A Teacher's View – Broadening Our Conceptions of Assessment to Improve Our Practice

Jimmy Pai

Abstract In this chapter, I delve into the idea of assessment as being about much more than measuring student achievement. Instead, I argue that assessment is a process that involves eliciting, attending to, interpreting, and responding to student thinking. This process can serve formative, summative, and interpersonal functions, depending on the circumstances of the classroom. First, I establish a practical definition of assessment, drawing from the literature on assessment and noticing. I then elaborate on this definition by considering how student thinking can be elicited, attended to, interpreted, and responded to in secondary mathematics. Classroom examples from my own practice are used to illustrate statements and connections. I then discuss the summative functions of assessment, since these are often a source of particular concern for teachers. I conclude by reiterating that assessment processes are embedded in all aspects of teacher practice that involve interaction with student thinking, and that an expansion of our definition of assessment may subsequently support student learning.

Keywords Classroom assessment · Formative assessment · Summative assessment

Introduction

Assessment is an important consideration in mathematics education, garnering much attention from educators, researchers (e.g., Suurtamm et al. 2016), and policy makers (e.g., National Council of Teachers of Mathematics [NCTM] 2000; Ontario Ministry of Education [OME] 2010). In my own experience as a secondary mathematics teacher, appreciation for the importance of assessment often depends on one's perception of the form and function of assessment. For example, some of my teacher colleagues have often used the word 'assessment' interchangeably with 'quizzes' or 'tests.' However, the literature on assessment indicates that assessment

J. Pai (✉)
Ottawa-Carleton District School Board, Ottawa, ON, Canada

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is far more powerful than a process for arriving at numbers that supposedly represent student learning (e.g., Harlen 2012; Suurtamm et al. 2016; Wiliam and Leahy 2007; Yorke 2011). In this chapter, I describe my own conceptualization of assessment as the processes of eliciting, attending, interpreting, and responding to student thinking. I begin by establishing a definition of assessment that has informed my practice.

A Practical Definition of Assessment

The word *assessment* originated (Klein 1966) from the Latin word *assidere*, meaning "to sit beside or with." This suggests that assessment involves supporting students on their learning journey, and not simply a process of arriving at a number that describes student achievement. In light of this, we must ask ourselves: What does assessment mean?

Assessment can be understood through its functions.[1] Assessment functions *summatively* when teachers elicit, interpret, and act on available information as part of their efforts to *sum* up evidence of student learning, which is often represented as a test score or grade. On the other hand, assessment functions *formatively* when teachers elicit, interpret, and act on available information in order to support students to *form* understandings. It is important to note that many researchers (e.g., Harlen 2012; Wiliam and Leahy 2007) have noted that an assessment may serve either or both summative or formative functions, depending on how the information has been used. This dualism, however, does not capture the emotional dynamics (Stiggins 2007) of the assessment processes, which may be helpful to consider if assessment is to be envisioned as a process of being *with* students, as its root word *assidere* suggests. In this vein, Pai (2016) suggested that assessment may also function *interpersonally*, which can improve, or make more difficult, the possibilities for ongoing or future assessment processes to serve formative or summative functions.

Purposefully paying attention to moments in the classroom, reflecting on them, and using them to inform future practices are among the critical processes of assessment. I found Mason's (2002) work on noticing as "experiencing and exploiting moments of complete and full attention" (p. 27) to be helpful for better understanding assessment. As a teacher collects and reflects upon accounts of his or her interactions with students, he or she might "[develop] sensitivities by seeking threads among those accounts" (Mason 2002, p. 87). Paying attention to his or her own experiences in this way also encourages the teacher to break out of habitual responses.

[1] I note that 'assessment for/of/as learning' can also be used to describe the functions of assessment (Daugherty and Ecclestone 2006; Earl 2003), and that there are many intersecting and interconnected ideas between assessment for/of/as learning and formative/summative assessment. However, for the sake of brevity and clarity, in this chapter, I primarily utilize the terms *formative* and *summative* in subsequent discussions.

