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Reflection on the Educator Mindset for Teaching Mathematics to Diverse Students in the Constructivist Elementary Classroom

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In this perspective paper, we present seven elements of the appropriate educator mindset for teaching in the constructivist elementary mathematics classroom. The elements include supporting students as they construct their own understanding, eliminating deficit view of slow learners, setting new understanding and growth as the learning objective, providing opportunities to co-construct meaning with peers, using student contributions as the source of curricular material, encouraging all students to participate in learning, and providing instruction not bounded by time. In our struggles to provide authentic, inclusive elementary classrooms, we hope that our discussion of the educator mindset can increase discourse on constructivism from philosophy to practice in the community of mathematics education and policy makers.

Keywords: open task, constructivism, elementary mathematics, teacher mindsets, intellectual development
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I. INTRODUCTION

One of the fundamental goals of school mathematics is to support each student to achieve his or her intellectual growth (Confrey, 1994; Lovell, 1972; cf. intellectual development in higher education in Eljamal et al., 1999). This statement, however, does not mean that teachers should support all learners to attain the same benchmark of growth. Rather, it underlines the importance of learner growth and experience as a child develops

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(Cobb, Wood, & Yackel, 1991; Confrey, 1994). The close relationship between intellectual growth and mathematical thinking is well documented in the literature: the learning of mathematics can foster children's intellectual growth, and thus justify the value of mathematics in school curriculum (Bramall & White, 2000).

Reflecting more on the statement about the goals of school mathematics, we view that individual children construct different understandings in the classroom and thus attain different intellectual achievements. This view authentically represents an ideal constructivist elementary mathematics classroom, where students demonstrate a variety of thinking and cognitively construct their own understanding. When students work on the same mathematical task, teachers often discover that each child naturally produces different artifacts of the task. This observation underscores the importance of mathematics tasks in the elementary classroom, and compels us to consider the opportunities for learning that different types of tasks afford diverse students (cf. Henningsen & Stein, 1997, for the relationship between student cognition and tasks). Open tasks in particular aim to give a student the opportunity to make his or her own decisions in completing the tasks (e.g., Maher, Mueller, & Yankelewitz, 2009) and makes room for diverse mathematical thinking (Lesh et al., 2000).

In this paper, we recognize students' different intellectual readiness and development, and recommend a list of elementary mathematics educator mindsets to guide constructivist instruction through open tasks. A teacher's selection of cognitively demanding tasks, and their facilitation of learning through appropriate questioning and differentiated teaching strategies, are just important as educator mindset. In this paper, we hone our focus on teacher mindset in regard to open tasks, and although they are related, teacher practices are beyond the scope of this paper.

1. WHY OPEN TASKS?

Before we argue for open tasks in mathematics education, it is necessary to revisit our premise that, "school mathematics should support each child to achieve his or her intellectual development" and to expand it. The statement does not necessarily mean that all students have the same learning objectives; rather the essence of the statement indicates that the common mathematics task in the classroom might not result in the same understanding for each student. Why so? In response, we bring awareness to the fact that each child in the classroom possesses different intellectual readiness and will therefore follow different paths towards intellectual development (see Steencken & Maher, 2003, for children's learning of fractions). That is, each student possesses different entry points and shall respond differently to the same instruction (lecture, task, and experience). Further, this means that the end product of instruction *should* result in different sets of achievement. This precisely points to the value of open tasks, which is certainly well documented in the literature for making room for student thinking in the classroom. Having said that, students may benefit little from closed tasks, or from the kind of open tasks which are enacted as closed tasks in the classroom (Boaler, 1998; Latterell, 2004; Wu, 1994). More importantly, any tasks (or homework) in the traditional classroom could serve as open tasks – meaning that all tasks have the potential to remain open or closed, depending on the teacher's method of implementing the task.

2. AN EXAMPLE OF OPEN TASK: TODAY'S NUMBER

An open task for the whole class may use a common mathematical context, yet should create the opportunity for individual learners to make their own decisions and provide their own thinking and reasoning. For example, $1/10 = 2 \cdot a$ becomes an open task with the instruction, "find *a* in any method of your choice." We illustrate this further by reviewing student artifacts in a task titled "Today's number." The task gives students a number that they must reproduce through the use of four operations (Kim, 2016; Ronfeilt, 2003). A variation of this task includes, "use two operations to make the number," or "use addition and three numbers only to make the number." Third graders' responses (in the first author's fieldwork data) to a prompt of Today's number, "____ + _____ = 100" were as follows:

99.5 + 0.5 = 100
100 + 0 = 100
150 – 50 = 100
50 × 2 = 100
200 ÷ 2 = 100

These responses illustrate that all children can use their number sense to create an equation, despite being at different readiness levels. The task has the effect of dignifying student thinking by honoring a variety of student methods. Some students used decimal numbers and some limited their options to counting numbers. In this way, the opportunity to make progress at an individual pace of development outweighs the learning outcomes of a common understanding.

