Opportunities for Questioning: Moving Both the Learner and the Learning Forward

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Introduction

Today's college and career readiness standards require mathematics teachers at all levels to provide authentic mathematical experiences regularly for their students. At all levels, mathematics students are challenged when engaging in contextually based problem scenarios that go beyond basic procedure. In addition many mathematics teachers struggle with strategies to incorporate that move the learner and the learning forward. This white paper focuses on tools that address the following three challenges:

1. Students' lack of the skills needed to successfully engage in a rigorous contextual problem-solving process,
2. Teachers' lack of understanding about supporting the development of these skills through the use of effective differentiated questioning,
3. Students' heavy dependence upon facilitated guidance throughout the problem-solving process.

Background & Problem

According to NAEP reports dating back over 25 years, one of the greatest deficits in U.S. students' learning of mathematics is their ability to solve word problems (National Research Council, 2001). Furthermore, "For some, the problem lies with an inability to read and comprehend the problem." (Bley & Thornton, 1995) With the advent of college and career ready standards that are more rigorous in nature, this deficit is even more apparent not only in the mathematics classroom, but across all disciplines. This is exacerbated by the shift in emphasis on informational text.

As we shifted roles from classroom teachers to teacher-trainers, the number one question posed by educators at all levels has been how to support students in being successful at solving word-based contextual problems. The difficulties are further compounded by the diversity of student populations in the classrooms of today. Students' lack skills needed to successfully engage in a rigorous contextual problem-solving process that hinges on students being able to answer these questions;

1. Can I **read** and understand what the problem is asking?
2. Do I have the **problem solving skills** to successfully propose a solution strategy?
3. Do I have the **content background** to engage in the problem?

Teachers' lack understanding in how to support the development of contextual problem-solving skills. The use of effective differentiated questioning hinges on teachers being able to answer three questions that demand action;

1. **Why would doing the problem** yourself help you to understand the complexity and possible student misconceptions?
2. **How would creating questions** for each of the four opportunities for questioning move both the learner and the learning forward?
3. What organizational structure can I use to **plan for** the explicit **implementation and facilitation** of the problem-solving task?

Students' heavy dependence upon facilitated guidance throughout the problem-solving process is another issue confronting teachers at all grade levels. "Students' actual opportunities to learn depend not only on the type of mathematical tasks that teachers pose but also on the kinds of classroom discourse that takes place during problem solving…" (NCTM, Cai & Lester, 2010) How much support is just enough and when does it become too much? Teachers need to be cognizant of never doing anything for their students that they can do for themselves. Some tools and suggestions for facilitated guidance will be shared. These tools will be beneficial to teachers in supporting students but will ultimately be used by students to help themselves.

Solution

We propose some tools that have proved to be successful in meeting the original three challenges stated in the introduction. These tools include a problem-solving process, a questioning structure, and bridging models that allows students to learn to create questions themselves.

Tools

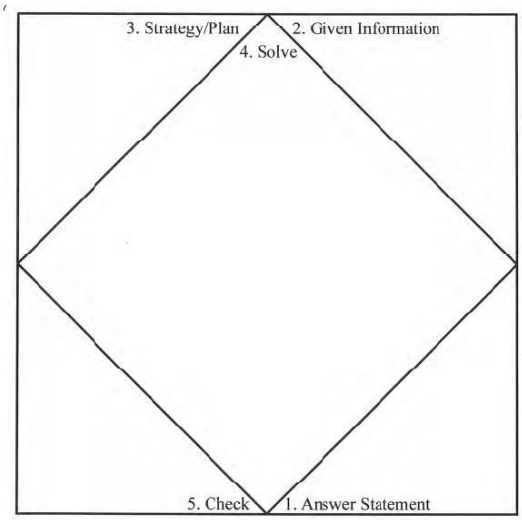
Problem-Solving Process with Graphic Organizer
4 Opportunities for Questioning
Q-Pyramid & Overlay

Teachers need to be mindful of providing tasks that have a low threshold but a high ceiling to allow all students room to grow. These types of tasks provides more successful scaffolding and differentiation. In preparing to implement an authentic rich task with students, teachers must first complete the task themselves. Engaging in the experience as a student, a teacher can anticipate challenges that may arise, such as vocabulary issues that may need to be addressed. One way to think about this is to consider where there will be opportunities to ask students questions throughout the **Problem-Solving Process (PSP)**. (Texas & Jones, 2013). The realization of the need for the PSP came about while working with students at the high school level. Assumptions were that by the time students reached high school they had been involved in solving word problems for several years. From our own personal classroom experience as well as our consulting work with teachers across all grades we found evidence that this was untrue. For example, teachers often assigned the computational problems from the text (section A) and omitted the contextual problems (section B). This may have been because the contextual problems were where students struggled and more time would be needed to support them. Regardless of the reason, it became apparent that students would need to be taught how to engage in these types of problems.

To explicitly facilitate students successfully solving contextual word problems, all of the components that benefit students from this would need to be addressed: reading and understanding (decoding) the

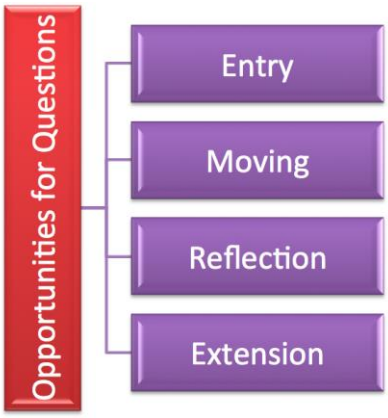
text; employing a strategy for getting started; having a structure for organizing one's thinking; and answering the question that was posed rather than responding with the first resulting quantity. To support instruction, we determined there would need to be an explicit of statement of process as well as a PSP graphic organizer to help the student's employ the process independently.

