CHAPTER 8

Gathering and Making Sense of Information

We described a number of creative and novel learning experiences for teachers in the previous chapters, but some traditional learning experiences still have much to contribute to teacher learning. Indeed, in several of the illustrations reported in the previous four chapters, participants read articles or listened to presentations. In this chapter, we show how teachers can benefit from these as well as other forms of data gathering and sense-making, including action research, as a main venue for learning. More specifically, we will examine ways in which teacher education informed by a constructivist paradigm can facilitate teachers' learning *from and with* texts, videos, presentations, and even data they have gathered in their own research.

Theoretical rationale and empirical support

Having teachers listen to experts' presentations and doing assigned readings has been the preferred mode of professional development so far at both pre-service and in-service levels. Interestingly, however, not much research documents the effects of these learning modes on teachers' knowledge, beliefs or practice.

Nevertheless, gathering and making sense of information continues to be a valuable tool for teachers and any other learners. This mode of learning can become an integral part of constructing a personal understanding of issues and theories that are at the core of school mathematics reform. Indeed, readings, presentations, and data collection and analysis can all contribute to teacher education although they may take on different forms and purposes when informed by a constructivist perspective.

Recent research on reading, in particular, can help us begin to reconceptualize how *making sense of information* can become an active and socially constructed process. Reading researchers have argued that

reading does not need to occur as an isolated, or even individual, activity (e.g., Harste & Short, 1988). First, reading should be purposeful. In other words, teachers should read either to address questions that *they* feel the need to know more about or because their concerns could not be resolved through discussion. Reading can also be a catalyst for other experiences. Indeed, reading can fulfill many functions while teachers inquire into any topic (Siegel, Borasi & Fonzi, 1998). Readings can provide background information, raise questions for further inquiry about a topic, synthesize different points of view, and offer models for teachers' own practice. Research also teaches us that reading is not a passive or straightforward matter of decoding or extracting information from text (e.g., Pearson & Fielding, 1991; Rosenblatt, 1994). Rather, readers always construct meaning in interaction with the text, their own background and interests, and their purposes for reading the text. Furthermore, such construction of meaning can be even more productive when it is augmented by interactions with other learners, so that different interpretations can be shared and discussed.

Action research thus offers an ideal way for teachers to learn more about teaching and learning mathematics and to apply the results immediately to their own practice.

Reading researchers also argue for expanding our notion of what constitutes a text (e.g., Bloome & Egan-Robertson, 1993; Green & Meyer, 1991), noting that the principles of reading outlined above also hold true for other "texts," such as videos, presentations or electronic media. Indeed, teachers can benefit from actively constructing and negotiating meaning not only through written texts but also videos they watch together or independently, information they gather on the Internet or presentations made by an expert or a colleague.

In addition to benefiting from information others provide, teachers can gather their own data to illuminate issues of particular interest to them. Teachers can gain from participating in many forms of research, but "action research" is especially promising as a form of professional development (Holly, 1991; Eisenhower National Clearinghouse, 2000). Action

research is defined as "an ongoing process of systematic study in which teachers examine their own teaching and students' learning through descriptive reporting, purposeful conversation, collegial sharing, and reflection for the purpose of improving classroom practice" (Eisenhower National Clearinghouse, 2000, p.18). Action research thus offers an ideal way for teachers to learn more about teaching and learning mathematics and to apply the results immediately to their own practice, although conducting full-blown action research studies is not the only way that teachers can benefit from gathering and analyzing classroom data.

Illustration 9: Using a variety of resources to rethink the teaching and learning of geometry in middle school

The experience captured in this illustration took place in the Leadership Seminar that was one of the components of the Making Mathematics Reform a Reality (MMRR) project we described in Chapter 2. After several teachers had participated in the first year of the program, they wanted to make more radical changes in their teaching. During the first year, they had attended a Summer Institute introducing them to an inquiry approach to mathematics instruction and then implemented an illustrative inquiry unit on either tessellations or area in their own classrooms. Their experiences with the tessellation and area units made them aware of the inadequacy of traditional approaches to teaching geometry in the middle school curriculum. Although they felt that the next logical step would be to revise their school's geometry curriculum, they were not sure how to proceed. In the usual process for rewriting curriculum, teachers sat around a table, and based on the current textbook, discussed what contents should be covered at each grade and how. The teachers suspected that this process might at best eliminate some repetition in the existing curriculum, but that it was not likely to help them reconceive the entire middle school geometry curriculum.

