2016-05

Addressing the Challenge of Differentiation in Elementary Mathematics Classrooms

Babb, Paulino Preciado

University of Calgary

ADDRESSING THE CHALLENGE OF DIFFERENTIATION IN ELEMENTARY MATHEMATICS CLASSROOMS

Paulino Preciado Babb Martina Metz Soroush Sabbaghan Geoffrey Pinchbeck

Ayman Aljarrah Brent Davis

University of Calgary

Addressing students' diversity of skills and knowledge for mathematics instruction has been a common challenge for teachers. This paper reports results from an innovative partnership of school district, university and curricular material developers aimed at improving mathematics instruction at elementary level. We report successful cases of lessons enacting instructional practices that engage all students in the classroom, ensure they meet expected outcomes, and challenge them with further bonuses. The cases are analyzed based on mastery of learning, with a particular focus on continual assessment during class. We also include challenges we have faced in supporting teachers as they incorporate these practices in their daily teaching.

Keywords: Mathematics teacher knowledge; student diversity; mastery of learning; formative assessment.

Academics have emphasised the importance of differentiated instruction for several decades (Bloom, 1968, Guskey, 2010), and there is now an extensive body of literature on formative assessment (e.g. Chappuis, 2015; Stiggins, Arter, Chappuis, & Chappuis, 2004; Wiliam, 2011);

2016. In M. A. Takeuchi, A. P. Preciado Babb, & J. Lock (Eds.). *Proceedings of the IDEAS: Designing for Innovation*, pp. 203-212. Calgary, Canada: University of Calgary.

however, suggestions for teachers' immediate responses to in-class assessment are not as common. This paper addresses the approach to differentiation in mathematics instruction adopted in the Math Minds initiative, a partnership aimed at improving mathematics instruction at the elementary level—more details about the initiative and previous research results can be found in Metz, Sabbaghan, Preciado Babb, & Davis (2015), Preciado Babb, Metz, Sabbaghan, & Davis, (2015), and Sabbaghan, Preciado Babb, Metz, & Davis, (2015). This approach is informed by Mastery Learning (Guskey, 2010), the Variation Theory of Learning (Marton, 2015), and Intrinsic Motivation (Pink, 2011). We provide examples of differentiation based on continuous assessment from lessons in which all students have engaged in the targeted object of learning in a way that they met the expectations of the lessons and were further challenged with additional mathematical explorations and extensions. We also discuss teachers' difficulties in the implementation of this approach.

APPROACH TO DIFFERENTIATION

A key principle of Mastery Learning (Guskey, 2010) is that students should move to the next unit of instruction once they have mastered the concepts or skills required to engage in that unit. Formative assessment plays an important role in determining when students are ready for the next step, as well as in identifying students who have mastered the learning outcome and can be engaged in extensions or enrichment material. One of the principles in the Math Minds initiative is to assess continually during class with careful attention to critical features of the concepts or procedures. This assessment is meant to avoid the need for remediation and, at the same time, to challenge students through "*bonuses,*" which are immediate extensions of the work everyone is doing in the classroom. This approach contrasts with other forms of Mastery Learning in (1) the

frequency of assessment, (2) the focus on pre-empting instead of remediating, and (3) the scope of the enrichment activities.

In this paper we stress two distinctive features of continuous formative assessment. One feature is what Wiliam (2011) called "all students' response system" (p. 87), in which the teacher receives responses from all students at the same time during class. He suggested, for instance, that students might write answers to questions on personal mini-boards that are visible to the teacher. The teacher may respond with what we, in the initiative, call *step-backs* (Sabbaghan et al., 2015): a form of scaffolding in which the teacher offers simpler tasks or questions that everyone can engage in and then continues increasing difficulty—with *step-ups*—until everyone meets the immediate learning objective. The Variation Theory of Learning (Marton, 2015) can inform these step-backs and step-ups, as Metz et al. (2015) explained through an analysis of sequences of questions that draw attention to features students need to discern to understand particular mathematical ideas. We acknowledge that this is not a simple input-output process and that the teacher still has to address the complexities of the classroom; however, this feature provides specific guidelines for assessment and teacher response.

The other distinctive feature of our use of continuous formative assessment is the way we conceive *bonuses*. We do not consider these tasks as 'enrichment,' because they are direct extensions of the work everyone is doing in class. This approach contrasts with Mastery Learning in which enrichment activities "lie beyond the established curriculum" (Guskey, 2010, p. 56).