In the effort to focus on what teachers think and do, I draw from the above literature to establish a practical definition of assessment, which will serve as a foundation for the discussion in the rest of this chapter. The definition below is grounded in the literature on formative and summative assessment (e.g., Harlen 2012; Wiliam and Leahy 2007), as well as on noticing (e.g., Mason 2002):

> Classroom assessment is an ongoing process of eliciting, attending, interpreting, and responding to student thinking, which may be influenced by teacher knowledge, experiences, and goals, as well as considerations for student experiences and classroom culture. Assessment may function formatively, summatively, and/or interpersonally, and particular functions that the process has served can only be determined retrospectively.

I deem this definition practical because I have found it helpful in thinking about and informing my practice. I elaborate below on the aspects of the definition that I have found to be particularly meaningful:

- Assessment is a process (e.g., NCTM 2000; Wiliam and Leahy 2007) that involves eliciting, attending, interpreting, and responding to student thinking (Pai 2016). These processes are always in play for a classroom teacher. Snapshots of learning, such as written tests, are products that cannot represent the rich tapestry of learning that is woven over time. Instead, assessment processes naturally involve moments in the classroom: observations, conversations, and interactions. This aspect of the definition helps me focus more on the dynamic action in the classroom rather than on isolated events, such as written tests, as I reflect on student achievement.
- How teachers elicit, attend to, interpret, and act on student thinking depend on many factors (Son and Sinclair 2010; Watson 2006) that might be categorized under teacher, student, relationships, and contexts (Pai 2016). This implies that assessment is a human (rather than mechanistic) process, and that there is no one-size-fits-all assessment strategy. This aspect of the definition helps me to break free from the illusion that assessments are or can be designed to be objective.
- Positive classroom culture is an important consideration in the classroom (e.g., Heitink et al. 2016). Without students' active participation in classroom activities, it becomes difficult for students to learn, and, for the purposes of assessment processes, difficult for the teacher to support learning. This aspect of the definition reminds me of the importance of paying attention to how students feel about mathematics and about themselves in relation to mathematics, and of fostering positive attitudes about mathematics and one's abilities in mathematics.
- The descriptors 'formative,' 'summative,' or 'interpersonal' can only be determined retrospectively—that is, after an assessment process has occurred (e.g. Harlen 2012; Wiliam and Leahy 2007). Put another way, activities and teacher actions are not effective in and of themselves—their effectiveness in achieving a particular aim can only be evaluated in hindsight. This aspect of the definition reminds me that simply believing that certain activities have been helpful in giving rise to student learning does not automatically make it true. Instead, I need to listen carefully to students in order to make appropriate pedagogical decisions.
- Offering a mark is only one aspect of assessment (a summative function, in particular), and assessment encapsulates far more than grading (Harlen 2012;

Wiliam and Leahy 2007). This aspect of the definition reminds me that I must focus on facilitating an effective learning environment.

In summary, assessment, as I have framed it, is involved in every aspect of my teaching practice that involves eliciting, listening, and responding to students' thinking. Assessment processes are always in play for a mathematics teacher, and include preparations for, acting in, and reflections upon, moments that support learning in the classroom.

Eliciting Student Thinking During the Assessment Process

Teachers cannot read minds. In order to assess, therefore, teachers first need to access student thinking and learning. Thus, the eliciting aspect of the assessment process is about getting students to talk, write, and do mathematics. It is as simple and as complex as that. The following examples of eliciting are not meant to be presented as fail-safe strategies. Instead, they are ways of eliciting information about student learning that have worked for me, or considerations that have continued to improve my teaching.

For many reasons, vertical non-permanent surfaces (Liljedahl 2016) in my classroom help to elicit information about student learning by encouraging student actions and conversations. The use of vertical non-permanent surfaces (VNPS) involves students working together to tackle problems while standing and recording their thinking with non-permanent writing tools such as chalk or erasable markers. The non-permanence of the recordings allows students treat the writings as helpful, yet temporary representations of their thinking. The fact that these representations are displayed on vertical surfaces allows students to easily share and discuss their ideas. When students are intrigued by strategies from other groups, the vertical boards help to facilitate conversations, and give students the opportunity to consider how others have tackled a problem when they feel lost while problem solving. For these reasons, I have found VNPS to be a helpful tool in eliciting information about student thinking.

