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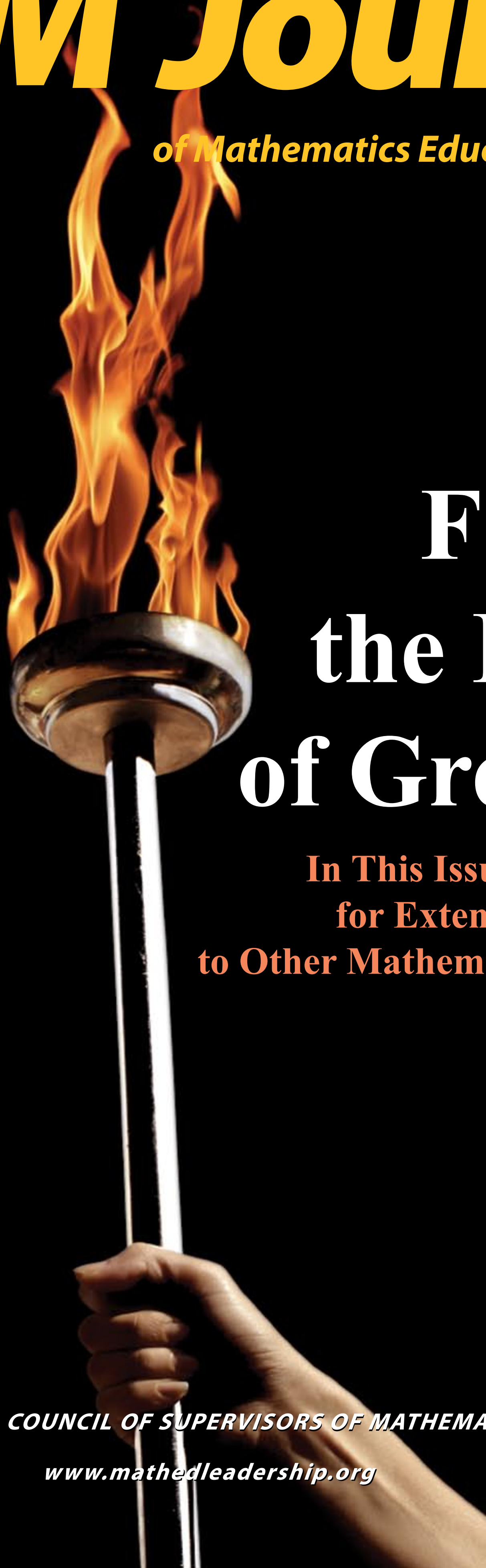

Fanning the Flames of Greatness

In This Issue, We Offer Ideas for Extending Your Passion to Other Mathematics Professionals

NATIONAL COUNCIL OF SUPERVISORS OF MATHEMATICS

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CORRECTION FROM WINTER 2008 JOURNAL
The Winter 2008 *NCSM Journal* omitted co-author Daniel Clark Orey from the byline of the article, “It Takes A Village: Culturally Responsive Professional Development and Creating Professional Learning Communities in Guatemala.” Dr. Orey is a professor of mathematics and multicultural education at California State University, Sacramento. We regret the omission.

Purpose Statement

The purpose of the National Journal of Mathematics Education Leadership is to advance the mission and vision of the National Council of Supervisors of Mathematics by:

- Strengthening mathematics education leadership through the dissemination of knowledge related to research, issues, trends, programs, policy, and practice in mathematics education
- Fostering inquiry into key challenges of mathematics education leadership
- Raising awareness about key challenges of mathematics education leadership, in order to influence research, programs, policy, and practice
- Engaging the attention and support of other education stakeholders, and business and government, in order to broaden as well as strengthen mathematics education leadership

Prediction as an Instructional Strategy

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In various disciplines, using prediction has been investigated and incorporated into an instructional sequence in order to facilitate teaching and learning, and research has reported the effectiveness of using prediction (e.g., Gunstone & White, 1981; Palincsar & Klenk, 1991; Battista, 1999). However, using prediction in the mathematics classroom is a relatively new idea, and practitioners have been provided limited guidance of how prediction can be used to help mathematics instruction.

