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DYNAMIC RESPONSIVE PEDAGOGY: IMPLICATIONS OF MICRO-LEVEL SCAFFOLDING

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In mathematics education, scaffolding is often viewed as a mechanism to provide temporary aid to learners to enhance mathematical understanding. Micro-level scaffolding is process by which the teacher returns the student(s) to a conceptual point where scaffolding is not needed. Then the teacher creates a series of incrementally more complex tasks leading to the original task. This process is dynamic, as it often requires multiple steps, and it is responsive because involves moment-by-moment assessment, which shapes each increment. In this paper, we present data on how experienced teachers in the Math Minds Initiative employ micro-level scaffolding. Implications of micro-level scaffolding are discussed.

Keywords: Scaffolding; Responsive pedagogy; Mathematics education; Mathematics for teachers

INTRODUCTION

In this paper, we report on a shift in how elementary school teachers implement scaffolding to enhance mathematics learning. The data we gathered as researchers in the Math Minds initiative include video recordings and observations of classrooms that used JUMP Math as their primary resource. The Math Minds initiative is a five-year partnership that includes the University of Calgary, JUMP Math, and the Calgary Catholic School District. The project aims to enhance early

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numeracy, and our research is framed within the broad goal of understanding what teachers need to know to effectively teach elementary mathematics.

Our data was collected at a small urban K-6 elementary school in Alberta. The national percentile ranks (NPR) on the Canadian Test of Basic Skills (Nelson, 2014) was used to track students' mathematical competencies after one year of participating in the Math Minds initiative, which used JUMP Math as its primary resource, and included professional development informed by ongoing research. The results indicated that there was a significant increase in NPRs. Therefore, it would seem that teachers have had some success in implementing Math Minds principles and in using the resource effectively.

Drawing from the data we have gathered over the course of two years, we witnessed the evolution of teachers' implementation of scaffolding strategies in the Math Minds Initiative. In this paper, we present two types of sample data. First, we describe scaffolding strategies implemented by two teachers teaching the same lesson, one during their first and one during their second year of participating in the initiative. Second, we report on teachers' (some using JUMP Math for about 3 months, and some using JUMP Math for more than a year) scaffolding strategies in response to a semi-fictional scenario in a professional development session. Finally, we offer some insights on why micro-level scaffolding strategies are more educative than mainstream strategies.

SCAFFOLDING IN MATHEMATICS EDUCATION

Scaffolding in mathematics education is a structure that has three key components (van Oers, 2014). First, it is generally considered to be an interactional process between a competent user of mathematics (teacher or peer) and a student or a group of students. Second, the aim of this process is to provide appropriate and temporary aid to enhance mathematical understanding, which may include the learning of mathematical actions and problem solving strategies. Third, scaffolding is essentially a temporary measure of assistance, and it is supposed to fade away as the learner becomes more competent.

The idea of supporting a learner through interaction until the learner is able to complete a task without support is unequivocally connected to the Vygotskian notion of zone of proximal development (Vygotsky, 1978). Building on this framework, Stone (1993) has suggested that successful scaffolding does more than allowing the learner to achieve a specific goal in the immediate context. In other words, Stone asserts that scaffolding is successful when the learner understands the value of the scaffolding action for future activities. To evaluate the effectiveness of such scaffolding, it is logical to provide students with opportunities to implement the knowledge acquired through scaffolding.

Employing scaffolding strategies in mathematics education can be quite a daunting task for the mathematics teacher. To aid teachers, some scholars have introduced different educative strategies for implementing scaffolding with different levels of explicitness (see van de Pol 2012). One the most popular scaffolding strategies is *modelling*, which is basically showing aspects of task performance. *Giving advice* or providing learners with suggestions with the aim of helping them improve their performance is another strategy. *Coaching* or giving tailored instructions for corrective performance is another common scaffolding strategy. Although these strategies are important in mathematics education, with each serving a different purpose, they are designed to provide remediation rather than take the students to the edge of their mathematical competence.

SCAFFOLDING IN THE MATH MINDS INITIATIVE

First year

The video recording data we gathered early in the project seems to indicate that teachers often employed traditional scaffolding strategies such as modelling, coaching, and giving advice. In one classroom video recording, we observed the teacher asking students to identify two-digit numbers on a 100s chart. The procedure was simple. The teacher spoke a number between one and 100, and the students found the number on their 100s chart. The teacher then randomly asked a student to come to the Smart Board and highlight the number that was read. In one occasion, the teacher asked the students to find “43” on their 100s chart. Then the teacher asked a student to come to the Smart Board to “find” the number 43, but the student highlighted the number “34,” as shown in Figure 1.