After some lead teachers shared these concerns in the Leadership Seminar, the facilitators decided to use this opportunity to lead the group in a systematic rethinking of the teaching and learning of geometry in middle school. Such an experience could serve as a model for lead teachers interested in replicating a similar process with colleagues in their own school. An even more important goal for this experience, however, was to familiarize the lead teachers with the resources offered by relevant

research studies and exemplary instructional materials, so they could use these resources well in the future.

The group inquiry started with a few readings about geometry. As a homework assignment, participants read two mathematical essays from the book *On the Shoulders of Giants* (Steen, 1990). One essay focused on the concept of "Shape" (by Senechal) and the other on "Dimension" (by Banchoff). As part of the same assignment, participants reviewed the NCTM Standards (1989) for geometry in middle school.

In the group discussion that resulted, the lead teachers analyzed the meaning and rationale of each of the NCTM geometry standards in light of the "big ideas" of geometry presented in the two essays. This discussion enabled participants to enhance their understanding of the mathematical concepts presented in the two essays and to consider implications for instruction. For example, some teachers said they found it very helpful to think of geometry as the study of "shapes," especially as they had come to realize the connection between the geometric properties of a shape and its possible functions. This realization helped them frame in a more meaningful way the study of geometric figures for their students. It also helped them change their instructional goals because they agreed that students should learn strategies for identifying the attributes of any geometric figure, not just memorize a pre-established set of properties for a few standard figures.

Although very helpful, this activity did not immediately result in a plan for what to teach about geometry, and how, at different grade levels in middle school. The facilitators then suggested that the group look at the choices made by two of the comprehensive middle school math curricula funded by the National Science Foundation, the *Connected Mathematics Project* and *Mathematics in Context*. In both cases, groups composed of mathematicians, mathematics educators, and teachers had grappled for years with the same question: What should students learn about geometry in middle school? The facilitators argued, then, that the group should capitalize on all the thinking that had gone into the development of these exemplary curricula.

However, it turned out to be difficult to extract from the curricula the choices that the authors had made about what geometry content to cover and how, and the rationale for these decisions. Although the background materials accompanying each of these curricula did address, to some extent, these choices and how they were made, the information was not

specific enough for the group. It soon became clear that the group needed to examine the individual geometry units in each curriculum.

To make this task less daunting and time-consuming, the group divided up the responsibilities. Each participant, including the facilitators, agreed to review one or two units from each curriculum to identify what was taught and how and to present their findings to the group. To ensure consistency, the facilitators proposed some guidelines for the review and report on each unit and then modeled a presentation.

A 3-hour session was then devoted to the geometry unit presentations. To get a sense of how topics in each curriculum were sequenced, participants presented the units in the order they were intended to be taught. As each unit was presented, a facilitator recorded on newsprint the key ideas about geometry that the unit addressed. At the end of the presentations, the teachers had a detailed list of the geometry content that each curriculum covered.

The group then compared these lists to identify similarities and differences between these two Standards-based curricula and the traditional middle school geometry curriculum. Many teachers were amazed at the richness of the lists describing the new curricula when compared with the traditional middle school math curriculum. They were struck especially by the emphasis in both of the new curricula on three-dimensional geometry and spatial visualization, topics they rarely covered but that were highlighted in the geometry essays they had read. On the other hand, they were puzzled by the presence of some new topics, such as Euler's formula and graph theory in the *Mathematics in Context* curriculum.

The facilitators then suggested they seek a mathematician's help to examine further the relative importance of the topics on the lists. The facilitators met independently with Dr. Sanford Segal, a research mathematician on the faculty at the University of Rochester, to share the group's lists and ask whether he felt comfortable commenting on the mathematical significance of the topics listed. They also shared some information about the group's background and goals to help him prepare his contribution.

Dr. Segal then joined the group for a 2-hour session in which he presented his comments on the relative importance of items on the lists from a mathematical stand-point, and then he answered questions. His presentation and the follow-up discussion further confirmed the critical role of spatial visualization in mathematics, and hence the importance of

developing this skill in middle school through appropriate learning experiences. On the other hand, Dr. Segal's personal position on the relative importance of graph theory and transformation geometry challenged the need to introduce these topics at the middle school level.