Because open tasks promote diverse student thinking, any task that requires students to present various approaches to the same problem could qualify as a good open task. Diverse approaches to a problem are desired as all mathematics questions are open to multiple approaches. That is, any random math problem can be solved in multiple ways.

Alternatively, a task that allows multiple answers may do the trick. Or a task that provides a context and encourages students to create a math problem could be a good open task. For example, with the prompt to complete a following sequence: 2, 4, ___, ____, ___, … , a student can say 6 for the third number. Seven, 8, or 2 (as in 2, 4, 2, 4, 2, 4 …) could be a good answer, depending on how students explain the rule of their sequence and learn to justify the terms of a sequence. Additionally, when the teacher provides a context such as, “your class has 12 boys and 8 girls,” a study may propose the question, “how many more boys are in the class than girls?” Other students may ask, “what is the ratio between the boy and the girl,” or “what is the total number of students in the class?” In these ways, students have the opportunity to work with their own intellectual development, contribute to the classroom discussion, and learn from their peers.

II. RECOMMENDED MINDSET FOR ELEMENTARY MATHEMATICS EDUCATOR TO GUIDE CONSTRUCTIVIST INSTRUCTION

1. RECOGNIZING STUDENT’S OWN CONSTRUCTION OF UNDERSTANDING

Each student in the classroom differs from their peers in readiness, experience, and their unique path of intellectual development. As a result, students can demonstrate different levels of understanding from the same instruction. When a teacher accepts this notion of diverse paths of intellectual development, they should support students’ differing needs by focusing on engaging each student in the learning process of creating or completing their own understanding. Given this, teachers should select open tasks such that they can facilitate a learning process that honors individual intellectual development (Kim, 2018; cf. science instruction in Haverly et al., 2018), instead of setting the same benchmark of achievement and evaluating student knowledge and skills accordingly.

The traditional approach of providing students with a worksheet of math problems during the class, assigning the incomplete worksheet as homework, and grading the homework the next day could be effective in involving students in intensive mathematical work. However, such practice could deny students of the opportunity to build their own understanding and regulate their own intellectual development (Chapin, O’Connor, & Anderson, 2013; Kamii, 1994). A teacher who believes their students should grow at their own intellectual pace should recognize this as a mindset and align practices accordingly. Teachers who hold this mindset should seek to involve elementary students in learning opportunities in which they can exercise their intellectual prowess and develop their own understanding.

2. ELIMINATING DEFICIT VIEW OF SLOW LEARNERS

When we frame teaching as a set of activities to support learners in achieving individual intellectual development, the deficit view of *slow learners* (Mercer, 1996) remains detrimental to the spirit of an appropriate educator mindset; this is especially true for effectively teaching a mathematics lessons with open tasks. The assumption that high achievers can construct their own understanding but low achievers cannot engage in meaning making (see Bulgar, 2003, for students' sense-making of fractions) is the primary form of a teachers' deficit perspective towards slow learners. Such assumptions are a direct repudiation of the U.S. National Council of Teachers of Mathematics' position about "the opportunity for *all* (NCTM, 1989, p. 4)," articulated in *Curriculum and Evaluation Standards for School Mathematics*. Here, the quantifier "all" indicates the inclusion of various student populations, not only girls or minority students, but also slow learners and special education students. In addition, one of the *Common Core State Standards for Mathematics*' (2010) practice in the U.S. is reasoning abstractly and quantitatively. Along with the NCTM's view, this is the key indicator of successful mathematics learning, which engages populations such as slow learners and elementary students that are often mistaken for being either unable or unwilling to think abstractly in deep learning, when slow learners may well be the learners engaging in the slow process of making meaning (Boaler, 2015).

We view the notion of slow learner as rooted in the kind of schooling that targets the mastery of knowledge and skills. In this framework of schooling, those who need extra attention primarily because they engage in their own intellectual development are identified as "gifted" or "slow." In reality, slow learners are not able to participate in mathematics tasks when the task requires unfamiliar prior knowledge or skills. This leads them to remain unengaged in meaningful learning, and they end up labelled as slow learners (Boaler, 2015). Research often tells the story of excellent teaching producing high achievements, though few studies look into what happens when *slow* students get support for pursuing their own intellectual development in the classroom. Two studies have reported the high achievement of slow learners in classrooms implementing open tasks (Cha, in press; Chapin, O'Connor & Anderson, 2013). For example, one student in the study who would score 30% to 40% on unit tests performed at 70% on the fractions unit test (Cha, in press), affirming that slow learners can thrive when they have access to tasks that encourage meaning making.

