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Good Mathematics Teaching is NOT Telling, it is Facilitating

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"Sometimes students approach the same problem from different mathematical perspectives or representing the mathematics in different ways until they find methods that enable them to make progress. Alone or in groups, they work productively and reflectively, with the skilled guidance of their teachers. Orally and in writing, students communicate their ideas and results effectively. They value mathematics and engage actively in learning it." (National Council of Teachers of Mathematics, 2000, p. 3)

While working with a group of teachers, I showed a movie clip from the movie Apollo 13. The clip showed the Lunar Excursion Module (LEM) being stuck in space. In the clip the technicians have come into mission control to speak with Gene, the National Aeronautics and Space Administration (NASA) Flight Director. They are informing him that there is a CO_2 filter problem on the LEM, the CO_2 levels are rising, and the LEM is becoming toxic. In addition, the scrubbers in the command module are square and the ones on the LEM are round thus they have a major dilemma. Gene informs the technicians they need to invent a way, "to put a square peg in a round hole". The movie then cuts to a scene when the top technicians at NASA are gathered. In the scene the lead technician, Ted, informs everyone they must devise a way to make a cube fit into a cylinder using an assortment of parts that are spread on the table, which represent the current parts available to the astronauts on the LEM.

At the conclusion of the clip I asked the teacher's the following questions:

1. What formula or algorithm did the technicians use?
2. What direct instruction did Gene provide to the technicians?
3. How did Gene model "his" thinking?
4. What worksheet did the technicians complete prior to the task?
5. Did Gene gradually release responsibility?

According to Smith and Stein (1998) the technician's task would be classified as a high-level demand task. The task is considered high level as it requires complex and non-algorithmic thinking, one has to access relevant knowledge and experiences and make appropriate use of them in working through the task, and require considerable cognitive effort (Smith & Stein, 1998). As the technicians were engaged in complex thinking, they required relevant knowledge, had to self-monitor, and required considerable cognitive effort. Repairing the LEM was the epitome of a real-world problem-solving task. In today's technologically advanced society how often will students be asked to complete a rote, routine task and/or a worksheet in the "real-world"? If students will not encounter a formulaic or prescribed task in the future, why are they completing such tasks in the classroom on a daily basis? Schools districts and teachers must reflect and ask themselves, are they preparing their students to become problem solvers or rule followers?

Many school districts throughout the United States utilize the Gradual Release of Responsibility (GRR) model as their instructional framework for teachers to use. The GRR model (figure 1) consists of four components: focused lessons (I do it), guided instruction (we do it), collaborative learning (you do it together), and independent work (you do it alone) (Fisher and Frey, 2008).

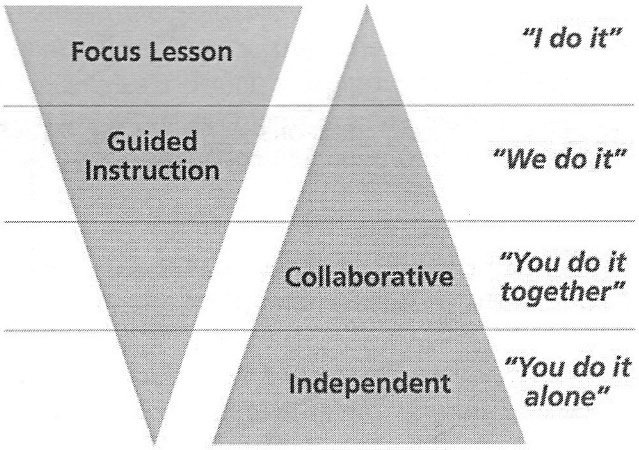

Figure 1. Gradual Release of Responsibility Model. Adapted from Fisher, D. (2008). Effective use of the gradual release of responsibility model [Author Monographs]. *Treasures.* Columbus, OH: McGraw-Hill.

The goal of the framework is to move from teacher knowledge to student understanding and application (Fisher and Frey, 2008). The GRR model is based upon the notion that "teachers need to provide systematic, purposeful, and direct instruction in skills and strategies if students were to make progress" (Fisher and Frey, 2007, p. 35).

