

## The Fourth “R”: Reflection

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Research promotes reflective teaching as an important distinguishing strategy between experienced and novice teachers and is a critical tool for developing teacher knowledge. Reflective teaching practices are supported by national reform efforts and have the potential to affect student achievement in the mathematics classroom. Unfortunately, reflective teaching practices are not always a component of teacher preparation and professional experiences. This discussion highlights: (1) research concerning the importance of teacher reflection; (2) the results of a study implementing reflective teaching practices in an elementary mathematics and science methods course; (3) the resulting “best practices” applied to other teacher learning contexts; and, (4) the benefits of the fourth “R”.

National standards, having emerged from educational reform, promote learning environments that encourage meaningful learning, rather than rote learning, and create a different view of teaching and learning. A component of these reform efforts is to develop teachers who are reflective about teaching and learning. Reflection is seen as what a teacher does when he or she looks back at the teaching and learning that has been experienced, and recreates the events, emotions, and happenings of the situation (Wilson, Shulman, & Richert, 1987). Hoberman and Mailick (1994) believe that learning and competence are gained by practice in performance that involves reflection before, during, and after the action.

Research indicates that teacher reflection is a key aspect for obtaining teacher knowledge and pedagogical content knowledge. There exists a stage in which teachers look back on the teaching and learning that has occurred as a means of making sense of their actions and learning from their experiences (Wilson, Shulman, & Richert, 1987). Reflection is seen as a process of reconstructing classroom enactments, including both cognitive and affective dimensions that involve a developmental progression through stages. Experienced and novice teachers differ in their ability to learn from reflection on experience. Reflective experts are more discriminating in their perception and more resourceful in their actions and problem solving. Experienced teachers have a highly developed knowledge base concerning students; notice different

classroom aspects; are more selective in their use of information during planning and teaching; and, make greater use of instructional and management routines (Borko & Livingston 1989; Borko & Shavelson 1990; Carter, Cushing, Sabers, Stein, & Berliner, 1988). The basis for instructional decisions (teacher’s practical knowledge) is dynamic as it builds through reflective experience (Elbaz, 1983).

The *Principles and Standards for School Mathematics* (National Council of Teachers of Mathematics [NCTM], 2000) advocates new ways of teaching and learning mathematics in the classroom. As mathematics educators begin to implement these guidelines, it is even more crucial that teachers become reflective in practice. However, reflection on teaching is not a traditional component of mathematics instruction. As it is believed that teachers tend to teach the way they were taught, reflective teaching will only be implemented and flourish if teachers become knowledgeable of and are supported by “best practices” in the classroom.

The importance of reflective teaching is a central component for designing teaching and learning experiences for teachers. I have implemented a variety of strategies for encouraging reflection into all my courses with both preservice and inservice teachers. Effective protocol for becoming a reflective teacher has emerged through these experiences. This discussion describes original research findings with preservice teachers that led to creating and implementing reflective practices into other teacher education courses. A collective synthesis of these successful efforts resulting in “best practices” is presented for creating learning experiences for teachers that are conducive to begin and support reflective teaching. No longer can there be traditional reliance on just “Reading, ‘Riting, and ‘Rithmetic” as the basic ingredients for providing a quality education. It is vital

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for all teachers, especially teachers of mathematics, to take a serious look at a fourth “R”: Reflection.

### **Reflective Research**

Even though the role of reflection in teaching is considered important, reflective action in preservice and inservice teachers is either inhibited by isolation of teachers or by structure of courses and schools (Feiman-Nemser & Buchmann, 1985; Lortie, 1975; Nisbett & Wilson, 1977). Fenstermacher (1994) has suggested reform needed and wanted in teacher preparation requires a tremendous effort in understanding teaching and teacher learning. Other advocates in the renovation of teacher preparation programs appear to confirm this and suggest that such new programs must understand the conditions that promote reflection in beginning teachers. Research findings confirm that the likelihood of long-term success for many novice teachers is hindered by the absence of expert guidance, support, and opportunities to reflect (Tisher, 1978; Veenman, 1984).

