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EPIPHANIES IN MATHEMATICS TEACHING: THE PERSONAL LEARNING OF AN ELEMENTARY TEACHER IN THE MATH MINDS INITIATIVE

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The Math Minds partnership strives to increase student engagement, self-esteem and achievement in mathematics and also to deepen teachers' conceptual understanding of mathematics for instruction. Through this partnership, elementary teachers are changing the way they teach mathematics. By breaking concepts into small steps, continually assessing all children for understanding along the way and giving opportunities for independent "practice" frequently during each lesson, students have shown a significant improvement in mathematics. We present the transformative learning experience of one teacher during one year in this partnership, with surprising results.

Keywords: Mathematics teacher knowledge; Teacher practice; Elementary mathematics

INTRODUCTION

Several educators have contested the belief that some people can learn mathematics while others cannot (e.g. Davis & Preciado Babb, 2015; Dweck, 2008; Mighton, 2003, 2007). Even students

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with learning disabilities, including mathematics disorders, can reach levels of achievement typical of the general population (Gouvier & Baumeister, 2011; Wei, Lenz, & Blackorby, 2013). Consistently, Carol Dweck's (2008) extensive research on intelligence and ability has shown that intelligence and ability can be nurtured and improved. Due to space limit, we do not elaborate on this research. Our point is that this evidence compels us to constantly strive for improvement in mathematics learning in schools. The Math Minds initiative—a partnership including the Calgary Catholic School District (CCSD), the Werklund School of Education (WSE) of the University of Calgary, and the JUMP Math organization—was created in an attempt to improve mathematics instruction at the elementary level, so every student learns and enjoys mathematics. Results from the early stages of this initiative have already shown significant, positive impact on students' performance in mathematics, as well as teachers' improvement of their knowledge to teach mathematics. In this paper, we describe the dramatic changes on teaching practices of one of the authors, McInnis, during the early stages of the initiative.

MATH MINDS

The overarching goals of the Math Minds initiative were to: (a) increase student engagement, self-esteem and achievement in mathematics; (b) deepen teacher's conceptual understanding of mathematics and application of mathematical knowledge to enhance classroom instruction; and (c) showcase excellence in teaching and learning mathematical concepts to the wider community. A team from the WSE has contributed to the partnership by undertaking research in the initiative as well as informing the ongoing teacher professional development. The CCSD provided a research school, as well as other schools involved in the project, and participated in the design of the sessions for professional development. The JUMP Math (2015) organization provided the

curricular material for teachers and contributed to teachers' professional development. Each partner has contributed to, and learned from, the overall project.

The instructional approach and the materials for teaching mathematics—the JUMP Math (2015) program—stresses the importance of continuous assessment during class to spot mistakes and misunderstandings right away, making sure that everyone can engage in the mathematical tasks and students build self-confidence as mathematics learners. This type of assessment has to be efficient and effective, so the teacher can make decisions in the moment, during class. Two main components of the approach in the initiative are: the breaking down of learning into fine-grained steps, consistent with the literature on variation theory (Marton, 2015); and the building of student self confidence, supported by the extensive research on mathematics anxiety and mathematics learning (e.g. Wu, Barth, Amin, Malcarne, & Menon, 2012).

By the second year of the initiative, all the teachers in the research school had adopted the JUMP Math materials and received continuous professional support. Additionally, one researcher visited each teacher's classroom at least every week, to observe and sometimes video-tape lessons. The researchers very often engaged in conversations with teachers, providing learning opportunities for both teachers and researchers.

Preliminary results

While we observed a general improvement of student performance in mathematics at the school during this year, McInnis's Grade Six students showed an impressive shift. The Canadian Test for Basic Skills (CTBS; Nelson, 2015) was administered at the beginning and at the end of the school year. The average score of the Grade Six class moved from 34th on the National Percentile Rank (NPR) to the 54th percentile. The results for students with initial performance below the average of

the group were even more surprising; the mean for this group of students went from the 10th NPR to the 41st NPR. Students with initial score above average also improved their performance. The mean for this group changed from the 68th NPR to 73rd NPR. We also noticed that students improved their attitudes toward mathematics as reflected in their participation and engagement during class, as well as the enjoyment reported by interviewed students.