School systems have adopted the GRR framework based upon the literacy framework of Fisher and Frey (2007). The framework was initially developed to teach students to read and write. This framework has been slowly integrated into other subject areas including mathematics. Schools currently emphasize differentiated instruction for students. How can these same schools districts select a static instructional framework for all subject areas? The GRR model is effective for literacy achievement (Fisher & Frey, 2007), however this is not the case for mathematics. Carpenter, Fennema, Peterson, Chiang, and Loef (1989) state effective mathematics instruction consists of teachers making sense of children's thinking which affects student's achievement. Thus the focus during instruction must be student-centered and not teacher-centered.

To fully understand the GRR, one must understand its origins and derivation from the Rosenshine (1979) direct instruction model (see figure 2) for reading comprehension. The model included the following components: a) complex skills is broken down into small steps, the teacher demonstrates how it should be performed, the teacher provides guided practice, the teacher provides time for independent practice, and the teacher provides feedback (Rosenshine, 1979). In this model the teacher is the focal point of the instruction as they are the giver of knowledge of the information.

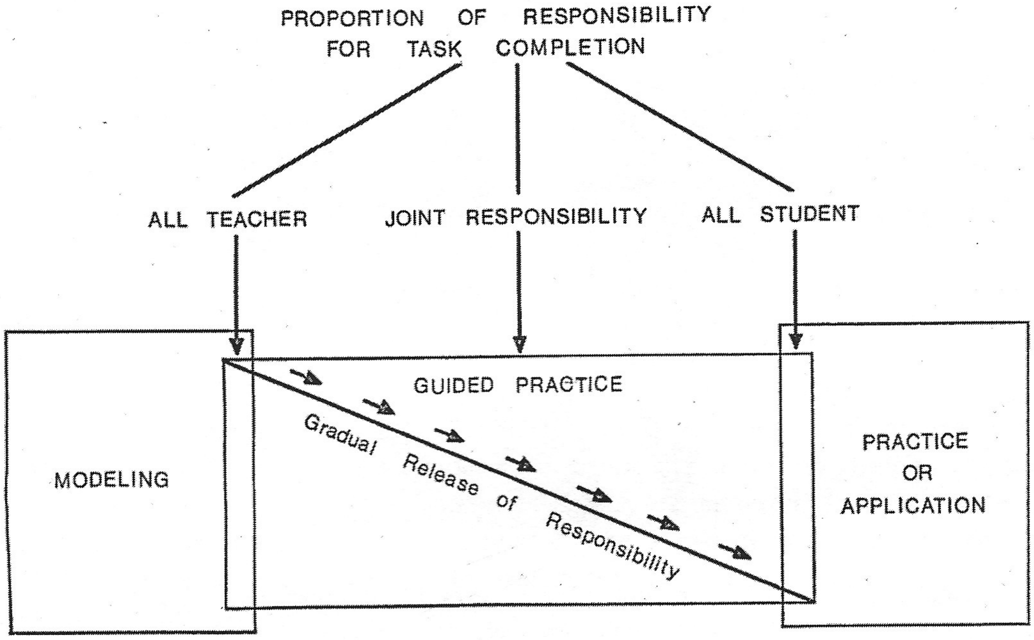

Figure 2: Proportion of responsibility for task completion. Taken from Rosenshine, B. V. (1979). Content, time, and direct instruction. In H. Walberg & P. Peterson (Eds.), *Research on teaching: Concepts, findings, and implications*. Berkeley, CA.: McCutchan Publishing Co.

Using the GRR model limits the engagement of students in the Standards for Mathematical Practice, which describe characteristics of students who are developing mastery of the subject matter. The Standards for Mathematical Practice are based upon the National Council of Teachers of Mathematics Process Standards and the National Research Council's Report *Adding It Up*. The process standards highlight was of acquiring and applying content knowledge (National Council of Techer of Mathematics, 2000) and the mathematical proficient five strands capture what it means for anyone to learn mathematics (National Research Council, 2001). The Standards for Mathematical Practice are student-centered while the GRR model has a strong teacher focus; thus, minimizing the opportunity for students to immerse within themselves in the content.