Examination of the role of reflection involved in learning how to teach can make significant contributions in strengthening the preparation of teachers by complementing a growing knowledge base for teaching. The purpose of this inquiry was to examine the construction of teacher knowledge in learning to teach elementary mathematics and science. Implementing teacher reflection was an integral component of the study. A qualitative methodology was employed and facilitated the discovery of the importance of reflection in learning to teach by preservice teachers in a school-based setting. The respondents were twenty-one junior and senior level interdisciplinary studies majors at a large university who were enrolled in methods courses required for the fulfillment of certification in elementary mathematics and science instruction. The site for this content-focused (mathematics and science only) professional development school was located on a middle-class, suburban, public K-5 elementary school campus in a central Texas school district. The methods course experience was non-traditional and innovative in: the approach (constructivist<sup>1</sup>); the content (standards-based<sup>2</sup>); the site (school-based with immediate access to inservice teachers and elementary students); and the instructional strategies (reflective practices). Additionally, during the semester, the preservice teachers participated in teaching and tutoring elementary student’s mathematics and science lessons.

Groups of three or four preservice teachers were assigned to elementary grade level teachers for creating

and teaching these elementary mathematics and science lessons. They debriefed and reflected in small groups, and then individually responded to the course tasks of analyzing, evaluating, and synthesizing all experiences. These activities created the opportunity for the required reflective journals, lab entries, classroom tasks, and summative portfolios that were assigned course products, and consequently used as data sources. In addition, I conducted interviews with the students to obtain additional information. The data were processed following the suggested steps of synthesis of a constant comparative method adapted from Glaser and Strauss (1967). Both evidence and extent of the value in the use reflection were apparent. Knowledge of self, of the learner, and of the task (content) were prevalent themes that emerged from the data.

Development and use of the reflective process was an objective of the methods course. Course instructors considered reflective thinking before, during, and after teaching imperative for a thorough teaching experience. The reflective process is valued in professional growth and successful teaching (Dewey, 1933; Schön, 1987). The entire collaborative learning environment was subjected to the reflective process. Reflection on learning occurred in the large group tasks and activities; while working and planning with teachers; while teaching children mathematics and science; while working and planning within grade level groups; and while working and interacting with course instructors. To aid in simplifying the communication of data sources for the purposes of this paper, I will rely on the codes (see Table 1) I used during analysis while I discuss these findings below. Through reflection, much was revealed about the learning components of teacher knowledge and pedagogical content knowledge in mathematics and science.

Reflection is not an easy task. Initial reflections in notebooks and in weekly evaluations were superficial and more descriptive in nature rather than reflective (RJ: 12.17.96). Reflections grew in depth and quality over the semester to culminate in the product of the personal portfolio. The portfolio was the ultimate expression of the acquisition of learning that the preservice teachers experienced in this context. The summative portfolio was a deep, elaborate reflection that revealed construction of teacher knowledge. Individual interviews, focus group interviews, and other data sources confirmed and verified results reported in portfolios. These results can largely be

Table 1.  
Codes developed to distinguish data sources.

Source Origin	Data Source	Code
Preservice Teachers (PST)	Individual interview	PSTI
	Overview	PSTIO
	Focus group interview	PSTF
	Overview	PSTFO
	Lab notebook	LN
Artifacts file	Overview	LNO
	Weekly Evaluations: Question #: Date	WE: Q3: 9.4.96 ( <i>sample</i> )
	Final Examination: Question #: Response #	FE: Q4: 6 ( <i>sample</i> )
Field Notes (Researcher)	Portfolio: Artifact #: Response #	PF: 6: 1 ( <i>sample</i> )
	Overview	FN
Reflexive Journal (Researcher)		FNO
		RJ

sorted into 4 themes for the purpose of this report: (1) knowledge about self, autonomy, self-efficacy; (2) the importance of confidence and competence; (3) the importance of the value of content, coordinating lesson planning, and questioning; and (4) expanding knowledge about children, assessment, relevancy and group dynamics

*Knowledge about self.* Personal growth was revealed through reflective processes, such as the portfolio. Enthusiasm and patience were among those reported. Knowledge of self as a learner and as a teacher was important. At the end of the semester, the preservice teachers expressed the importance of the reflective process in tracking their growth and experiences.