The Grade Six teacher

McInnis had been a teacher for 14 years before participating in the Math Minds initiative. Based on the results of her students, she was invited to be a CCSD Consultant for the partnership during the third year of the initiative. In this position, she participated in the design and delivery of professional development for teachers, as well as supporting teachers in many other CCSD schools that started using the material. Such involvement contrasts with McInnis's initial reluctance to adopt the material and participate in the initiative. We elaborate on these changes, as well as the change process she experienced in the following sections.

CHANGE IN TEACHING PRACTICE

The changes of teaching practices that McInnis experienced during the initiative are strongly related to the emphasis on continuous assessment and breaking down content and instructions into small steps. Before the Math Minds initiative she used to spend a large part of the class introducing new content, and then assigning work and assisting students individually and in small groups. After being involved in the initiative, McInnis paced her lessons in a very different way. Instructions and information were given in small steps during the class, accompanied by instant assessment that informed the next steps in class. We summarize the changes in four overlapping categories described as follows.

Breaking down instruction and practice into small steps

Like many elementary mathematics teachers, McInnis often taught an entire new concept before assigning practice work—e.g. she provided many instructions and explanations and then students were expected to complete multiple tasks on one or two pages of practice. During the Math Minds initiative, she changed this practice by breaking down new concepts into very small steps—examples of this can be found in Metz, Sabbaghan, Preciado-Babb & Davis (2015) and Sabbaghan, Metz, Preciado-Babb & Davis (2015). Only one instruction or idea was introduced at time. As new content was broken down into small steps in the resource (JUMP Math, 2015), she assessed students' understanding and assigned practice only when she was sure that students were ready to successfully engage in the corresponding tasks. In contrast to her previous approach, practice consisted of a few items related to one single idea introduced at a time.

Assessing continuously

Previous to Math Minds, McInnis spent a lot of time assisting students individually, then running out of class time and not getting to assist everyone. This changed when she started assessing students continuously during class. She almost entirely eliminated the common practice of calling on students who raised their hands to give answers because, she realized, that only gives the opportunity to assess one student. Instead, during instruction, students constantly answered questions on individual whiteboards, which they held up for the teacher to see. This allowed her to ensure that every student understood the concepts during instruction. With small examples of practice throughout the lesson, most students were ready to do the mathematical task correctly and independently. There were, after implementing this small step during teaching and assessing, only one or two students who required individual assistance during practice work.

Assessing for previous skills and knowledge

Assessing students' previous skills and knowledge prior to presenting new content is also a component of assessment. The whiteboards were very useful for this purpose. After asking some questions at the beginning, McInnis was able to decide if students were ready to move on, or if some previous activities or scaffolding measures were required. While she was aware of the need to diagnose students before her involvement in Math Minds, such assessment became more systematic and effective during the initiative.

Assessing and assisting students in class

Typically, when introducing all the instructions and explanations at the beginning of a class, many students did not finish their practice and subsequently took it home to complete. McInnis was not able to assess and assist these students. In contrast, when parsing the content of the class into smaller steps, she was able to assess and assist students right there during class time. Throughout her first year in the initiative, her students never had mathematics homework.

Bonusing

An important component of the Math Minds Initiative is the use of bonus questions and tasks for students who finish their work early. Before being part of Math Minds, only a few of McInnis's students finished their work during class. Preparing something for early finishers was not required. As a result of participating in the initiative, she began challenging students with bonus questions and tasks. These never consisted of busy work or of letting students work on without instruction. Bonus work always challenged students deeper, but within the same concept that everyone was working on. It is worth noting that students became comfortable when being challenged with bonus

questions; moreover, many of them often requested bonus questions to the teacher, or even created their own bonuses for themselves.