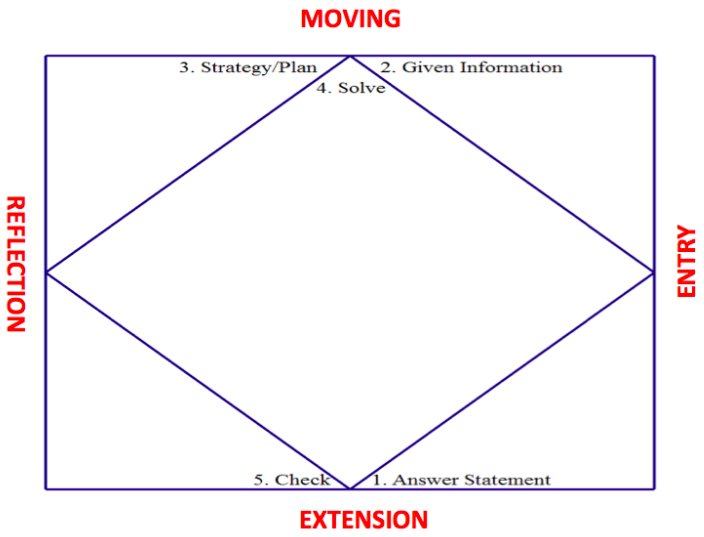
Problem Solving Process



1. **Answer Statement**
    a. Hint: The question usually appears as the last sentence of the problem. Cover the other information and focus on the last line to determine what the problem is asking. (Note: If the question is not here, go to the preceding line until it is found.)
    b. Write the question as an answer statement and leave a blank for the solution.
2. **Given Information**
    a. Hint: Use the same process of covering everything and view each sentence separately (See 1a.)
    b. Determine and record relevant information from the problem.
3. **Strategy/Plan**
    a. Use this space to state additional ideas for the problem. This may include other information you know about the problem, possible strategies for getting started, estimations for the solution, constraints, predictions, etc.
    b. NOTE: This is the section where you can formulate your own idea about the problem and create your own meaning about what is being asked.
4. **Solve**
    a. Select a strategy (translate verbal statements into mathematical statements, draw a picture, make a table, etc.) and solve.
    b. NOTE: Compare this to your estimation to determine the reasonableness of the answer.
5. **Check**
    a. Check your answer by substitution or by using another method to justify.
    b. NOTE: Once the answer has been checked, write the answer in the blank from step #1.

While working with the PSP, students often need support moving through the process. We suggest the following four opportunities that exist for questions which will support the learner and the learning.





There are a few basic questions that serve most problem-solving scenarios we have developed through our years of teaching and consulting. Questions beyond these should be refined to be task specific. Here is a sampling of questions that can be utilized at each phase:

Entry: for students having difficulty getting started
- What is the problem asking?
- What do you know?
- What information do you need?

Moving: for places where students could get stuck
- What pattern(s)/relationship(s) do you see?
- What strategy (ies) could be used here? Why?
- How might you model the situation?

Reflection: for students to use for metacognition (after completing problem)
- How do you know if your answer is reasonable?
- How might you justify your answer using a different strategy or representation?
- What resources/tools were helpful? Why?

Extension: for students to engage in higher order thinking skills with respect to the same concept and/or problem
- How would the solution change if the constraints in the situation?
- Why did…?

- How might you use the patterns/relationships you identified to make a general conjecture about…?

Practically, the entry questions (and possibly the moving questions) can be projected on the board to allow student groups needing access to these questions. Allow students to attempt the problem for a brief period of time, before offering these guiding questions as support. This will teach students to try and make sense of the problem and not automatically looking to the teacher for guidance. Too many students have learned that playing helpless is the best way to get the teacher to "tell them what to do." This is the role of the PSP. If students do not refer to the board throughout the process, another approach would be to print these questions on a strip of paper and place at their desk for reference. Make sure to tell students that these questions have been generated to help them help themselves by taking ownership of their own learning and being resources for one another (Wiliam & Thompson, 2007).

The reflection questions and extension questions can be copied on separate strips of paper and can be placed at student desks as students progress through the process. These are the questions that allow for differentiation for those students who complete the problem early and need to move deeper. For students who finish early one possible extension is to help their peers but only through following several rules:

1. They are not allowed to use declarative sentences that "tell what to do."
2. They are not able to show their own paper and what they did.
3. They are not able to take a pencil and write for the peer.
4. They are only allowed to ask the peer questions to assist them in their understanding. (They need to write down the questions that seemed to help move the learning forward.)

The Q-Pyramid and Overlay were developed as tools that could easily and effectively provide teachers and students with a way to develop questions as they work through the PSP. It can sit on the desk to remind students of where they are in the process and to aid them in moving forward as needed.

It is our belief that most students who disengage, do so because they do not know what to do. They really do care. These tools provide students the scaffolded support they need to help themselves and allow them to experience success while perfecting their problem-solving skills. This beginning success will grow exponentially if nurtured.

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