Watching myself evolve into an educator who desires to be a constant learner has been one of the most important changes that have taken place during the semester (FE: Q4: 25).

*Confidence and competence.* Growth in confidence and competence were reported in the portfolios, the final exams, in weekly evaluations, and through interviews. The preservice teachers were continually encouraged to develop reflective thought as a tool for developing confidence and competence in teaching mathematics and science.

... my attitude toward teaching math and science. Now I know that the best way to teach these subjects is through discovery and exploration, connecting math and science to the real world is vital. I feel more confident about math and science as I enter student teaching (FE: Q4: 6).

This experience has been beneficial to my confidence as a teacher and a person in general. ... I have learned from my instructors that science and math must move away from worksheets and become hands-on, minds-on activities. The

children must be actively engaged in their learning. Children grow so much deeper when they have opportunities to discover for themselves (PF: 6: 1).

The summative evaluation task, a personal portfolio, required the preservice teachers to confront their own learning and the extent of that learning. Reflecting on previously recorded reflections over the semester was part of the process in the creation of portfolios.

I also feel that I have gained confidence in my knowledge of mathematics and science. I always enjoyed these subjects, but did not feel confident about my knowledge until now. This was such a valuable experience because I will carry this confidence with me during my teaching career (FE: Q4: 19).

I have always been afraid of math and science. I have never been good at either one because they were boring and abstract to me. Through this semester, I have learned ways to make math and science relevant, fun, and interesting. I now enjoy learning scientific things and events and look forward to teaching them (FE: Q4: 13).

*Expanding knowledge of the content.* Mathematics and science content learning was experienced as a group and individually. Many preservice teachers had previously had limited or no meaningful experiences with mathematics and science content. There were “Aha’s” while working as learners in content activities.

I really enjoyed the math we experienced today. I love math and I am excited to hear that it is not being taught the way I was taught (PSTWE: Q1: 4.9.1).

I learned how to explain math in a meaningful way (PSTWE: Q3: 12.14.3).

The preservice teachers had progressed from the lower levels of ability such as question-response

techniques, to a level of higher-order thinking skills. From there, they began asking open-ended questions to stimulate children's thinking and responses. Through reflection on their own deeper learning of the content, teachers identified the value of effective questioning as an important instructional strategy.

... go further than the teacher asking simple questions – have children ask questions and find their own answers (PSTWE: Q2: 3.9.2).

Today we worked with individual children who were having trouble with borrowing and subtraction. [The student] didn't really understand when to borrow and when not to borrow. I picked up that he wasn't understanding the concept with the way his teacher was explaining it to him. So I took a different approach and I could see that he truly understood the concept after I explained it. At this point, I could tell his confidence was boosted and he had more enthusiasm. Seeing his excitement made me feel great. I had actually taught him something. When we finished with the activity, he asked the teacher if he could work with me some more. I felt really special when he said that (PF: 6.4)!!!

*Expanding knowledge of pedagogy.* During individual interviews, preservice teachers were asked what they saw as the most important aspects about science/mathematics teaching that an elementary teacher should know. Responses suggested that teachers should work with the students using hands-on, real-world situations; make lessons relevant and challenging; realize that abstract concepts are hard; have more problem solving; know the students; act as a facilitator of learning; and integrate math and science, as well as other areas. Through reflection preservice teachers came to terms with their own attitudes toward mathematics and science, as was evidenced in the data.

I also feel that I have gained confidence in my knowledge of mathematics and science. I always enjoyed these subjects, but did not feel confident about my knowledge until now. This was such a valuable experience because I will carry this confidence with me during my teaching career. (FE: Q4: 19).