Of course, in order to share their thinking, students also need problems to think about and to discuss. Godin (Part IV, this volume) discussed several types of problems and their roles in engaging students in problem solving, and provided some examples of how he presents tasks to students. It should be noted, however, that teacher decisions about the kinds of problems to use, as well as how he or she will present them, often depends on his or her goals, students, and classroom dynamic. In addition to the strategies that Godin (Part IV, this volume) has illustrated, I have also had success with engaging students in posing their own problems. One way I do so in my own classroom is through a series of related activities, spanning several days, where students examine a scenario and then develop their own related questions. To give an example, at the beginning of one such series, I showed students an image of a Lego Star Wars play set (Fig. 1) and a Lego Friends play set (Fig. 2) (Pai 2015), and asked students to share what they noticed and wondered.

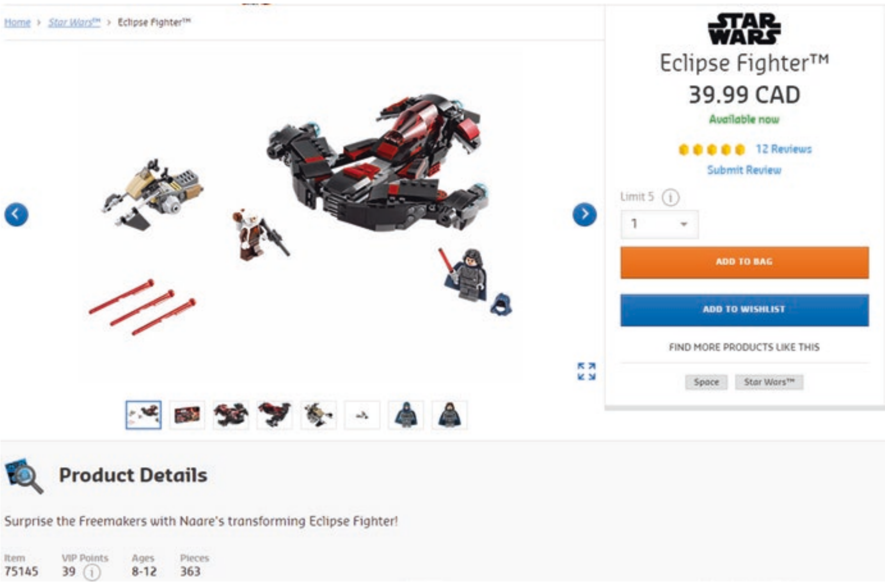


Fig. 1 Lego Star Wars play set, retrieved from https://shop.lego.com/en-CA/

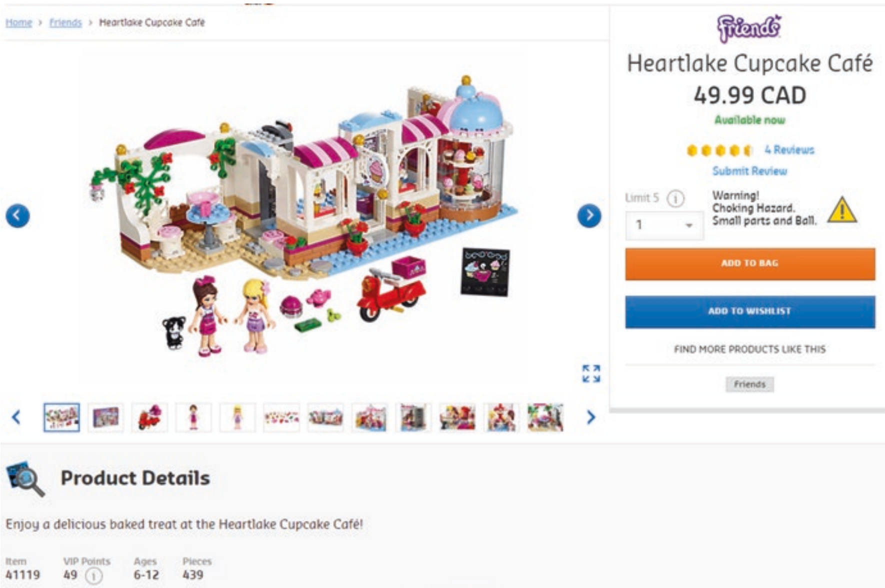


Fig. 2 Lego Friends play set, retrieved from https://shop.lego.com/en-CA/

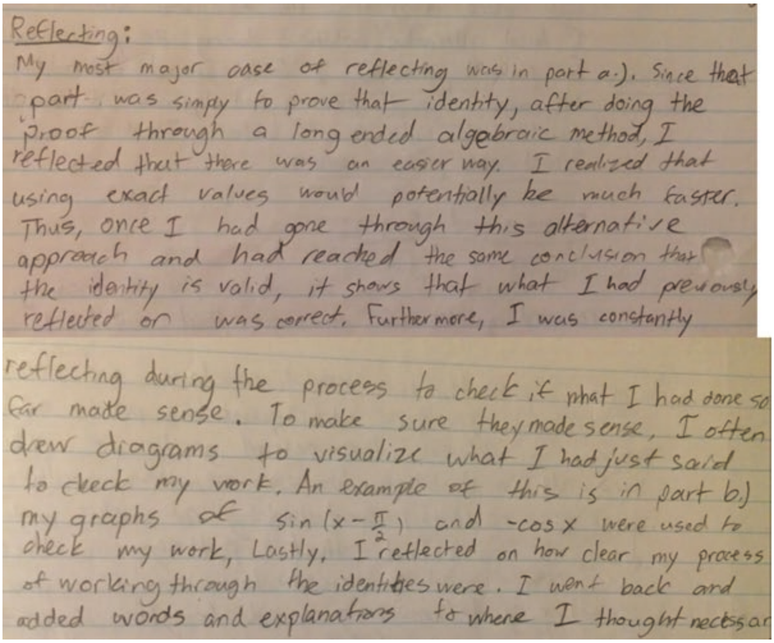

Reflecting:
My most major case of reflecting was in part a.). Since that
part was simply to prove that identity, after doing the
proof through a long ended algebraic method, I
reflected that there was an easier way. I realized that
using exact values would potentially be much faster.
Thus, once I had gone through this alternative
approach and had reached the same conclusion that
the identity is valid, it shows that what I had previously
reflected on was correct. Furthermore, I was constantly
reflecting during the process to check if what I had done so
far made sense. To make sure they made sense, I often
drew diagrams to visualize what I had just said
to check my work. An example of this is in part b.)
my graphs of $\sin(x-\frac{\pi}{2})$ and $-\cos x$ were used to
check my work. Lastly, I reflected on how clear my process
of working through the identities were. I went back and
added words and explanations to where I thought necessar

Fig. 3 Sample Grade 12 student entry for portfolio

Students engaged in conversations about stereotypes (e.g., why one set had more pink pieces than the other) and about mathematics (e.g., how much they cost per unit). Often discussions about social justice raised questions or made claims that mathematics was subsequently helpful for supporting. This then led to discussions about mathematics that were rooted in the contexts of their lived experiences. Students were thus willingly entering conversations involving mathematics, which, in the process of assessment, helps to generate information that I, as the teacher, can attend to, interpret, and act upon.