Overall, all participants, facilitators included, emerged from this inquiry with a much deeper understanding of what the "big ideas" in geometry are and a greater appreciation for the complexity of making good choices about mathematics content at any grade level.

Illustration 10: A teacher's action research on her own biases

We adapted the illustration in this section from a teacher's personal account of her eye-opening experience with action research (Wickett, 1997). Her experience took place in the context of the NSF-funded Equity in Mathematics Education Leadership Institute project (also known as the EMELI project).

In a workshop on equity issues, this teacher learned about the empirical evidence showing that teachers call on boys more often than girls in mathematics classrooms. She became interested in exploring whether she, too, had some unrecognized biases in the way she called upon students in her class. She feared such biases might impede her goal of providing equitable access and support to *all* her students.

While the focus of her action research was clear, she struggled with the decision of what kind of data to gather. She searched for a systematic way to examine her classroom practices that would not make her self-conscious and unduly influence her daily practice. After rejecting, for various reasons, the options of audiotaping or videotaping some of her classes, she decided to examine the charts that she routinely created to record students' contributions in a mathematical discussion. As it was her practice to create these charts by writing down each student's contribution verbatim, followed by the student's name, these existing records were indeed ideal to address her question.

Her analysis of the charts created over several weeks revealed some interesting and surprising patterns. While there was not much difference in the numbers of girls and boys she called on, she noticed that she tended to call on the boys first. She also noticed that she usually included students with limited English proficiency only toward the end of the discussions. The teacher describes these findings as "upsetting" to her because they suggested unconscious biases in her behavior.

These finding led to the teacher reflecting on the *reasons* she called on students in a mathematical discussion and the potential *implications* of these instructional choices for her students' learning opportunities. She realized that she tended to call on certain students first because she expected their contributions to be catalysts for other students' ideas; she was also hesitant to call on students until they volunteered, and some students (especially students with limited English proficiency) tended to do so only later in the lesson, if at all. Despite these reasonable justifications, she concluded that her current practices were not truly giving all students equal opportunities to participate in her mathematics classes. She decided to try to change these practices.

To make sure that she gave all students an equal opportunity to answer first, she made a conscious effort to pause before calling on students during a mathematical discussion. Whenever possible, she asked other adults in the class to write down the students' responses so that she could pay more attention to facilitating the discussion and to asking questions that could invite more students to contribute. To encourage more students to share in a large group, she also successfully experimented with the use of "dyad." In this technique, each student has the opportunity to express his or her thoughts to a partner without interruption; each partner is allotted an equal amount of time and students may choose to use their primary language.

The teacher reports feeling empowered by this process. She was able to make positive changes in her classroom practice that resulted in better learning opportunities for her students. At the same time, she had done it at her own pace, taking only the steps she felt comfortable taking at the moment. She sums up her experience in this way:

> I had enough information that I could make positive changes yet not so much information that I felt overwhelmed and defeated. … By looking at my practices honestly and without condemning myself, I began the process of recovery and change. … I was able to remain open, freeing myself to try new ideas with my students' best interests in mind. (Wickett, 1997, p. 104)

Main elements and variations

Teachers can gather and make sense of information in many different ways. In the illustrations in this chapter, we highlighted the following elements common to gathering information and making sense of it:

- ***Teachers gathered information for a purpose.*** In other words, teachers gathered data and evaluated it to address a felt need or answer a question they had posed themselves.
- ***Teachers actively made sense of the information.*** Teachers engaged in hands-on interpretation of data, readings or presentations in each activity we reported.
- ***Teachers made sense of the information in interaction with others.*** In all the activities, teachers at some point negotiated interpretations and made meaning with peers, facilitators and/or experts. Through this process, they benefited from different perspectives and others' constructions of meaning.

Despite these common elements, professional development experiences in which teachers gather and making sense of information can be quite varied. This was already evident in our two illustrations, and many more variations are reported in the literature. Indeed, the professional development experiences examined in this chapter can be seen as a "collection" related by the fact that each example explicitly engages teachers in learning from and with information of various kinds.

Variations within this collection mostly depend on the *source of the information, how the information is gathered*, and *how the information is examined and used.*

As we consider the first variable, the *source of the information*, the following possibilities should be considered, as they can all present valuable learning opportunities for teachers:

- ***Lectures or presentations.*** These can be offered by an expert, such as the mathematician in Illustration 9, a more experienced colleague, or even another member of the group. In Illustration 9, for example, each participant contributed a unit presentation.