Now I know that the best way to teach these subjects is through discovery and exploration, connecting math and science to the real world is vital. I feel more confident about math and science as I enter student teaching. (FE: Q4.6).

Preservice teachers confronted their own learning and the extent of that learning through their summative portfolio assessment. The portfolios, along with the

reflective journals, indicated that these preservice teachers attributed the following types of learning to interacting with mathematics and science lessons: content knowledge; the importance of hands-on manipulatives; relevancy; instructional strategies; group dynamics; and student cognitive attributes, abilities and levels. Instructional strategies were identified and implemented, including effective questioning, timing, lesson planning, classroom management, preparation, and authentic assessment. This collaborative interaction was a relevant, authentic learning environment for preservice teachers. Through reflection, preservice teachers were able to track, evaluate, and project their learning.

The researcher in this study also used other modes of reflection. A reflexive journal was maintained to record the researcher's learning, decision-making processes for data collection, analysis, in report writing, and in the embellishments of the field notes, interviews, and others.

In this study, reflection was a binding thread for all the experiences of the preservice teachers. Reflective practices allowed the professors and preservice teachers to actively assess, evaluate, and modify the learning experiences. Data indicate that through reflective practices, preservice teachers had a greater sense of self, autonomy, self-efficacy, confidence and competence in teaching mathematics and science, and had incorporated the value of reflection into their belief system. These research findings promoted the implementation of reflective practices used here into other teacher education courses. Inservice teachers have provided similar reports in graduate classes of valuing the use of reflective teaching. From this study many strategies emerged that were effectively used to promote reflection.

### **Best Practices**

Over time working with these emerging "best practices", I've seen that a belief in the importance of reflection and strategies for becoming a reflective mathematics teacher are developed and progress through three levels: understanding reflection; implementing reflective practices; and developing a reflective venue. In this section, I will share the strategies used and developed in situations such as those in the above research, to illustrate ways to utilize this three-level plan to promote reflective teaching.

### *Level One: Understanding the Importance of Reflective Thinking*

Understanding prior knowledge and beliefs provides a foundation for becoming a reflective teacher. Teachers are encouraged to explore the meaning of “reflection” by actually negotiating an operational definition individually, in small groups, and in whole class discussion.

#### *Prompts for Defining Reflection*

- *Write your own definition of “reflection”.*
- *What do you perceive as “reflective teaching”?*
- *In your group, discuss your responses.*

Once common ground is established teachers are asked to put reflection into action. Reflecting on past experiences, prior knowledge, and expectations helps to provide more insight into a teacher’s current perspective on teaching and learning mathematics. Teachers are asked to write an autobiographical sketch that visualizes their own perspectives as a learner and as a teacher.

#### *Reflecting on Mathematical Experiences*

- *What were your experiences with mathematics at school/home/other? What kinds of instructional activities and practices did you experience?*
- *Describe any influential teachers, either positive or negative.*
- *What are your preferred learning strategies? What do you do to learn? What do you enjoy learning? How did you come to be like this? What stories reveal your roots as a learner?*
- *What does this mean for your current instructional strategies? What is (are) your teaching styles/instructional strategies? How might you do things differently?*
- *How do you envision mathematics learning for my students?*

To validate these reflections, teachers share their thinking in a safe, collaborative group situation only to uncover common attitudes, apprehensions, and beliefs about mathematics. Large group discussion offers an even greater opportunity to connect with peers and to deepen reflective thinking.

Many preservice and some inservice teachers are not excited about teaching mathematics. A teacher’s perception of the nature of mathematics greatly influences the mathematics instruction and learning environment in the classroom (Cooney, 1985; Hersch, 1986). The following exercise challenges teachers to come to terms with their own perspectives of

mathematics teaching and learning. Charged with the task of developing a statement of the nature of mathematics, teachers are encouraged with these writing prompts.