Besides mathematical ‘content’ such as factoring polynomials, I also believe it is important to elicit how students think mathematically as they engage in mathematical processes.[2] I begin with explicitly discussing mathematical processes by co-constructing what it means to, for instance, problem solve. My students maintain a ‘mathematical processes portfolio’ throughout the semester documenting their reflections on their improvements with each mathematical process (see Fig. 3 for an example from a student in my Grade 12 Advanced Functions class). I have found that explicit acknowledgements and discussions about mathematical processes are helpful. Students are able to see that I value their thinking processes over ‘perfect

[2] For example, the Ontario Ministry of Education (e.g., OME 2007) identified the following 7 aspects of mathematical processes: problem solving, reasoning and proving, reflecting, selecting tools and computational strategies, connecting, representing, and communicating.

answers.' For example, 'representing' mathematics is one of the seven mathematical processes described in OME (2007). Throughout the semester, students see that developing multiple representations helps to better visualize strategies, to illustrate their thoughts, or to arrive at solutions. Unpacking students' mathematical processes is important for both the students and the teacher. For the students, a focus on the processes helps to alleviate anxiety around solutions because it provides value to making mistakes. For me, the focus helps me to purposefully integrate mathematical processes in my interactions with students. Furthermore, by eliciting student thinking about mathematical processes, I can then listen and respond in ways that may improve, for example, their ability to represent mathematical ideas in different ways when solving a problem.

Finally, it is important to note that students may not always verbalize their thinking. It is important, then, to structure opportunities that allow students to represent their thinking through concrete materials, such as manipulatives. There are often mathematics inherent in the structure of manipulatives that afford thinking. For instance, as my students were using linking cubes to explore the painted cube task (e.g., Youcubed 2016), one group became stuck. They then decided to use colours to count and subsequently account for the cubes. This colourful three-dimensional representation then led them to develop several conjectures about possible patterns. In this case, the existence of the linking cubes helped to elicit their mathematical thinking and supported further conversations. In addition, student actions with the linking cubes also help me, often a fleeting observer, quickly attend to the mathematical thinking that has surfaced.

Attending and Responding to Student Thinking During the Assessment Process

Hunger is not alleviated simply by cooking—it also requires eating. In other words, it is not enough for a teacher to simply elicit mathematical thinking—he or she needs to also attend to, interpret, and respond to it. As indicated in my definition, it is important to recognize that assessments may serve formative, summative, and/or interpersonal functions, and that these functions are interrelated. In this section, I will briefly (constrained by the length of this chapter) discuss some ways of attending, interpreting and responding to opportunities for assessment, focusing primarily on teacher interpretations and teacher actions as part of the assessment process.

In the classroom, I often join different groups of students as they work on their VNPS. It is important that I *listen to*[3] students when I am there. This means that I attend carefully to what students are saying and, as necessary, seek clarification on what they are thinking about as they work on a task. As I interpret what students are

[3] Davis' (1994, 1997) work on listening has been influential in my thinking and in my practice.

saying, I need to remember that they may still be negotiating meaning and developing their understanding, and as such, their explanations may not immediately represent their thinking. In some cases, I may say nothing at all, as students sometimes simply need to verbalize their thoughts in order to continue thinking. In other cases, I may wonder together with students—for instance, when the strategies that students use are unexpected but are supported by their reasoning. When this happens, I find it is powerful for me to follow students' reasoning and to continue thinking with them.

Attending to student thinking, or listening, is an important action in and of itself. Listening to students is helpful in several ways. First, it helps me to establish a better understanding of what the students might have understood and what they are working toward understanding. In other words, listening may elicit more information about student thinking. Second, the presence of a listener may help students get 'unstuck' while problem solving. This is because, in order to explain, students need to reiterate aspects of what they have done. Reiterations may lead to reflections, which may in turn lead to realizations about alternative strategies, representations, or solutions. This means that listening is a teacher action that can also further student thinking. Third, it is important for me to model listening so that my students learn to value the input from their classmates. This supports a positive classroom culture and may encourage more conversations in the classroom, which may facilitate future eliciting of student thinking.