- ***Published texts.*** These could include for example articles, books, textbooks or curriculum series. All these resources were used in the inquiry on the geometry curriculum reported in Illustration 9.
- ***Texts produced by other members of the learning community.*** These texts could be created by a facilitator, individual teachers or even the group as a whole. The list of key geometry ideas the group generated based on the unit presentations in Illustration 9 is a good example of this kind of text.
- ***Videotaped excerpts.*** These could capture examples of classroom practice as well as other events related to school mathematics reform.
- ***Materials available in electronic form.*** These could include CD-ROMs, information gathered from the Internet, and even data available in electronic databases.
- ***Various kinds of artifacts.*** These could have been generated in classroom implementations (such as student work, lesson plans or the "discussion charts" used by the teacher in her action research reported in Illustration 10), or in other reform-related experiences (such as agendas or minutes of important meetings, policy documents, etc.).
- ***Various kinds of data.*** These data could be the results of the teacher's own observations or analysis of artifacts and/or demographic information (such as the number of times and the sequence in which different categories of students were called upon in the teacher's classroom, as transpired from her analysis of the discussion charts in Illustration 10) or data available in the research literature or other sources (such as the data about boys being called on more than girls in mathematics classrooms that the teacher in Illustration 10 read about prior to her own action research).

Each source of information listed above may convey some informational content better than others. Also, different kinds of activities may be more appropriate than others for making sense of information conveyed from these different sources.

A second source of variation in this kind of professional development is *how the information examined was gathered*. This can happen mainly in two ways:

- The *facilitator* selects the information and makes it accessible to the participating teachers.
- The *teachers* themselves gather the information, following some directions or guidelines set by the facilitator.

The first option is often the preferred one because it saves teachers valuable time. Teachers also benefit from the facilitator's expertise. However, there is value in empowering teachers to gather their own information, at least some of the time. Whether they search the library, browse the Internet, or collect their own data, teachers can learn skills that will serve them in the future as they research issues independently.

Finally, this type of professional development varies according to *what is done with the information*. Since the options in this case are too many and too context-dependent to list, we will simply refer readers to the two illustrations featured in this chapter for some examples. We would like to point out, however, how reading and conducting action research seem greatly enhanced when they occur in conjunction with other activities in summer institutes, workshops or study groups, rather than in isolation.

The role played by the professional development provider in this type of experiences may appear to be less central, yet it is by no means unimportant. Professional development providers can serve as invaluable resources for participants as they gather and make sense of information. Moreover, providers can be very influential in framing and guiding these activities and in connecting them to other parts of the professional development program. Depending on the content and format of the information gathering activities, providers may require different kinds of expertise in order to be effective.

Teacher learning needs addressed

When presented as a purposeful, active and social process of meaning-making, gathering and learning from information has the potential to address many of the teacher learning needs we identified in Chapter 1. Of course, the content and source of the information, and even more

importantly, how it is used, determine the extent to which specific teacher learning needs can be addressed in any implementation of this kind of professional development experience:

- ***Developing a vision and commitment to school mathematics reform.*** Developing a vision and commitment to school mathematics reform requires an understanding and appreciation of what such reform calls for and its rationale. Therefore, readings and presentations that explain each recommendation for mathematics reform and that review research supporting these recommendations can address this teacher learning need. When teachers also have concrete opportunities to draw implications from this information for their own practice, the benefit is even greater. Videos and stories of reform-oriented mathematics classrooms can also provide images of what reform is really about. Hearing the success stories of more experienced teachers may also motivate some teachers to attempt instructional innovation in their own classes.

- ***Strengthening one's knowledge of mathematics.*** While reading mathematics texts should not be the primary vehicle for teachers to learn new mathematics, this mode of learning has valuable potential if approached correctly. It should, for example, occurs in combination with, not as an alternative to, other experiences. For example, videos or multi-media materials that take advantage of computer animation can help teachers visualize and thus grasp specific mathematical concepts more clearly. Also, by reading mathematical essays on key mathematical ideas (as those used in the inquiry on the geometry curriculum reported in Illustration 9) or on the history and philosophy of mathematics, teachers can learn not only new mathematical content, but perhaps more importantly, begin to rethink their beliefs about the discipline of mathematics.

