stop using them after the project. A reason given was that they had to work to a very tight prescribed schedule and found it hard to carve some time for the self-assessment strategies in their daily lessons. Already in place were the prescribed activities and worksheets the department had developed, and these would be inspected by the schools and presumably the parents. The self-assessment activities had to be done on top of the prescribed ones.

Indeed, had it not been for the strong support of their schools (Head of Department (HOD) and Principal) and sense of commitment to the project, they would have stopped using the activities when the novelty wore out and when other professional concerns set in. The participating teachers felt that a mandate would be necessary if schools were to adopt and allocate time for these assessment activities in their mathematics programme.

The teachers from the high-performing school had several parents query them on the value of these self-assessment activities to their child’s learning; the teacher from the non-high performing school did not mention any parental concerns.

Overall, all teachers reported that the information collected from the self-assessment activities was helpful. However, they also reported that some pupils were soon “bored” with the self-evaluation exercise, which asked basically the same generic questions (see a sample in Fig. 1). It seems to us that a possible response to avoid “boring” the pupils is for teachers to ask these questions verbally or to paraphrase them.

**Dear Pupil: This topic: Money was taught two weeks ago. Think about your experience of learning this topic.**

**Complete this self-assessment sheet so that I can know better how you have learned and how I can help you.**

1. **Circle your answer.**
   1. This topic was easy
   2. I enjoyed learning this topic
   3. I had difficulty with this topic
   4. I feel I was quite lost with this topic
   5. I am confident about this topic

   Yes  No  Not Sure

Fig 1. Pupil self-assessment sheet
One teacher observed that the few pupils who reported no difficulty with a topic were the ones who performed poorly in the topics. Were these pupils giving socially desirable answers when asked if they understood a topic? Would an honest disclosure of failure to learn be reported to their parents? Also observed was that the few pupils who reported they knew they were “careless” in reading the question or in calculating, continued to be careless in their work. Taken positively, this finding suggests that a “careless” pupil may require a different set of metacognitive skills (other than being aware of their carelessness) to work carefully through computations and to monitor text comprehension.

The preceding discussion suggests that a shift in assessment practice requires more than just keenness on the part of an interested teacher. There may simply be no provision in terms of curriculum time for any classroom activities outside of the prescribed ones. Even when a school is prepared to support a conception of assessment as being more than grades and its teachers given the flexibility to try out different assessment modes, there is still a need to persuade parents of the value of these activities. Hopefully, mandated change may become a thing of the past now that Singapore schools are being given more and more autonomy to decide on assessment matters. In all, a change in assessment practice here seems to require negotiating a complex of factors, from resource to stakeholder demands, before an assessment mode can fulfil its potential.

Survey questionnaires
What is mathematics to the primary 3 pupils? Did they experience “alternative” assessment strategies before primary 3? How did the pupils take to the self-assessment activities? What effect did the self-assessment activities have on their mathematics performance? For a preliminary analysis of the questionnaire, the 9-point scale was
collapsed into three – Disagree, Neutral, and Agree. Below are some findings from the pre-questionnaire survey.

Part A of the survey questionnaire, with an internal consistency estimate (Cronbach alpha) being .89, revealed that mathematics was interesting and enjoyable to about 80% of the primary pupils, and hard to 37% of them. About 20% reported that they felt scared or nervous about doing mathematics. However about 90% of the students believed that they can learn mathematics well.

Part B of the survey revealed that about 76% of the primary pupils had never or rarely been asked to write or talk about their mathematics learning. Perhaps they are considered too young to be engaged in such activities. About 44% had never been or rarely been asked to make up mathematics questions or tasks. No significant difference between intervention and comparison classes was found. However, only 15% reported that they were exposed to problems amenable to multiple solution methods. MAP was thus timely and relevant, at least in these schools.

Responses to self-assessment tasks
In the non-high-performing classes, the pupils took to the self-assessment activities as they would any other teacher-directed activity. The self-evaluation and self-reflection sheets were no different from the other worksheets they would do in a daily lesson. The pupils enjoyed most the problem construction tasks (see a sample in Fig. 2). This was also reported by the pupils interviewed and mentioned by the teachers. Remark: In contrast, the secondary students participating in the same project could discern the activities as something new. It seems to us that these assessment strategies should be put in place at the primary levels for ease of integration into the daily lesson.

Fig. 2. Problem construction tasks
Responses such as these provide a window into the child’s conception of a mathematics problem for that topic. This should help demystify mathematics in that the pupils are able to be active participants in the generation of mathematics problems. Additionally, they are “fun” to the pupils.

**Conclusion**

In general, it appears to us that self-assessment is a helpful and feasible way for teachers to use in teaching primary school mathematics. However, we feel there is a need to address a few fundamental questions/concerns both theoretically and practically. In particular, is it a matter of good instruction that teachers include pupil self-assessment activities as part of the daily lessons? Or, is it a measurement rather than a pedagogic concern? A narrow conception of assessment as for marks and grades may prevent a wider use of pupil self-assessment activities in the daily classroom, especially if the label of “assessment” is attached to it. The lack of a firm handle on matters of reliability surrounding such assessment methods may turn teachers and schools away from their use. The definition of assessment as the process of gathering of information to make decisions regarding a student learning may be too encompassing to be useful and to gain acceptance among the stake-holders in Singapore. It may be best to restrict the term assessment to making a value judgment regarding the extent to which a pupil has attained the curricular goals designed for that pupil.
References


Appendix: Sample of self-reflection activity

For this activity, pupils first worked at the solving the given problem. The teacher then presented the solution(s) and the pupils “marked” their own work. Once done, they “think back” to their experiences of solving the problem and responded to the self-reflection prompts.

1. You have tried to do the mathematics task given below

   Mary bought a bottle of milk and a packet of sweets. She gave the cashier $10 and received $4.35 change. The packet of sweets cost $3.45. How much did the bottle of milk cost?

   $10.00 - $04.65 = $04.35

   The bottle of milk cost $04.65

2. After doing the given task, I think (Please tick the sentences that describe what happened when you did this task)

   □ I was able to do the work.
   □ I did not understand the question.
   □ I was able to the working but not the model drawing.
   □ I understood the question but got wrong answers.
   □ I can explain how to solve this task to someone else
   □ The task was easier than I thought it would be.
   □ The task was harder than I thought it would be.
   ✔ If I try a similar task like this next time, I will have confidence to solve it.

   □ I enjoyed the task because ______

   It is easy and fun.

3. I think I made mistakes in solving this task because (e.g., tell the difficulties or problems encountered. [If you did not make any mistake, please skip this item]) (tick the response that describes you most, you may tick more than one)

   √ I didn’t understand the question.
   — I was careless in my working.
   ✔ I was careless in writing the answer.
   ✔ I didn’t read the question carefully.

4. I think the most important thing (e.g., mathematics knowledge, methods, etc.) I learned from doing this task is:

   √ how to add money
   — how to subtract money
   ✔ how to change money from dollars to cents
   — how to use models to help me understand a question
   — how to use drawing to understand the question.
   — Others:____________________________

Pupil B’s self-reflection task
Appendix (cont.): Sample of self-reflection activity

Guess and check: 81, 72, and 63 are the possible numbers as those digits add up to 9.

The number which has 7 as a factor is 56.

So Judy guessed correctly.

I think both methods of solving are the same.

After I had been practicing working, I am still confused.