In this article, we address using prediction as an instructional strategy to enhance classroom practices. Researchers emphasized the importance of effective teaching practices on student learning (Marzano, Pickering, & Pollock, 2001; Wenglinsky, 2002; Wright, Horn, & Sanders, 1997). For example in his evaluation of data from the National Assessment of Educational Progress (NAEP), Wenglinsky indicated that teaching practices seemed to have more of an influence on student learning than socioeconomic status on NAEP student outcomes. Using prediction as an instructional strategy can lead to classroom practices where students actively engage in the meaningful learning of mathematics. Some immediate questions that arise are: What does prediction mean? How can using prediction create desirable pedagogical practices? What are some effective ways of using prediction? We address these questions in terms of the role that prediction can play in the teaching and learning of mathematics.

What is Prediction?

Prediction can be understood as reasoning about the mathematical ideas of the lesson at the launch by using prior knowledge, patterns, or connections. Prediction does not necessarily mean a simple premature guess. Rather, prediction is a sophisticated reasoning process connecting relevant ideas. In order to make a plausible prediction, students have to activate their prior knowledge and connect concepts from previous explorations. For example, students may be asked before exploring a problem to predict what effect increasing walking rates will have on the table, the graph, and the equation as they examine the relationship between distance and time. When making such predictions, students have to look back on what they already know (i.e., what walking rates mean, and how those rates are represented in a table, a graph, or an equation) and use that to reason about what will happen when a rate is increased. Such an opportunity helps students build a better understanding of key ideas based on the connections they make.

Advance Organizer

Predictions can be used as advance organizers. Advance organizer is one of the instructional strategies that Marzano, Pickering, and Pollock (2001) suggest. Originally, Ausubel (1968) introduced advance organizers as "relevant and inclusive introductory materials" presented in advance of learning. According to Ausubel, "advance organizers are … at the same level of abstraction as the material to be learned, [however] are designed to bridge the gap between what the learner already knows and what he needs to know before he can successfully learn the task at hand" (p. 148). Lesh (1976) conjectured that these advance organizers are valuable tools for learning new material. According to Kim and Kasmer (Kim & Kasmer, 2007a, 2007b; Kasmer, 2008), posing prediction questions prior to students exploring the mathematical ideas of a problem helps invoke prior knowledge and bridge between mathematical concepts (e.g., previous concepts and a new one). Prediction helps make sense of the problem context and identify related mathematical concepts. How is this problem similar to and different from previous ones? What mathematics are embedded in the problem? As a result, engaging in prediction activities prompts students to make connections of mathematical ideas which helps set the foundation for future learning. Overall, prediction encourages students to engage in mathematical sense making.

Consider a classroom episode below (Kim & Kasmer, 2007a). In this example, middle school students solved a problem involving a race between two brothers:

> Emile's walking rate is 2.5 meters per second and his little brother Henri's walking rate is 1 meter per second. Henri challenges Emile to a walking race. Emile gives Henri a 45-meter head start. How long should the race be so that Henri will win by just a bit? (Adapted from Lappan, Fey, Fitzgerald, Friel, & Philips, 1998)

Prior to solving the problem, students were asked to make several different types of predictions related to this problem, write their predictions and supportive reasoning on paper, and then discuss which of the predictions seemed reasonable. First, they predicted whether graphs, tables, and equations of this problem would look similar to what they had done before. One student said that this problem would produce lines with constant rates, which made them "linear." Other students agreed with him and said that some of work they had done previously were constant rates and some were not.

Next, they predicted which line would be steeper if they graphed the situation. One student said, "Henri's got steeper because he has a 45-meter head start." Another student offered, "I think Emile because he goes further and faster in a shorter time." When the teacher asked how she knew he went further and faster in a shorter amount of time, the student answered, "Because he's a lot faster." Some students agreed with her. One student said, "Because he goes 2.5 meter per second and he travels faster, so his line will be steeper."

Last, students predicted how long they thought the race should be. Students offered various predictions ranging from 50m to 250m (50m, 100m, 200m, 60m, 55m, 75m, 70m, 250m, 175m, and 150m were their predictions, in order of being offered). One student whose prediction was 250m said, "There should be a longer distance so Emile can catch up." As soon as he finished, another student said, "I disagree with him because Emile's walking rate is double Henri's. So, it's not going to be 100 and up." Many agreed with her and said, "100 is too high" and changed their prediction for the race distance. A couple of students were attempting to determine the distance that each could make in a certain amount of time, for example, 10 seconds. At that point, the teacher asked students in pairs to solve the problem using the ideas that they had generated.