Attending and responding to mistakes is another powerful teacher action: not only are mistakes valuable opportunities for learning, they also contribute to how students see themselves in relation to mathematics, which may subsequently impact how they participate (or not) in classroom activities. I find it important, then, to pay attention to instances when students attempt unfruitful strategies or reason inappropriately, and to be tactful when responding to their thinking. Depending on the student, I may ask him or her to explain the strategy or reasoning; in addition, I may ask for more examples or alternative representations that illustrate the points. Besides the teacher being able to better interpret the perceived mistake, in clarifying and thinking further, the student might identify inconsistencies on his or her own, and subsequently resolve the mistake. Another possible teacher response might also be to direct the student to think about how the strategies of other groups cohere with his or her thinking. The presence of VNPS is helpful in this situation, because the student is able to simply look over at other whiteboards without stepping away from his or her workspace.

As we attend to and interpret students' mathematical thinking, we also cannot ignore existing power dynamics in the room. The most obvious one is the perception of a teacher in the position of power. In particular, I need to be cognisant of the fact that when I speak, at least in the beginning of a semester, my words carry weight. One implication of this, for me, is that I cannot only wonder and question when mistakes are made—I also need to offer wonderings and questions when students are successful with their strategies, lest students think that I only offer input when they are wrong. Besides perceptions about the teacher, students also hold perceptions about each other, and I believe it to be helpful to recognize these and respond accordingly. For example, if a student is extremely hesitant about speaking to other students, I might give him the erasable marker and ask him to note down the thoughts of others on the group whiteboard. In addition, I might task this student with the role of asking clarifying questions to the others in the group, and to reiterate these ideas to me when I drop by. These considerations of power dynamics are important for being able to attend and respond to student thinking in a way that supports their learning.

When conversing with students, I also pay attention to mathematical processes. After introducing and co-constructing the meaning of terms related to mathematical processes (e.g., problem solving, connecting, reasoning), I sometimes explicitly refer to these terms when discussing strategies with students or posing questions about their thinking. Since my students keep a process portfolio throughout the semester, I also dedicate class time to discuss and encourage student reflection about mathematical processes. I believe it is important to refer to these metacognitive processes because it helps students see that I value these thinking processes as much as the products of their thinking. This in turn may help to improve how students think mathematically and view themselves in relation to mathematics, and may subsequently encourage mathematical activity in the classroom.

Functions of the Assessment Process

My descriptions of the assessment processes in the previous sections may serve formative, summative, and/or interpersonal functions. It should be noted, however, that none of the teacher actions in my examples are meant to be presented as ideal. This is because acting appropriately is not algorithmic (e.g., Davis and Sumara 2006), meaning that it is *not* true that certain actions will always yield the best outcomes, even in similar situations. Similarly, whether or not the assessment processes described above serve formative, summative, and/or interpersonal functions depends on a wide variety of factors, including context and the individuals involved. In the many instances I described, the actions may serve formative functions when the assessment process leads to an improvement in students' mathematical thinking. Interpersonal functions may be served when the assessment process improves the rapport between teacher-student and student-student such that students are more likely to continue mathematical discussions and therefore allow for other assessment processes to take place. Summative functions can also be served, but sufficient information must be accumulated and considered before I am able to 'sum' up what a student has learned about a particular topic, strategy, or way of thinking mathematically. In my experience, the summative functions of assessment often give my colleagues (and myself) the most headaches; for this reason, the next section focuses on some aspects of the summative function.