3. SETTING NEW UNDERSTANDING AND DEVELOPMENT AS THE LEARNING OBJECTIVE

When the teacher recognizes individual differences in intellectual interests and readiness (and even ability or capacity) and believes in honoring all students' thinking and dignifying students as valued participants in the classroom community (Helgevold, 2016), the ultimate goal of instruction shifts *from* producing consistent learning outcomes for all students *to* fostering individual gains in learning and producing new understandings for each student. In this mindset, different levels of student mastery are not an indicator of ineffective instruction, rather a welcome sign. Indeed, the variety of learning progress in an open task projects quite an authentic snapshot of intellectual development, which may look chaotic and unstable on the surface but indicates individual knowledge construction. Related, we echo Skemp (1987) for claiming that few students develop understanding through one episode of instruction. In reality, most students *begin* to understand after an initial lesson and attempt to clarify confusions, resolve misconceptions, master procedures, and relate to peer's thinking after a series of lessons are taught. We refer to this as the *due process of teaching* in this paper.

In light of the due process of teaching, the teacher should consider instruction as creating space for development and experience rather than a discrete entity of 45 or 90 minutes. That is, considering the connected nature of teaching related lessons and the diverse nature of student readiness and needs, the teacher's instructional goal should be aimed at building a network of diverse student thinking and understanding in the classroom community and creating meaningful development through authentic experience. Still, the network is not meant to be something students have to comprehend as a whole; rather the network is the community, and what matters is that students participate in the network and become a source of the network. This view is quite useful in drawing a picture of an authentic classroom and overcoming the dogma that all students shall achieve the same level of cognitive gains if instruction is effective.

4. PROVIDING THE OPPORTUNITY TO CO-CONSTRUCT MEANINGS WITH PEERS

The "Today's number" task produced a variety of student responses, indicative of different intellectual readiness in the elementary classroom. That is, the open task was instrumental in creating space and opportunity for students to review and reflect on peer ideas. In particular, each student notices a new idea (e.g., two students using decimals to make 100, such as 99.5 + 0.5) and decides to pursue a new topic as the next challenge. Such peer interactions (or influences) are the essential element of the type of teaching that empowers students to build on their understanding and make their own decisions. These interactions provide opportunities for students to offer not only their own ideas and strategies, but to set their own learning goals as motivated by peer ideas. In fact, Polya

(1957) already argued that students need flexibility and autonomy in learning; however, this approach may not be so popular among teachers, especially when they perceive that students' flexibility in problem solving strategies may hinder the teacher's predetermined path of instruction. In that case, the diversity of student ideas would be undesirable. On the other hand, if the teacher sets the instructional goal as "providing the opportunity to co-construct meanings with peers in the classroom," then student ideas - whether great or erroneous - may lead to uncovering an extensive network of students' mathematical thinking and reasoning. These in turn can serve as important resources to facilitate highly authentic mathematical communications (Empson & Levi, 2011; Kim, 2009).

5. USING STUDENT CONTRIBUTIONS AS THE SOURCE OF CURRICULAR MATERIAL

Even when a teacher believes each student has a different readiness and path of intellectual development, there is the issue of curriculum (i.e., what students learn) as a *white elephant* – what our children should learn in school. Considering students' own decisions, the traditional curriculum, especially when it is housed as a set of the teacher's predetermined teaching procedures, may do little to be inclusive of students' diverse thinking and needs. As an alternative, open tasks which are carefully aligned with curricular standards, have the potential to be a springboard for student ideas and therefore serve as the curricular material. For example, the "Today's number" task asked each student to make a number equation and contribute their equations to the class community. These contributions *are* the source of the teacher's curricular material (Kim, 2014). In turn, students are responsible to make sense of and understand their peers' contributions – that is *learning through participation*. Students' contributions include the student's own idea, other ideas that the student does understand, and some ideas that are either unclear or too difficult to understand. In this way, all students can own their knowledge and expand, thanks to peer ideas. Further, the teacher's instruction includes all students, yet poses different levels of challenges, as well as the opportunity to communicate and formatively assess. Individualized instruction (Melton, 1981) supports our view of individual experience and development since the approach too is guided by the principle of individual intellectual development. However, individualized instruction offers few opportunities to *communicate* with peers. Student understanding should involve the kind of peer interactions that nurture individual development. Open tasks can provide an authentic platform for student ideas – some ideas will survive and some ideas will dwindle away through peer interactions (Atwood, Turnbull, & Carpendale, 2010).