#### *Developing a Perspective of the Nature of Mathematics*

- *What is mathematics? What is the nature of mathematics?*
- *What are the components of mathematics?*
- *What is the conception of mathematics that you believe is important for your students to know?*
- *What mathematics do you want your students to learn?*

The resulting statements are shared in small groups and then in the large classroom group. This initial draft is revisited periodically to modify and enhance. At the end of the semester, each teacher reviews the first draft, revises, re-writes, or edits as they deem appropriate to complete a final draft to submit. Along with this final draft, teachers submit a “reflective rationale” for any changes that were made in the process. Teachers explain and justify any changes. This allows for growth and clarity of reflective thought and teaching. Teachers need time to “reflect” on the value, complexity, and beauty of mathematics and teaching mathematics.

### *Level Two: Implementing Reflective Strategies – The Reflective Cycle*

The revelations from Level One create a foundation for implementing the power of reflection into practical classroom applications. Experiences in my undergraduate and graduate classes are created for both field-based preservice and inservice teachers to put reflection into active classroom interaction. These exercises, presented and elaborated below, have successfully enabled teachers to begin reflective thinking and teaching practices. They form a cycle of reflective activity.

This reflective cycle includes reflective planning, reflective teaching, and creating a guided reflection. Teachers use prompts individually and then in small groups for self-questioning. Teachers write responses to establish a thinking routine. Small group discourse is used to facilitate reflective thinking practices. As more experience in reflective thinking and teaching develops, many of these become automatic, and the cycle begins to feed upon itself.

*Reflective planning.* A strong emphasis is placed on the first phase of this strategy, reflective planning. Efforts involved in this area appear to benefit all areas of reflection. Teachers are asked to carefully and

thoughtfully respond in depth to three components of planning (the lesson, the learner, and the teacher).

### *Reflective Planning*

#### *The Lesson*

- *What is the content or topic and what prior reasoning, strategies, and thinking skills are expected?*
- *What learning venues are required for learner success? (e.g., communication and representations)*
- *What are expected outcomes?*

#### *The Learner*

- *What are the goals for the learner?*
- *What are some of the possible misconceptions?*
- *How will the learner be assessed?*

#### *The Teacher*

- *What must be done to plan and organize?*
- *What are the most effective strategies and questions? (Write some examples.)*
- *What are expected outcomes? What modifications are anticipated?*

Teachers proclaim this initial step in reflective teaching prepares them for teaching a better lesson by creating competence and confidence.

*Reflective teaching.* Reactive reflection or reflection in action is sometimes quite difficult if not impossible to recall after the events. However, reflection here is crucial. Experienced teachers have a rich repertoire of exemplars from which to choose when confronted with problematic situations in the classroom. Experienced teachers may demonstrate an uninterrupted flow of teaching easily adapting to the unexpected. As more classroom experience is gained, novice teachers develop their own similar resources. Why was this done? What questions prompted the course of the teaching and learning? Making mental notes may be all that is possible to do. However, written notes are very effective. Periodic video or/and audio taping of teaching lessons can also be a valuable reflective tool for all teachers and is especially revealing for preservice teachers.

In addition to taping teaching sessions, another best practice for reflection in action for preservice teachers involves using small groups. Groups of three to four preservice teachers are created as teaching teams to experience all facets of classroom teaching. Team members are able to collectively recall more of the events and sequences that occurred. Some teams even record notes or use the taping strategy for later debriefing. As the semester progresses and a well established reflective teaching routine is rooted, the

teams diminish from four members to individual efforts as confidence and experience grows. The following are the prompts used as the basis for encouraging reflective teaching and frame informal assessment of learning interactions. While instruction is occurring, teachers try to keep these items in mind.