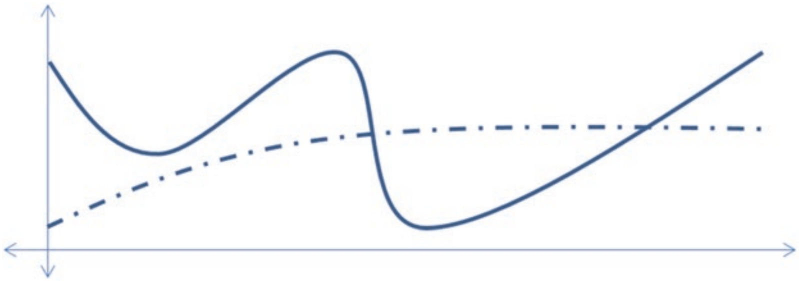
The Summative Conundrum

What does it mean to 'sum' up learning if learning is an ongoing process? To sidestep the question somewhat, I believe that it is particularly difficult for a single assessment process to function summatively. In order to glimpse student understanding, it is necessary to create an image out of *incomplete* and *interpreted* puzzle pieces. These puzzle pieces are collected from several interactions with students and their thinking about mathematics, and can take permanent (e.g., written) or ephemeral (e.g., verbal) forms (e.g., Harlen 2012; Pai 2016). As such, the interactions mentioned in previous sections all have the potential to be an account of and/or an account for[4] students' mathematical thinking, depending on how they are used. Here, I elaborate on some strategies that have been helpful in serving the summative functions of assessment.

My students also add reflections (with respect to the mathematical processes) about their mathematical work into their portfolios. These portfolios, for example, can serve as mosaics that represent the ongoing process of learning (summative), but that also encourage conversations (interpersonal) and invite reflections and feedback about how to move learning forward (formative). The continued use, and reference to, portfolios is also helpful because it means that my students and I are following up on the co-constructions that we had worked on. This helps to further illustrate to students that I value how they think more than whether the products of their thoughts are 'correct.' During the semester, I often conference with individual students while they reflect on the contents of their portfolios. These instances provide me with opportunities to listen and offer feedback and wonderings. For example, I ask about their decisions to include certain pieces of work and not others, or how they elaborated on particular instances of their thinking that demonstrated mathematical processes.

Besides ongoing projects such as portfolios, there are also tests and quizzes in my classroom that provide students with opportunities to demonstrate learning. My tests and quizzes often include open questions that invite students to demonstrate their understanding through a variety of strategies, representations, or reflections (an example is provided in Fig. 4). Moreover, as tests and quizzes are returned with only feedback and no marks, I often act in ways that illustrate to students that these tests and quizzes are learning opportunities, and not isolated events. Students are then often given class time to respond to and reflect on the feedback and participate in one-on-one interviews. During these interviews, I ask specific questions that give students another opportunity to demonstrate what they were unable to show in writing on the test or quiz. Thus, in framing tests and quizzes as part of an ongoing process that helps both myself and the students better understand their learning, students are better able to focus on improving their mathematical thinking.

[4] Mason (2002) distinguished between giving an account-of an event and accounting-for it. He identified an 'account-of' as an attempt to draw attention to something, and an 'account-for' as explaining the something that was accounted.



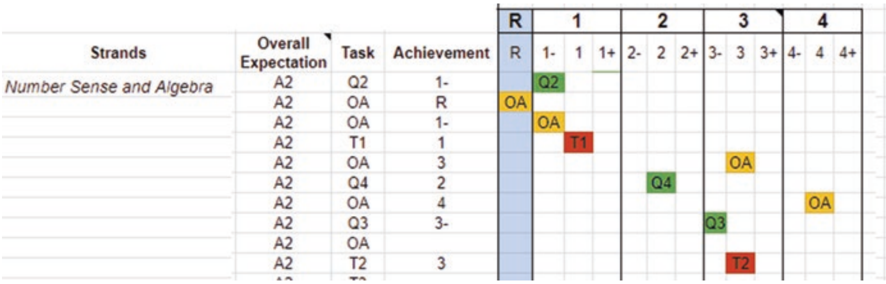
(Example from a grade 12 advanced functions test)
Laura and Abdi weren't happy with the results of the cup-stacking race from class. After 30 long years of feuding, they decided to settle things by making robots and having the robots compete through cup-stacking. The graph above tracks the velocity vs time of their robots.
Who won? What more information might you need? How would that help? Justify your reasoning and showcase what you know.