In this example, predictions were made about three ideas: a) if the problem looked familiar with respect to the graph, table, and equation; b) which of the two lines would be steeper; and c) what would be the optimal distance of the race. As advance organizers, predictions related to the first two ideas enabled the students to make connections between what they had previously explored and the problem they had been given to solve. In making such connections, the key concepts were constant rates and steepness of lines. Using these concepts, students also predicted some characteristics of the lines that the problem would produce. Particularly interesting is that even though students knew Emile would win eventually since he was faster, they had not yet built the connections between the problem context and its graphical representations at this point. In fact, this was challenged by the first two prediction questions.

Predictions related to the last idea certainly invited students' interest in the problem and provided motivation to solve the problem. It also made them consider the relationship between the two lines in terms of two different constant rates as well as a head start. When predicting the brothers' race distance, students provided random guesses at first, but revised their predictions in more sophisticated manners once they began to discuss the reasoning behind the predictions. When a girl pointed out the brothers' walking rates in relation to one another ("Emile's walking rate is double Henri's"), many students were convinced and changed their predictions. Having this discussion prior to solving the problem enabled students to actively engage in the problem, to agree or disagree with each other's predictions based on their reasoning, and to make sense of the problem situations by visualizing the two linear relationships.

To summarize, in the above classroom example, making predictions and discussing related mathematical ideas served as an effective advance organizer.

Aids for Visualization

A number of researchers expressed the importance of visualization in learning (Bishop, 1988; Brown & Wheatley, 1990; Clements, 1982; Cuoco, Goldenberg, & Mark, 1996; Presmeg, 1991, 2006; Skemp, 1987; Suwarsono, 1982). For example, Dunham and Osborne (1991) suggested that students learn "how to see" in order to promote conceptual understanding. Kim and Kasmer (2007a) and Kasmer (2008) found that using prediction invoked visualization. The classroom example provided earlier illustrates that prediction can encourage the visualization of problem situations and related concepts. Through predictions they made, the students were encouraged to imagine what was happening in the problem context and with the given condition what would happen in the end. They also were thinking about pictorial images of graphs and tables that the problem context would produce. According to Presmeg (1991), the first type of visualization (i.e., mentally picture the problem situation) is considered as "concrete imagery" and the second (i.e., utilizing graphical images of the problem situation) as "pattern imagery." When visualizing graphical representations of the problem situation, students had to utilize the fact that the problem context involved linear relationships. More specifically, they had to connect rates of walking distance with steepness of lines and the head start with a y-intercept. Eventually, such visualizations helped the students make sense of the problem situation and relate the problem context with various representations (e.g., what the graph of the situation would look like).

Tool for Informal Assessment

Using predictions allows teachers to assess students' thinking prior to the investigation of a task (Kim & Kasmer, 2007a, 2007b; Kasmer, 2008). When students pose their predictions, teachers have an opportunity to establish what students have understood from prior explorations and what connections they are able to construct with reference to the current problem. In addition, teachers can determine students' misunderstandings and misconceptions through their predictions. Such informal assessments enable teachers to adjust their plans taking into consideration the students' predictions to further develop and focus on the mathematics of the lesson. Prediction also allows individual students a chance to assess their own thinking as they prepare to begin a new problem.

In the classroom example above, the teacher could see where his students were before the exploration of the problem. Students were able to see the linearity of the problem context. However, the specific aspects of the problem, such as different walking rates and the head start, were not clearly connected back to the characteristics of linear relationships. Some thought that the 45-meter head start would yield a steeper line: others thought the faster walking rate would produce a steeper line. While discussing their ideas, students were able to see some agreements and disagreements with their own thinking. Such arguments and reasoning would be resolved and pursued through the exploration of the problem.

