Towards a Conceptual Framework for Assessment Literacy for Mathematics Teachers

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As part of a mathematics teacher's skillset, knowing what kinds of assessment, when and how to assess, and for what purposes, are important. Although there have been frameworks outlining the various facets of teacher assessment literacy, recent literature suggest that gaps exists on the theoretical underpinnings as well as in psychometric claims of the measures. A framework of assessment literacy is proposed in this paper, informed by the mathematics education literature: (1) knowledge about assessment concepts; (2) skills in applying the knowledge in actual assessment practices; (3) communication and action in providing feedback or changing instructional practices based on assessment information; (4) attitudes and beliefs about assessment and its role in mathematics teaching and learning; and (5) meta-cognition and self-regulation of teachers' own assessment literacy.

INTRODUCTION

As a platform to provide feedback for follow-up instructional activities, it has long been recognised that assessment plays a pivotal role in the teaching-learning process. Although assessment literacy of teachers is an established field within the general education academic community (see Kahl, Hofman, & Bryant, 2013), it is still developing in mathematics education. Indeed, Santos and Cai (2016) provided a timely reminder on this in their chapter on Curriculum and Assessment in the Second Handbook of Research on the Psychology of Mathematics Education because there was no chapter on assessment in the first Handbook. Additionally, Lin and Rowland (2016) who reviewed several models of teacher knowledge in the studies presented in PME conferences and forums discovered that knowledge about what, when, and how to assess students was not raised as aspects of pedagogical content knowledge or mathematics knowledge for teaching. Whilst it is important for teachers to be literate on generic assessment issues such as validity and reliability, it is also crucial to help mathematics teachers develop a more in-depth understanding of assessment within the sensitivities of the subject matter knowledge. This paper presents a preliminary conceptual framework for mathematics teachers' assessment literacy to help anchor future discussions on mathematics teachers' assessment literacy. Implications of the framework for the wider international mathematics education community will be discussed.

LITERATURE REVIEW

The word *assessment literacy* has been attributed to Stiggins (1991), who averred that assessment literates are able to “know what constitutes high-quality assessment” and to seek and use appropriate assessment methods “that communicate clear, specific, and rich definitions of the achievement that is valued” (p. 535). Knowledge of the importance of the sampling of performance information, the extraneous factors that can interfere with assessment, and the usability of the assessment data are critical aspects of assessment literacy (Stiggins, 1991).

**Assessment Literacy: Definition of Terms and Key Aspects**

Assessment literacy is multidimensional; its meaning changes with context (Stiggins, 1991). Several issues and debates in concepts about assessment and measures of assessment literacy were raised in previous research. Taras (2010) argued that the dichotomy made between formative assessment (view of assessment as process and part of pedagogy) and summative assessment (view of assessment as product, with negative connotations) is problematic. An assessment strategy (a single process) can be used for formative or summative purposes (function), and formative assessment necessitates an initial summative evaluation followed by pedagogical action (for example feedback). In addition, Gotch and French (2014) conducted a systematic review of 36 assessment literacy measures from 1991 to 2012, and found that the psychometric support for the measures was weak.

In the mathematics education community, related components of assessment literacy such as the use of formative assessment, providing quality feedback, the choice of tasks, and the statistical literacy of interpreting summative assessment data are on-going topics of concern and research in mathematics teacher education.

Formative assessment, one in which the assessment information is used to improve teaching and learning, usually includes a myriad of assessment strategies (e.g., journal writing, diagnostic tasks). Santos and Cai (2016) described three aspects when considering assessment strategies: the conditions for creating a supportive environment for using an assessment that contributes to teaching and learning, characteristics of assessment strategies themselves, and the effectiveness of such strategies for mathematics learning. We summarise some main ideas of these aspects to highlight that they are important considerations for inclusion in our proposed framework for teachers’ assessment literacy.

In creating the appropriate conditions of assessment for learning, a classroom culture that treats errors as “natural and inherent to the learning process (only one who is learning errs)” (Santos & Cai, 2016, p. 158) should be encouraged rather than abhorred. Moreover, as part of the classroom assessment culture, the assessment criteria need to be appropriated by students. This demands the teacher not just to declare the criteria, but also engage in a continuous process of communication and negotiation to create student ownership of the criteria. Past literature revealed that teachers found it challenging to clearly define the assessment ownership of assessment criteria. Teachers’ mathematics learning are possible barriers to literacy.