According to Dixon, Nolan, Adams, Brooks, and Howse (2016) "the classroom needs to support the thinking and learning of students" (p. 10).

Imagine two teachers teaching the standard CCSS.MATH.CONTENT.2.OA.A.1 *Use addition and subtraction within 100 to solve one- and two-step word problems involving situations of adding to, taking from, putting together, taking apart, and comparing, with unknowns in all positions.*

Teacher A is utilizing the GRR and Teacher B utilizing the Layers of Facilitation (Dixon, Nolan, Adams, Brooks, and Howse, 2016). Teacher A during instruction demonstrates to students how to solve the following story problem: ***Kyla has 82 marbles she gives 36 to her sister. How many does she have leftover?*** Teacher A explicitly states to student to circle the numerical values, underline the keyword(s), and then utilize the in-class word wall to determine the operation. Teacher A meticulously goes through the process. At the conclusion Teacher A provides a similar story problem for the class to solve collectively. Then Teacher A provides story problems for students to work on individually. The students use Teacher A's previously demonstrated problem solving process as a guide.

Teacher B, poses the following story problem to students: ***Kyla had 82 marbles. She gave some to her sister. Now she has 46 marbles. How many marbles did she give to her sister?***
Teacher B, reads the problem to the class to ensure understanding then allows students to individually make sense of and solve the problem. During this time teacher B circulates, monitors and engages in discourse with students (within groups and individually). Teacher B then, through scaffolding, has students present their different solution pathways, requiring students to explain and justify their problem solving process.

In both scenarios the teachers provide the students with rich problem solving tasks. These rich tasks were implemented at different levels. One must remember the intent of the standards is not for students to recite memorized information, but to develop problem solving skills utilizing the knowledge they bring into the classroom. Thus, which teacher's instructional practice allowed students to gain better understanding of the mathematical topic?

The Layers of Facilitation (Dixon, Nolan, Adams, Brooks, & Howse, 2016) instructional framework allows the teacher to become a facilitator during mathematics instruction, as opposed to the provider of knowledge. The layers of facilitation consist of three layers: "(a) I facilitate the whole class to engage in meaningful tasks through questioning, (b) I facilitate small groups to extend the learning initiated in the whole-group setting, and (c) I facilitate individuals to provide evidence of their understanding of the learning goal" (p. 10). Using this instructional model students have the opportunity to engage in the mathematics concepts from a fully student centered approach. Student knowledge and understanding is built upon, rather than prescribing general instruction that produces generic understanding. Therefore, using rich problem solving tasks that allow students to complete complex procedures with connections and do the mathematics allows for the facilitation discussions among the layers (Smith & Stein, 1998).

Consideration must be taken that typically teachers with low content knowledge are placed in schools with students from low socioeconomic status; students who lag their peers in regards to their current student achievement status (Adamson & Darling-Hammond, 2011). Consequently, these students; on the lower end of the achievement gap; are receiving direct instruction from teachers with limited mathematics content knowledge. This, results in limited student learning and mathematical comprehension. Teachers must understand "each student brings relevant knowledge to instruction" (Carpenter, Fennema, Franke, Levi, & Empson, 2015, p. 189). Such knowledge should be built upon through the layers of facilitation instructional framework by providing student-centered instruction that allows students to learn with understanding as opposed to learning rote algorithms, without conceptual understanding of the mathematical content.

The standards define what students should understand and a key indicator of students understanding is their ability to justify (National Governors Association Center for Best Practices, Council of Chief State School Officers, 2010). The intent of the standards is not for students to recite memorized information, but to develop problem solving skills utilizing the knowledge they bring into the classroom. When students are not allowed to initially make sense of the content, they are regulated to the teacher being the sole knowledge bearer. Teachers must allow students the opportunity solve problems and see themselves as problem solvers.

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