Means to Promote Student Engagement and Classroom Discussion

Earlier we illustrated that predictions invokes students' prior knowledge and engagement. Using prediction also helps guide classroom discussion. In a recent study (Kasmer, 2008) prediction was found to be an effective tool to engage students as well as assist teachers in focusing the classroom discussion. That is, the prediction questions provided a vehicle to begin or focus classroom discourse where the teacher was able to organize discussions based on the students' responses. These discussions in turn, afforded the teacher with an impetus to promote classroom interactions where students can justify their thinking and listen to and make sense of others' thinking.

Kasmer also found that students in an algebra classroom where prediction questions were routinely posed prior to the explore segment of a problem demonstrated a higher level of engagement compared to a similar class where prediction questions were not used. When prediction questions were posed and students responded with supportive reasoning, first in writing, then sharing their responses in whole group discussions, it was noted students were engaged in sustained conversations that were created by a culture precipitated by the inherent free virtue of prediction and its absence of certitude. Once students have had an opportunity to consider the question and record their predictions, they are more confident in their responses.

Furthermore, the prediction questions presented both the teacher and students a focus for discussion. This deliberate discourse is often difficult for teachers to orchestrate as they juggle both the complexities of the mathematics and the discourse. However the prediction questions along with the student responses, which were prevalent during the prediction phase of the lesson, provided both the teacher and students a direction for discussion. Moreover, permitting all students with purposeful time devoted to activating and consolidating their individual thinking prior to class discussion created richer discussions of mathematical ideas.

Suggestions for Using Prediction Questions

While using prediction as an instructional strategy provides benefits, it is not trivial to create appropriate prediction questions and use them effectively. Drawn from previous work (Kim & Kasmer, 2007b; Kasmer & Kim, under review), we provide some suggestions.

Create an appropriate classroom culture. At the beginning of the school year, it is important that teachers create a classroom environment where students feel comfortable taking risks and making predictions. The teacher must develop a culture that establishes the norms of interaction where students are reassured that all prediction responses will be valued and supportive reasoning should follow all predictions. Students should approach their prediction responses as plausible ideas and not merely a random guess. Also, students need to be encouraged to share ideas with one another and constructively evaluate each other's ideas.

Make a deliberate plan to include prediction questions. Teachers should examine the key ideas of the lesson when deciding to use prediction questions. Prediction questions should implicitly reflect the mathematical ideas of the main problem without revealing the essence of the problem. These questions should be presented to students as they potentially generate opportunities to engage students in the mathematics of the lesson. The teacher presents the prediction questions in conjunction with the launch of the investigation. Students would record in writing their individual responses to each prediction question the teacher poses, as described later. After students record their predictions, the teacher then elicits student responses without commenting on the accuracy of the prediction or the appropriateness of reasoning.

Have students write their prediction prior to class discussion. Individual student written responses are necessary to provide evidence of each student's thinking as time constraints do not allow each student the opportunity to share their predictions during the launch of the lesson. Furthermore, writing individual responses also affords students the occasion to organize their thinking about the mathematics of the problem before verbalizing their thinking to the entire class. Requiring students to respond in writing to the prediction questions helps students utilize their own reasoning, rather than those of classmates. Such writing also helps students prepare to engage in discussion and feel more confident.

Revisit the students' prediction responses. It is important to revisit the prediction questions and student responses during the summary segment of the lesson through which students can reconcile any discrepancies between their initial prediction and the outcome of the problem. Exploring elementary students' 3D geometry, Battista (1999) found that discrepancies between student predictions and actual results helped build a useful mental model to solve problems. Noticing the differences and examining "why" will encourage students to engage in careful thinking and thorough reasoning.

Final Remarks

Hiebert and Grouws (2007) suggest student engagement and students' entry knowledge are two aspects of opportunities to learn. The National Research Council (2001) reports that the "opportunity to learn is widely considered the single most important predicator of student achievement" (p. 334). Predictions made and discussed before exploring the main task of a lesson create learning opportunities for students by playing a role of advance organizer and enhancing students' engagement. When classroom teachers use prediction as an instructional strategy, they are creating a learning environment where students can activate their prior knowledge, make connections of mathematical ideas, make sense of what they explore through visualization, and actively engage in problem solving and discussion. This instructional strategy also allows teachers to informally assess students' on-going thinking. Therefore, we suggest that mathematics classrooms use prediction as an instructional strategy to promote students' mathematics learning.

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