### *Reflective Teaching*

- *Are the students on task?*
- *Do the students appear to understand the concept? If not, what are my alternatives/resources for actively adapting and modifying?*
- *Are my instructional strategies appropriate for all students?*
- *What are my expected outcomes?*
- *What modifications are needed for re-teaching?*

*Guided reflection.* Post-teaching reflection allows the cycle of reflection to continue and helps teachers develop a greater repertoire of learning experiences. Too often, teachers are not encouraged to reflect due to time constraints. Time for reflection is imperative for developing teacher knowledge in novice teachers and in furthering the depth of knowledge for experienced teachers. By looking deeper into the learning interaction, going beyond the superficial, reflection provides teachers with insight into their teaching successes and failures. Reflection affords teachers the opportunity to select best practices for specific contexts and specific students. In methods course experiences, debriefing after teaching with preservice teachers is an extremely valuable strategy. Debriefing for inservice teachers may be achieved in collaborative efforts within graduate classes or with colleagues in schools.

Developing an individual system of responding to the prompts discussed next is important. These prompts are similar to the ones initially addressed in the reflective planning section and have been used to begin classroom debriefing experiences for teachers, but notice the additional aspects addressed here. Teachers are asked to use specific examples from their teaching experiences to support, clarify, and elaborate responses.

### *Guided Reflection*

*Write a guided reflection.*

#### *The Lesson*

- *What were the goals of the lesson?*
- *What did you do to make this lesson relevant?*
- *What changes did you make in the flow of the lesson? Why and when?*

- *What strategies (if any) were used for remediation?*

*The Learner*

- *What questions were asked, how did you respond, and why were they asked?*
- *If no questions were asked, reflect and respond to this.*
- *What motivated student learning the most and why or why not?*
- *What did you learn about students' prior understanding and approaches to the content?*

*The Teacher*

- *How did you motivate and keep the learners on task?*
- *What type of questioning did you use?*
- *How did you assess the students' learning and the success of the lesson?*
- *What would you do differently? How and why?*

*\*Add other "teacher thinking".*

Expert teachers may regard many of these reflective questions as normal components of classroom instruction. It is important, however, for all teachers to view these strategies in a new light. Learners are better served, as reflection becomes a habit of mind for teachers. Devoting valuable time to writing post-teaching reflections is a positive action towards becoming a reflective teacher. Reflective teaching has the potential to directly impact instruction and student achievement. This, in turn, reveals the power of reflective thinking and teaching.

*Level Three: Developing a Reflective Venue*

Journal writing is a popular instructional strategy for teachers to use in the classroom with students. Often teachers overlook its value as a reflective tool for teaching. To initiate and maintain a professional reflective journal in teaching is quite rewarding. Once preservice and inservice teachers develop through levels one and two, level three offers teachers an opportunity to develop a practical and individualized approach to reflective teaching. Reflective journal entries enable teachers to track thinking and learning, to evaluate these processes, and to improve teaching. Entries are more than recording and reporting events. They are visions of teaching and learning experiences recreated through thinking, feeling, and intuition. Establishing a journal writing routine is revealing and rewarding.

Effective reflective journal writing provides evidence of and documents the details of how teachers plan, prepare, execute, and evaluate the teaching and

learning tasks. It encourages goal setting and documents the process as well as the products of the teaching experience. Teachers think about their own learning and understanding of the subject matter. Journals are the venue for implementing the reflective teaching strategies advocated in this discussion. Teachers are encouraged to begin journal entries at the beginning of the semester by addressing the prompts on reflection, on prior experiences in mathematics, and on mathematics and teaching from the first of this discussion.

As reflective journal writing becomes a natural part of teaching, teachers may find a free response format more appropriate. This format is also encouraged as a basic venue, since journal writing can be quite overwhelming for novice teachers.

*Free Response Format*

- *What did the class do today?*
- *What did I expect students to learn?*
- *What did I learn?*

*Give some thought to what you and the students learned from the activities. A brief description of what was done in class that day helps to reflect on the learning. Was it relevant? Too easy? Too hard? What did you learn about mathematics, about teaching, about students, and about yourself?*

Levels one and two, understanding the importance of reflective thinking and implementing reflective strategies, are core components of both my undergraduate and graduate courses. Reflective practices are used with preservice teachers as they plan mathematics lessons to be taught in an elementary, field-based context during a semester-long, mathematics methods course. Inservice teachers practice these same exercises with their own mathematics classrooms, and then report insights in the context of their university-based graduate methods course. As time and classroom experience progresses, teachers find individual and unique ways to use journal writing as a reflective tool to improve instruction and to increase student understanding and achievement.