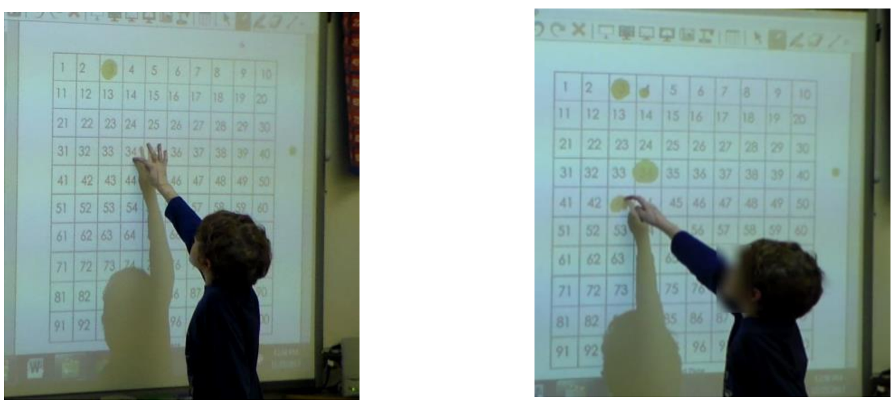

Figure 1: Identifying numbers before and after corrective measures.

A transcript of the conversation that followed is shown below:

Teacher: Look at what [name] did. [name] listen to the number. Forty-three. What number does that end with?

Student: Three

Teacher: Three. Does that end in a three? You have the correct number… the digits are correct, but where is forty-three? Come back and see if you could change your guess… so do we look at the 3 column or the 4 column to find forty-three? Where would be go for 43?

Student: here [correctly marks 43].

An analysis of the transcript reveals that the teacher used a coaching strategy by directing the learner's attention to the ones place value (3 or 4) in forty-three, then informing the students that the digits were correct, and finally refocusing the student's attention to the ones place value by asking which column to look for "43." In the lesson, once "43" was marked by the student, the teacher moved on to "63" and asked another student to identify it on the Smart Board.

Second year

In the second year of the project, a similar incident occurred in the same lesson described above. The teacher read numbers (from 1 to 100), and the students were asked to put a block on the number they heard on the 100s chart. The teacher went around the room and monitored students' performance. In one sequence the teacher asked students to identify "47." However, some of her students placed their blocks on the number "74," as depicted in Figure 2.

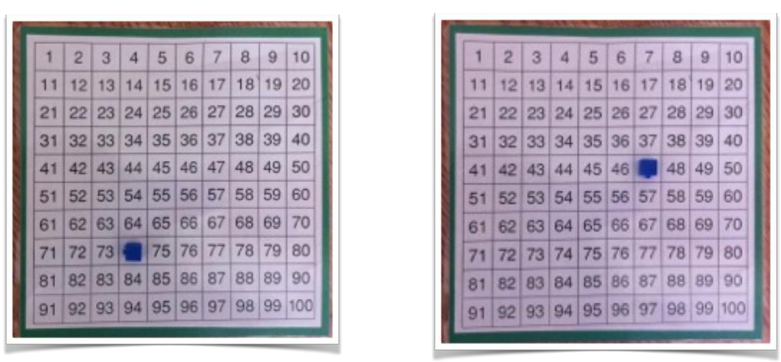

Figure 2: Student's misinterpretation of 47.

The teacher, who had participated in a series of professional development sessions focusing on mastery learning (Guskey, 2010) and formative assessment (Wiliam, 2011) as part of the Math Minds initiative, employed a micro-level scaffolding strategy. An important principle in micro-level scaffolding is starting with something known. In other words, micro-level scaffolding is not only a corrective measure per se: It is stepping back and building up in a manner that would allow the learners to complete the original task correctly and independently. In this instance, the teacher asked the students to identify the number "40" on their 100s charts. The reason this number was selected was because it is not possible to confuse the ones digit and the tens digit, as the number "04" does not exist on the 100s chart. We observed that everyone in the class correctly identified the number 40. Next, she asked her students to identify the number "41," and then she monitored the class to make sure that everyone had correctly identified this number. She then asked her students to identify the following numbers in sequence, each time monitoring to make sure that everyone had identified the correct number: 42, 43, 44, 45, 46, 47. Her decision to create a task with this particular sequence was likely informed by *variation theory* (Marton, 2015; Runesson, 2005; Watson & Mason, 2006), which includes the notion that the development of sequences in a task should systematically vary in a manner that would allow only one aspect to change while other aspects remain constant. In this particular sequence, the ones digits vary but the tens digits remain invariant. Structuring the task in this manner allowed the teacher to focus the students' attention on the ones place value, which was meant to rectify any confusion existing between the ones and tens place values. Next, the teacher asked the students to identify the number "67." This time, everyone in the class correctly identified the number on their 100s chart. This allowed the teacher to assess whether the confusion regarding place values had been alleviated. This objective would not have been met had the teacher asked her students to identify the number "55" or "90."