Fig. 4 Robot cup stacking question from Grade 12 Advanced Functions test

The way that I design my course is also significant in helping students see learning as an ongoing process. During both teacher- and student-generated activities, several curriculum expectations are typically involved in students' explorations. The series of activities involving Lego mentioned previously, for example, naturally involves many aspects of the grade 9 mathematics curriculum in Ontario (including linear relations, measurement and geometry, number sense, and algebra). Throughout the semester, then, students build familiarity with the concepts through repeated exposure and connections within different contexts. Since topics are revisited, each time in greater depth, students have many opportunities to strengthen their understanding, and to demonstrate their understanding to me. In other words, since 'topic units' no longer exist, the doors are never closed on students who are continuing their learning throughout the semester.

Grading

The end of the semester is a different story. While some ways of summing up learning (e.g., conferencing with students or clinical interviews) can often also serve formative and interpersonal functions, in Ontario, as in many provinces and states, secondary teachers are required to provide a final grade in the form of a numerical value. Grades, often in the form of percentages, give the illusion of precision. Yorke (2011) pointed out that "finely graded scales […tend] to seduce assessors into believing that assessment can be conducted with a precision which it manifestly does not possess […], [calling for] the eradication of the false consciousness regarding precision" (p. 265). Nonetheless, most teachers are faced with the immediate requirement of providing a grade.



				R	1			2			3			4		
Strands	Overall Expectation	Task	Achievement	R	1-	1	1+	2-	2	2+	3-	3	3+	4-	4	4+
Number Sense and Algebra	A2	Q2	1-		Q2											
	A2	OA	R	OA												
	A2	OA	1-		OA											
	A2	T1	1			T1										
	A2	OA	3									OA				
	A2	Q4	2						Q4							
	A2	OA	4												OA	
	A2	Q3	3-								Q3					
	A2	OA														
	A2	T2	3									T2				

Fig. 5 Evidence record

When forced to provide an aggregate number for a student, I lean on a variety of evidence as much as possible. Throughout the different conversations that I have with students, as well as through portfolios, interviews, and projects, I keep note of my interpretations and assumptions about particular students' understanding. Using a Google spreadsheet, I share an evidence record with each student, which is organized in such a way that one can visually identify growth with respect to a particular topic. The example shown in Fig. 5 refers to the same topic (manipulating polynomials) evaluated over time through different tasks, such as observations and conversations (OA), major tasks or tests (T), as well as quizzes and formal interviews (Q). This document is shared with students so that my perceptions regarding their achievement is communicated to them. The evidence record also serves as an invitation for students to discuss their progress in the course. As I conference with students, we often begin with this document and move on to specific strategies that might help to improve their grades. I must note that the current structure of my evidence records is a work in progress, much like the individual evidence records of my students. I do not claim that it is a perfect system for deducing students' level of achievement,[5] but merely that it has been helpful for my navigation toward an aggregate numerical representation of student learning.

Arriving at a mark is not a perfect process. A realization of this imperfection, then, implies both freedom and significant responsibility on the part of the teacher. Teachers are no longer restricted to formulas, averages, and medians that spit out high stakes numbers; at the same time, they are unable to hide behind algorithms that feign a sense of objectivity. Personally, I feel a need to stand on rationales built on a multitude of varied experiences, as well as to invite students to discuss their perception of their progress.

[5] In Ontario, levels R, 1, 2, 3, 4 are qualitative descriptors that integrate considerations of knowledge, understanding, thinking, communication, and application (OME 2010) for different topics in the course. The mathematical processes are also woven into the same considerations.

Conclusion

Assessment is far more than numbers, and it is far more than particular events, such as quizzes or tests. Rather, the assessment process embodies all teacher practices that involve eliciting, attending to, interpreting, and responding to student thinking. Throughout this chapter, I have elaborated on what I have established as a practical way of thinking about assessment in the mathematics classroom. For me, continuing to reflect on both the definition of assessment, as well as on assessment strategies, has helped improve my teaching practice. I hope the ideas in this chapter provide possibilities for readers to broaden their definitions of assessment in ways that honour its etymological roots—to sit beside or with their students on their journey of learning mathematics.

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