- ***Understanding the pedagogical theories that underlie school mathematics reform***. To understand the theories of learning and teaching that inform school mathematics reform, teachers need readings and presentations that explain and critically examine these theories. The effectiveness of this kind of information, however, depends to a great extent on the experiences organized to help teachers make sense of this information. For example, teachers are

likely to perceive the information as more relevant if it is connected to experiences-as-learners or videos of mathematics lessons that exemplify some of the same or principles of learning and teaching.

- ***Understanding students' mathematical thinking.*** Reading research on students' thinking about specific mathematical topics can aid teachers in making sense of their own students' work. Again, however, these readings are most effective when they are explicitly connected to other professional development activities, such as analyzing student work around the same mathematical topics addressed in the readings. In addition, by conducting their own action research studies, teachers can enhance their understanding of the results in other studies, or they can even contribute new results in less-researched topics. Conducting such studies also helps teachers develop their skills in listening to students and interpreting their work.

- ***Learning to use effective teaching and assessment strategies.*** Readings and presentations alone are not likely to help teachers teach more effectively. However, watching video excerpts of other teachers modeling innovative practices can be quite powerful in helping teachers understand what they need to do. Action research in which teachers monitor and evaluate their own practice can also help teachers as they begin to try out new teaching and assessment practices in their classrooms.

- ***Becoming familiar with exemplary instructional materials and resources.*** Exemplary instructional materials have the potential to greatly support teachers in implementing high quality instructional innovation in their classes, but only if teachers know what is in them and how they can find that information. Because most of these resources provide much more information than traditional textbooks and have a non-linear structure, teachers need guidance in using the materials effectively at the beginning. Presentations about the origin and structure of the exemplary materials, followed by modeling of how to navigate them, may be very helpful for teachers as they are first introduced to these materials. Reading *from* and *about* the exemplary materials is essential for becoming acquainted with these resources. In addition,

to understand what the materials require of students, teachers often have to do the mathematical tasks themselves first.

- ***Understanding equity issues and their implications for the classroom***. Readings and presentations about issues of diversity and equity can be valuable catalysts for discussing what it means to teach *all* students equally. Action research may be an even better way to meet this teaching learning need, as Illustration 10 shows. By researching their own practice, teachers can become aware of their own biases and prejudices, investigate the impact and implications of equity issues in their own classrooms and schools, and monitor their efforts toward more equitable teaching.

- ***Coping with the emotional aspects of engaging in instructional innovation.*** Stories of other teachers engaged in reform may help teachers headed in that direction to recognize in advance emotions they are also likely to experience. This kind of information can help teachers set realistic expectations and perhaps even suggest strategies to deal with the inevitable "emotional roller-coaster" that accompanies most first attempts at instructional innovation. An even more powerful variation on this type of professional development activity is hearing directly from teachers they know and being able to converse with them.

- ***Developing an attitude of inquiry toward one's practice.*** Engaging in any form of action research can contribute very effectively to addressing this teacher learning need. By definition, action research means that teachers systematically inquire about specific aspects of the teaching and learning of mathematics in their own classrooms.

Summary

Our analysis of information gathering and interpretation as a type of professional development activity confirms the value of more "traditional" professional development experiences, such as reading articles and hearing presentations, for teachers involved in school mathematics reform. As we stress in this chapter, however, these experiences need to be purposeful, engage teachers actively, and provide opportunities to share and discuss information with others. They should be combined with other

activities that encourage teachers to use information to draw personal implications for their own beliefs and practices. Various forms of data collection and analysis, and action research in particular, can also enable teachers to gain valuable and relevant knowledge and skills that help them become reflective practitioners and life-long learners.

Suggested follow-up resources

With a notable exception in the case of action-research, there are few published materials to support teacher educators in designing and orchestrating professional development experiences within this category – perhaps because gathering and making sense of information is often not even considered as a professional development strategy for which materials, or even guidance, is needed. For teacher educators interested in promoting and supporting action research we recommend the following resources, which describe methods and approaches to conduct sound action research in educational settings:

Calhoun, E.F. (1993). Action research: Three approaches. *Educational Leadership 51* (2), 62-65.

Sagor, R. (1992). *How to conduct collaborative action research*. Alexandria, VA: Association for Supervision and Curriculum Development.

Loucks-Horsley, S., Harding, C.K., Arbuckle, M.A., Murray, L.B., Dubea, C., and Williams, M.K. (1987). *Continuing to learn: A guidebook for teacher development*. Oxford, OH: National Staff Development Council.