**Reflective Summary**

Although the role of reflection in teaching is considered important, reflective action in teachers is inhibited often by isolation of teachers or by the structure of courses and schools. The promotion of reflection should begin early in preservice experiences and with novice teachers (Artzt, 1999). Expert teachers are encouraged to share reflective practices with colleagues. Research findings confirm that the

likelihood of long-term success for many novice teachers is hindered by the absence of expert guidance, support, and opportunities to reflect (Veenman, 1984). Through reflective teaching, all teachers acquire critical skills in determining the value of instructional strategies, in assessing students' mathematical understanding, and in developing curricular knowledge. School administrators, teacher educators, and expert teachers play pivotal roles in supporting the development of reflective teachers.

Successful classroom experiences of preservice and inservice teachers demonstrate the value of reflective teaching. Reflective teaching practices promote greater student achievement and success in the classroom. Benefits from reflective teaching include increases in confidence, autonomy, and self-efficacy for teachers (Lowery, 2002). More effective questioning techniques – such as use of those that promote higher order thinking skills and use of open-ended questions – are employed, and classroom discourse is enhanced. Reflection allows teachers to judge mathematics grade-level appropriateness, to assess student abilities, to evaluate the use of motivational techniques, and to design appropriate and challenging mathematical learning activities. Reflective teaching is an essential skill for teachers and is a powerful component of successful teaching (Goodell, 2000; Mewborn, 2000).

The power of reflection that blossoms from implementing reflective strategies strengthens the teaching and learning of mathematics. However, time is a critical factor. Time spent on developing reflective thinking and teaching is time well spent (Artzt & Armour-Thomas, 1999). The depth of understanding revealed in reflective teaching, the resulting improvement in instruction, and the ultimate growth in student learning far surpasses the initial sacrifice of time. Admittedly, this discussion asks for a lot from teachers. Yet, the best practices that have been presented here have merit. Teachers, preservice and inservice alike, have reported gaining much from reflective practices (Lowery, 2002). Reflective teaching in mathematics reaps incredible rewards. Inservice teachers report having taken the next step in promoting reflective practice by their mathematics students. Having students develop reflective perspectives on learning mathematics is promoted in the NCTM's (2000) principles and standards. Students benefit by reflecting on their own learning to make sense of mathematics. Reflection is a crucial component that must be incorporated into every teacher's toolkit of instructional strategies at all levels

of mathematics instruction and learning. To provide quality instruction and to increase student success and achievement in all classrooms, the basic three "R's" must include a fourth—Reflection.

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<sup>1</sup> I choose the word *constructivist* here to represent perspectives that learning is constructed by a learner who is developing new knowledge, based upon as well as

accommodating prior knowledge. The following selected passages may help to make evident what a constructivist learning approach means, for me as the teacher with the intent to create such a classroom:

Constructivism is not a theory about teaching. It's a theory about knowledge and learning. Drawing on a synthesis of current work in cognitive psychology, philosophy, and anthropology, the theory defines knowledge as temporary, developmental, socially and culturally mediated, and thus, non-objective. Learning from this perspective is understood as a self-regulated process of resolving inner cognitive conflicts that often become apparent through concrete experience, collaborative discourse and reflection (Brooks & Brooks, 1993, p. vii).

The constructivist viewpoint of learning supports reflective thought (Frid, 2000).

Prior knowledge influences knowledge construction. As a reflective tool, constructivism enables teachers to design appropriate learning activities, promotes higher levels of thinking about educational problems (reflection), and leads to questioning, and the construction of more knowledge (Tobin, Tippins, & Gallard, 1994).

<sup>2</sup> Here, I refer to the vision for teaching and learning set forth in the National Council of Teachers of Mathematics *Principles and Standards for School Mathematics* (2000).