6. ENCOURAGING ALL STUDENTS TO PARTICIPATE IN LEARNING

Intellectual development for all in the classroom community should ensure that all students participate in learning meaningfully and equitably. What we mean by equity here is that every student in the class should be encouraged to contribute to the class at least once, and that students who have more, if not better, ideas can participate more as desired. Participation does not always occur through spoken language, so the teacher should encourage various mediums of communication. Participation also entails other elements such as *time* and *space*. Open tasks should allow sufficient time for students to think and share, and should provide a sense of intellectual safety so that students feel comfortable with participation. Students must first feel comfortable with constructing their own understanding over time and next, feel uninhibited in sharing their ideas (Chapin, O'Connor, & Anderson, 2013; Charalambous & Pitta-Pantazi, 2016).

There has been increasing awareness about helping low achieving students in the math classroom. We view that involving these students in open tasks, at the risk of unpredictable student responses and getting off track of planned instructional procedures, could in fact create the effect of de-labeling low achievers and engage them in learning. Teachers should encourage low achieving students to share their ideas and encourage them to reflect on peer's ideas, just like the teacher would facilitate interactions among high achievers.

There is research about student willingness (or unwillingness) to participate in the classroom community. For example, Kim (2018) reported that first graders in his classroom research tend to say, "I am here," or "I have yet to speak," in order to indicate they have ideas or strategies to share with their peers. Research also documented that classes involving more students in classroom discussions showed higher achievement than non-participatory classes; an achievement growth by ability level was also found in participatory classrooms (Chapin, O'Connor, & Anderson, 2013; Cho & Kim, 2012). Additionally, Cho and Kim (2011) found that low achieving students in classes that encouraged student ideas and participation demonstrated high achievement, when compared to on-level students tested on the same material.

7. PROVIDING INSTRUCTION NOT BOUNDED BY TIME

Each country has the tradition of offering timed instruction. For example, Korean elementary schools offer a lesson of 40 minutes and Singaporean elementary classes run 30 minutes. In the U.S., Indiana County in Pennsylvania, for instance, offers a lesson of 35 minutes. We do recognize the role of timed instruction in the view point of school administration. However, we still envision a classroom that is free from timed instruction.

We do not mean to abolish the educational convention of timed instruction. Rather, we recognize the benefit of teaching a math lesson in elementary school with a wide latitude with regard to instructional time.

Throughout this paper, we frame instruction as the learning system that dignifies each individual student as a learner in open tasks capable of constructing his or her own understanding and that the path of intellectual development should therefore be different from one student to another. Administratively, this means instructional time which makes allowances for gathering student ideas, and creates opportunities for students to reflect on peer ideas to improve their own learning. Considering the complexity and unpredictability of the series of activities, the expectation for all elementary teachers to teach a math lesson with a set of learning objectives within a required time is undoubtedly unreasonable. Kim (2018) reported a case in which the teacher implements open tasks and involves students in communication with peers and self-reflection of learning, and as a result instructional time for each lesson varied and rarely turned out to be the same 40 minutes.

With increasing call for more opportunities for communication in the classroom (NCTM, 1989, 2000; CCSSM, 2010), discussion-based instruction has become a professional norm in the mathematics classroom, and it is a good start. However, such shifts in the paradigm of teaching should be coupled with policy and practice that afford teachers the flexibility to make decisions regarding the time to close a lesson (i.e., a series of open tasks) based on student responses and interactions.

III. CLOSING WORDS

Constructivism has left a footprint in today's classroom in the name of student-centered, individualized instruction and many different forms of mathematics instruction in schools. All forms commonly remain analogous to educational play, in which students become the major actors of learning in the classroom. Such an idea is rooted in the essential belief of constructivism that each individual student constructs his or her own understanding, and can improve their own learning through authentic and active socialization (Yackel & Cobb, 1996) in the classroom.

In this paper, we discussed the seven elements constituting the educator mindset, which is by no means an exhaustive list but gives an indication of the teaching profession that supports student-centered instruction in the constructivist elementary mathematics classroom. We view that a true meaning of student-centered instruction as community is based on the premise that our children come to the classroom with different entry points of intellectual development (and paths of progression as well). Further, the quality of instruction should lie in the very evidence that all students partake in individual intellectual development in a classroom community that shares ideas, co-constructs meanings, and sets a new path of individual inquiry arising from peer interactions in the classroom.

Some aspects of the mindset may conflict with the reality of schooling in today's educational policy and practice. Undeterred by this, we assert that constructivism remains relevant in today's mathematics classroom. The caveat, however, is that a constructivist classroom is viable only when the teacher has an appropriate mindset and policy makers establish a policy of flexible instructional time and curricular decision making.

We hope that our description of the educator mindset can contribute to creating space for discourse in the community of mathematics education as well as policy makers, as we all continue to grapple with creating inclusive classrooms and reframing meaningful learning outcomes for today's students. We call upon researchers to investigate instructional *practices* that presume different intellectual readiness and paths, shift a focus toward relevant formative assessment away from standardized testing as the primary mechanism for measuring, and aim to nurture and sustain *individual* intellectual development through meaningful peer interactions as community.

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