THE CHANGE PROCESS

McInnis identified a turning point of change in teaching practices in a particular session of professional development during the Fall of 2013. The session focused on pacing and parsing the content and practice during class. Teachers watched videos of themselves teaching and marked the time spent for instructions, assessment and practice—a teacher's activity sheet is included in the appendix. Before watching the video of her lesson, McInnis was sure she was doing what was suggested for instruction in the session: splitting the lesson into small steps and assessing all students before providing practice. However, after watching the video she was shocked to notice that she actually did the opposite—i.e. she talked for more than twenty minutes before students had an opportunity to do some work. After this realisation, she was very eager to switch her teaching practices. This change was also evident in the data for this study, which included weekly video-recordings and an interview at the end of the year.

Another turning point identified by McInnis was the introduction of the whiteboards for continuous assessment, suggested by the WSE team. She recognized, pretty quickly, the advantage of assessing all students constantly instead of asking questions such as "Can anybody tell me …?" which lead to an assessment dead-end once one student gives the correct answer.

Soon after changing the way she was teaching, McInnis felt that her lessons had developed a rhythm. It became effortless for her to have the students engaged in the tasks during class. JUMP Math material supported this approach in the way it breaks down the content in both the students' practice and assessment books and the teachers' guide. However, McInnis found that the teacher

must be aware of these steps in order to better parse the content of a lesson. This includes how the teacher responds when not all students provide the expected answers during instant assessment.

Another important factor contributing to McInnis's change was the interaction with Steven, a postdoctoral fellow hired as researcher for this study. He visited McInnis's classroom for the whole year, assisting students during practice time and engaging in after-class discussions with her. McInnis observed him posing questions to some students as bonuses of mathematical extensions of the content of each step of the class. Soon, she found it easy to come up with these extensions herself.

CONCLUSION

Initially, McInnis was very reluctant to incorporate the JUMP Math material. However, after working closely with the research team and using the resource for some months, she experienced a dramatic shift in teaching practices. This was evident in the pacing and parsing of instruction and practice, as well as in her use of continuous assessment. Both students' measured performance in mathematics and McInnis's observations of her students represent strong evidence of the benefits of such changes. It is important to note that such change did not happen only due to the JUMP Math material. The professional development sessions and her ongoing conversations and interactions with Steven played a major role in effecting such change.

The belief that all students can do mathematics compels us to continually strive to improve mathematics teaching. Early results from the Math Minds initiative suggest that a combination of curricular material and professional support can result in a rapid change of mathematics teaching practices with a positive impact on students' learning. The turning points indicated in this paper

have already been factors considered for future planning within the initiative. We will continue to further explore factors that impact on teachers' practices and students' mathematical learning.

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APPENDIX: TEACHER ACTIVITY SHEET FOR ANALYSING LESSON VIDEO-RECORDING

Lesson Self-Observation

Each section in the image below represents 1 minute. As you are watching your lesson, note at what points significant events and shifts take place.

Color-code the bars to show which minutes are primarily instruction (yellow), assessment (blue), and practice (green). Some sections may be left blank for transitions, announcements, etc. Note instances of bonusing with an *.

Of course, students may be working in their AP books as the teacher is circulating and assessing. We hope the following definitions will allow some consistency:

- ***Instruction*: Teacher is addressing the whole class.**
- ***Assessment*: The teacher is gathering evidence of understanding from the entire class.**
- ***Practice*: Students are practicing independently or with another student(s) (e.g. in a game or activity).**

Consider the transitions between colors on your bar:

- What prompted shifts between various sections? (e.g. getting through content, kids getting antsy, everyone ready, etc.)
- Would smaller chunks have been helpful? (e.g. smaller steps during instruction, less instruction before practice, etc.)