PERCEPTIONS OF SCAFFOLDING

As part of a professional development session, Figure 2 was presented to a group of elementary school teachers, who had various degrees of experience using JUMP Math (some a few months, others more than a year) as their primary resource. They were asked to provide an opinion on a scenario in which a second-grade teacher asked her students to identify the number "47," and the majority of the students put a block on the number "74." Table 1 summarizes and categorizes the teachers' suggestions based on their experiences.

Less than one year in Math Minds		More than one year in Math Minds	
Suggestion	Category	Suggestion	Category
Review skip-counting – ask them to change their answer	Modelling	Ask to find 10, 20, 30, 40, 41, 42, 43, …46	Micro-level Scaffolding
Ask them to make 47 with tens and ones blocks	Couching	Ask to find 10, 11, 15, 16, 26, 36, 46	Micro-level Scaffolding
Ask what comes after 46	Couching	Ask to find 1, 10, 20, 30, 40, 41, 42, …, 46	Micro-level Scaffolding
Give hint on which row and column has the answer	Giving advice	Ask to find 40, if they can, ask to find 45, if they can, ask them to find 46, and 47	Micro-level Scaffolding
Review 100s chart	Modelling		

Table 1: Teachers' scaffolding strategies.

The classification of suggestions by teacher presented in Table 1 is an indication of a fundamental difference between teachers, who where participants in the Math Minds initiative for more than one year, compared to those who were their first year, in how they view appropriate responsive pedagogical actions. While teacher who were participants in the project for less than one year seem to be inclined to use more traditional scaffolding strategies such as modelling and coaching, teacher in the project for more than one year view employing micro-level scaffolding strategies as responding appropriately. The more experienced Math Minds teachers also mentioned that after everyone in the class was able to identify the number "47" on their 100 chart, they would ask their students to identify a similar number such as 57 or 87 to make sure that the students were skilful enough to complete a similar task correctly and independently. Furthermore, one of the more experienced teachers also mentioned that she would extend this exercise by asking her students to identify the number which was "one more than 57" in order to create a challenge and keep her students engaged.

Implications of dynamic micro-scaffolding

Micro-level scaffolding seems to be deeply embedded in responsive pedagogy. One aspect in which it differs from mainstream scaffolding strategies is in the frequency of its occurrence. This type of scaffolding is meant to occur on a moment-by-moment basis. A JUMP Math lesson is structured in a manner that allows material to be presented in small increments (Mighton, 2007). After each increment, the teacher assesses whether the students can apply the knowledge independently and correctly. If for whatever reason the increment suggested by the resource is too big of a conceptual jump for a particular group of students, the teacher employs micro-level scaffolding.

Micro-level scaffolding is informed by a series of principles and actions. If students struggle to correctly implement the knowledge that they have received, the teacher *steps back* and returns the students to a point where the teacher is sure that all students can apply their knowledge correctly and independently. For example, in the scenario presented above, when students could not identify the number "47" on their 100s chart, the more experienced Math Minds teachers asked their students to identify either the number "1", "10", or "40" depending on what they perceived their students would be able to do. The teacher would then guide the students by *stepping up* in small increments, each time monitoring to make sure that all students responded correctly to the micro-task, until everyone in the classroom was able to correctly complete the original task (e.g. identifying the 47 on their 100s chart). Before moving onto the next increment, the teacher needs to make sure that the students are able to correctly and independently apply this new skill. To do so, the teacher should ask the students to do a task similar to the one they had just completed, without providing scaffolding. When all students are successful in their application, the teacher could either move on to the next increment, or create a more challenging task (but she has be reasonably sure that his/her students are able to complete this task) to keep students engaged.

Employing micro-level scaffolding ensures that no student gets left behind and that students are constantly and sufficiently engaged. Furthermore, the lesson structure when using this kind of scaffolding includes a series of cycles, which contain elements of new content, assessment, stepping-up/stepping-back, and practice. In this type of lesson structure, students' responses inform what the teacher needs to do next, which is in essence a form of responsive pedagogy.

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