In considering the main characteristics of assessment literacy, the community cautioned that regardless of the quality of feedback, and a challenge is for teachers to assure that a dialogical process rather than a one way communication process can be used to promote student problem solving skills, teachers would also need to develop affective, and emotional readiness in order for assessment to be effective. Furthermore, teachers’ assessment process is another avenue for further research.

In the era of accountability driven education, it is important and drive policy and practice. We refer to large-scale assessment globally (e.g., Trends in Mathematics and Science Studies) and nationally (e.g., Singapore’s Primary School Leaving Examination [PSLE], Australia’s National Assessment Program [NAPLAN]) are often scrutinised and interpreted domain. Thus, to a certain extent, school-level statistical literacy to understand and interpret scores. Further use of statistics as part of learning and teaching; comparing performance between different geographical areas, is important and drive policy and practice.

**Studies on Mathematics Teachers’ Assessment Literacy**

Assessment literacy can be considered as one important aspect of content knowledge. Indeed, Kahl et al. (2013) found that pre-service teacher education within the PME community concur with the community that teachers in general show knowledge of assessment concepts but answered correct on the extent they made use of assessment literacy in pre- and in-service teacher education. teachers sampled in their survey rated them positively with their extent of declarative knowledge of assessment literacy.

In the PME community, pre-service and beginning mathematics teachers in elementary schools, found that teachers lack knowledge of alternative assessment literacy compared to beginning teachers in elementary
challenging to clearly define the assessment criteria themselves and create student ownership of assessment criteria. Teachers’ beliefs about nature of mathematics and mathematics learning are possible barriers to this (Santos & Cai, 2016).

In considering the main characteristics of assessment strategies, Santos and Cai (2016) cautioned that regardless of the quality of feedback, its effectiveness is not guaranteed and a challenge is for teachers to assure that feedback is viewed and used as part of a dialogical process rather than a one-way communication. Although formative and self-assessment can be used to promote student self-regulation, metacognition and problem solving skills, teachers would also need to be mindful of students’ cognitive, affective, and emotional readiness in order to create a positive environment for assessment to be effective. Furthermore, teachers’ appropriate use of technology in the assessment process is another avenue for further research as part of their assessment literacy.

In the era of accountability driven education, research-based education practices are important and drive policy and practice. Within this context, student outcomes in large-scale assessment globally (e.g., Trends in International Mathematics and Science Studies) and nationally (e.g., Singapore’s Primary School Leaving Examination [PSLE], Australia’s National Assessment Program: Literacy and Numeracy [NAPLAN]) are often scrutinised and interpreted and results discussed in the public domain. Thus, to a certain extent, school leaders and teachers need some degree of statistical literacy to understand and interpret the results and findings from assessment practices. This means an understanding about sampling and assessment, descriptive statistics of assessment data (mean scores and standard deviation), and inferential statistics. Further use of statistics as part of teachers’ assessment literacy may involve comparing performance between different groups of students to investigate equity issues in teaching and learning.

Studies on Mathematics Teachers’ Assessment Literacy

Assessment literacy can be considered as one component of a teacher’s pedagogical content knowledge. Indeed, Kahl et al. (2013) called for the inclusion of assessment literacy in pre- and in-service teacher education courses. Recent research conducted within the PME community concur with the findings found in the general education community that teachers in general show a lack of declarative and procedural knowledge of assessment (Santos & Cai, 2016). Hoch and Amit (2013), on 139 pre-service and beginning mathematics teachers in Israeli elementary and secondary schools, found that teachers lack knowledge even in basic concepts of assessment. The teachers sampled in their survey rated themselves moderately on their declarative knowledge of assessment concepts but answered poorly (4.4 out of 11 questions correct) on the extent they made use of assessment concepts in their work. Teachers’ extent of use of assessment concepts in their educational practice also correlated positively with their extent of declarative knowledge. Beginning teachers in secondary schools significantly used less alternative assessment tools and more tests and quizzes, compared to beginning teachers in elementary schools.
In Singapore, Koh (2011) compared the assessment literacy of teachers teaching elementary years 4 and 5 (aged 10 and 11) in two kinds of professional development courses on designing authentic classroom assessment and rubrics: those in a short-term, one-session workshop versus those in an ongoing sustained programme. Focusing on two aspects of assessment literacy (quality of classroom assessment tasks and teachers’ conceptions about authentic assessment), it is not surprising that Koh found that teachers with on-going professional development sustained increased assessment literacy and better understanding of authentic assessment. Among the English, Science, and Mathematics teachers in his sample, Koh found that the quality of mathematics assessment only improved slightly compared to other subjects after the sustained professional development programme. He explained that “many mathematics teachers still believe that students’ mastery of factual and procedural knowledge is important for their conceptual understanding” (p. 272) and this is ingrained in their assessment practices.