EXAMPLES OF DIFFERENTIATION

This study involved two elementary schools, each with approximately 150 students. The data included video recordings from each teacher at both schools, and classroom observations in one

of the schools—more details can be found in Preciado-Babb, et al. (2015), Metz et al., (2015), and Sabbaghan et al., (2015). We have observed how students who initially struggled with the content successfully completed the tasks in class, as well as how students continued to engage in bonus tasks. We show three occurrences stressing different ways in which this form of differentiation has been enacted in the classrooms.

Example #1: Responsive Improvisation

This example is from a Grade 2 introductory lesson on subtraction. During the lesson, students showed answers to the teacher's questions on their mini-boards. The first two questions involved short stories, such as: "If you had five apples and someone takes three of them, how many would be left?" Subsequent items were presented as number sentences. Table 1 shows a sequence of items students had to work with, indicates whether all students showed a correct answer, and notes the type of response offered by the teacher. The table also indicates whether the teacher deviated from the original plan, i.e. whether she improvised in response to students' answers. As can be seen in the table, not all students provided correct answers even though the teacher provided individual feedback and re-explained the material. Then she improvised the lesson sequence by adding easier items, or stepping back, to 7 - 2 and 6 - 4, which involved smaller numbers than 8 - 5. Once all students showed a correct answer, she provided a harder question—a step-up—before proceeding with the next part of the lesson—which built, but differed from, the items in this part.

During class, students also worked independently on a sequence of similar questions, while the teacher walked through the classroom assisting students who required support. Students who finished earlier were challenged with variations of the items they had already solved, such as 17 - 4 after 7 - 4.

Item	In the lesson plan?	All students correct?	Teacher's responses
7 - 4 =	Yes	No	Feedback and Explanation
8 - 5 =	Yes	No	Feedback, Explanation and Step-back
7 - 2 =	No	No	Feedback and Explanation
6 - 4 =	No	Yes	Step-up
9 - 3 =	No	Yes	Proceed with the next part

Table 1: Task sequence and teacher's responses: Responsive improvisation

Example #2: Team Work

This lesson involved a combined Grade 4/5 group working on telling time using different representations. The final activity of the lesson was to indicate on a timeline the times students get up, eat breakfast, brush teeth, etc., using both digital and analog formats. The teacher assessed continuously, making sure every student was ready for each next step of the lesson. The class started by identifying the hour and minute hands on the clock. Then, students were asked to read the time from an analog clock. First, the focus was only on the hour hand, then on the minute hand, and finally on both hands (with minutes restricted to multiples of 5). Table 2 shows the teacher's responses in a part of the lesson in which she provided easier questions, or step-backs: 8:30 is easier than 12:15 and 8:25 due to the half mark. Once all but three students showed correct answers, the class began working in pairs: One student said a time and the other had to indicate it on a mini-clock (with students alternating roles). The teacher walked through the class checking on all students, but dedicating particular attention to the three students who did not initially provide correct answers. It is not possible from the video to hypothesize the source of

misconception or difficulty these students experienced; however, teacher's intervention seemed effective, as everyone in the class succeeded in providing correct answers.

Item	In the lesson plan?	All students correct?	Teacher responses
8:25	Yes	No	Feedback and Explanation
12:15	Yes	No	Feedback and Explanation, Step-back
8:30	No	Yes	Step-up
4:15	Yes	Yes	Step-up
6:45	Yes	No	Proceeded with the next part
Team work	Yes	No	Systematically assisted students

Table 2: Task sequence and teacher's responses: Team work

The teacher offered a bonus question on the board during the second part: "It is 2:45. I have to leave in 20 minutes. What time will I have to leave?" Students who already understood how to indicate time on the analog clock were encouraged to challenge their partners with questions similar to this one.

Example #3: Individual Assistance

This is an excerpt from a Grade 2 class on the language for comparing two numbers. The teacher showed an image on the board with a row of spiders and a row of ants and asked how many more spiders than ants were there. Students wrote their answers on their mini-boards, and the teacher asked them to show their answers at the same time. The teacher repeated similar questions, but just with numbers, as shown in Table 3. Most students' answers were correct; however, one student struggled with "How many more is 9 than 3?" The teacher supported this student

individually and then asked all students to show their answers: All students showed correct answers and then the class moved to the next part of the lesson: individual practice.

As in the previous case, the video does not allow hypothesizing regarding the reason for the student's struggle, but the teacher's intervention seemed to be effective for supporting this student.