The studies cited above suggest that teachers’ beliefs about and attitudes towards the use of certain assessment tools (such as alternative assessment or assessment technologies) are important issues impacting their assessment practices. Education context may well play a critical role shaping teachers’ beliefs and attitudes.

Koh’s (2011) study indicated that on-going professional development and support helps teachers in developing their assessment literacy. However, the nature of professional development programme on teachers’ assessment literacy depends on the assumptions and approaches teachers educators take too.

The two teacher educators Lee and Son (2015) had different expectations on the nature of pre-service teacher education on assessment literacy. One of them believed that it is important for pre-service teachers to learn from experience of designing their own assessment items from scratch, whereas the other emphasised the importance of critically selecting and modifying assessment items to suit the educational context. Lee and Son had made references to Kahl et al.’s (2013) generic framework on teachers’ assessment literacy to springboard their research. From analysis of their pre-service students’ written responses to a survey on both their beliefs about assessment as well as an item requiring them to critique a set of mathematics tasks, the teacher educators found that their students believed that assessment for learning (formative and diagnostic assessment) was the most important purpose of assessment, and that assessment requiring higher cognitive demand were better than those requiring routine computations. When asked to choose their most preferred mathematics task from a list of five different tasks on fractions, the sample in both groups led by the two educators were able to justify their choice based on cognitive aspects of assessment items in the critiquing task, citing cognitive demand, clarity, personal mathematical and pedagogical preference, mathematical complexity, format, and other issues. However, there were some differences in the pre-service teachers’ responses. In one sample, more attention was paid to visual representation of one of the mathematics tasks whereas the other revealed more cases of personal preference as a criterion for evaluating assessment items. Lee and Son (2015) proposed that further research be done to investigate the impact of teacher assessment literacy and also on the professional order to improve their own practice in this area.

Although documents from various teacher education programmes (e.g., Australian Institute for Teaching and School Leadership, 2012) have outlined levels of assessment literacy (and the practices expected from pre-service, beginning and experienced teachers) to be developed, the importance of reflection as a strategy for professional development as teachers improve their assessment literacy, has surfaced the need for teacher educators to define and connect the various aspects of mathematics teacher educational programmes in their professional development. In this paper, we attempt to synthesise findings from existing literature to describe teachers’ assessment literacy.

**TOWARDS A CONCEPTUAL FRAMEWORK FOR TEACHERS’ ASSESSMENT LITERACY**

Based on the literature reviewed, four aspects of assessment literacy are considered: (1) knowledge about assessment concepts; (2) skills with assessment practices; (3) communication and reflection on assessment practices based on assessment information about assessment and its role in mathematics teaching; and (4) meta-cognition and self-reflection about their own teaching and students’ learning. Inspired by the Singapore mathematics curriculum (MOE, 2012), the authors proposed a concept of five aspects to assessment literacy, shown in Figure 1.
TOWARDS A CONCEPTUAL FRAMEWORK FOR MATHEMATICS TEACHERS' ASSESSMENT LITERACY

Based on the literature reviewed, four aspects of assessment literacy were found: (1) knowledge about assessment concepts; (2) skills in applying the knowledge in actual assessment practices; (3) communication and action in providing feedback or changing instructional practices based on assessment information; and (4) attitudes and beliefs about assessment and its role in mathematics teaching and learning. Additionally, in reflecting about their own teaching and assessment practices for developing pre-service teachers’ assessment literacy, Lee and Son (2015) demonstrated the importance of reflection as a strategy for professional development (in their case professional development as teacher educators). Santos and Cai (2016) pointed to teacher reflection and teacher collaboration as professional development strategies for teachers to improve their assessment knowledge. From this, a fifth aspect can be considered: (5) meta-cognition and self-regulation of teachers’ own assessment literacy.

Inspired by the Singapore mathematics curriculum framework (Ministry of Education, 2012), the authors proposed a conceptual framework that includes five inter-related aspects to assessment literacy, shown in Figure 1.