Item	In the lesson plan?	All students correct?	Teacher responses
How many more is 9 than 3?	Yes	Yes	Assist one student, Proceed to the next part of the lesson
Individual practice	Yes	Yes	Walked through the room while assessing children

Table 3: Task sequence and teacher's responses: Individual assistance

Original task	Bonus
9 is __ more than 6	12 is __ more than 6
6 is __ more than 2	16 is __ more than 7
10 is __ more than 7	19 is __ more than 10
8 is ___ more than 4	20 is __ more than 10

Table 4: Practice items (first column) and bonus items (Second column): Individual assistance

During individual practice, the teacher supported the student who had struggled, then moved through the classroom to other tables providing feedback and assistance. She gave a bonus for

students who had finished their practice, as shown in Table 4. The student who initially struggled completed the bonus successfully.

CONCLUSION

The three examples we have provided show how three teachers used continuous assessment to respond immediately to all students in their classes. The use of step-backs contrasts with the common focus on remediation that is evident in different forms of Mastery Learning (Guskey, 2010). These examples also show students engaging in bonus questions that are direct extensions of the work everyone was doing in the class. This also contrasts with the enrichment and extension activities typical of Mastery Learning, in which advanced students engage in different activities that extend beyond the curriculum. Moreover, in our work, 'non-advanced' students could address the same bonus material, as demonstrated by the student who initially struggled with the questions in Example #3.

This approach to differentiation is not based on selecting different activities for each student, but on selecting a level of difficulty appropriate to each student within the same activity. The two stressed features, namely, continuous assessment of all students and the use of bonus tasks, help to address the diversity of ability and knowledge in the classroom.

We have found, nevertheless, that teachers have difficulties implementing this approach to assessment (Preciado Babb, et al., 2015). Teachers in the initiative have identified creating bonuses as particularly challenging. We have also seen teachers focused more on completing the material than making sure everyone was ready to move on. Finally, teachers tended to rely more on feedback and explanations in their responses to assessment during class, with less consideration of step-backs and step-ups. In fact, we believe that teachers' responses in the

examples provided in this paper could have been even more effective if careful attention to variation was considered.

We conclude by stressing the need to continue addressing the ways in which teachers respond to assessment for all students in class. Marton's (2015) Variation Theory of Learning provides a framework for both investigating this topic and for informing teacher's practice, especially for improvising tasks and questions in response to continuous feedback from students during class.

References

Bloom, B. (1968). Learning for mastery. *Evaluation Comment*, *1*(2), 1–12.

Chappuis, J. (2015). *Seven strategies of assessment for learning* (2nd Ed.). Hobeken, NJ: Pearson.

Guskey, T. (2010). Lessons of mastery learning. *Educational Leadership, 68*(2), 52-57.

Marton, F. (2015). *Necessary conditions of learning*. New York: Routledge.

Metz, M., Sabbaghan, S., Preciado Babb, A. P., & Davis B. (2015). One step back, three forward: Success through mediated challenge. In A. P. Preciado Babb, M. Takeuchi, and J. Lock (Eds.) *Proceedings of the IDEAS: Designing Responsive Pedagogy Conference*, pp. 178 - 186. Werklund School of the Education, University of Calgary.

Pink, D. (2011). *Drive: The surprising truth about what motivates us.* New York: Riverhead.

Preciado Babb, A. P., Metz, M., Sabbaghan, S., & Davis, B. (2015). Insights on the relationships between mathematics knowledge for teachers and curricular material. In T. G. Bartell, K. N. Bieda, R. T. Putnam, K. Bradfield & H. Dominguez (Eds.), *Proceedings of the 37th annual meeting of the North American chapter of the international group for the Psychology of Mathematics Education,* pp. 796 – 803. Lansing, MI: Michigan State University.

Sabbaghan, S., Preciado Babb, A. P., Metz, M., & Davis, B. (2015). Dynamic responsive pedagogy: Implications of micro-level scaffolding. In A. P. Preciado Babb, M. Takeuchi, and J. Lock (Eds.) *Proceedings of the IDEAS: Designing Responsive Pedagogy Conference*, pp. 198 - 207. Werklund School of the Education, University of Calgary.

Stiggins, R. J., Arter, J. A., Chappuis, J., & Chappuis, S. (2004). *Classroom assessment for students earning: Doing it right – using it well*. Portland, OR: Assessment Training Institute.

Wiliam, D. (2011). *Embedded formative assessment*. Bloomington, IN: Solution Tree Press.