Teachers' Perspectives on Mathematics Education Research Reports

Abstract

Practicing teachers' perspectives on a set of mathematics education research reports are described. Data were gathered through e-mail messages, group discussions, and questionnaires. Teachers identified positive influences of research on practice aligned with some of the strands of proficient mathematics teaching identified by Kilpatrick, Swafford, and Findell (2001). Teachers also gave negative critiques of the ability of research to influence practice aligned with Kennedy's (1997) discussion of historical factors underlying the gap between educational research and practice. The variety of perspectives documented provides some empirical ground for informing actions in the areas of teacher education and research.

Keywords: Inservice Teacher Education; Mathematics Education Research; Research Dissemination; Research-practice relationship; Teacher Education; Teacher Beliefs.

Educational research has recently been the target of much criticism for its failure to influence teaching practice (Hargreaves, 1996; Lagemann, 2000). In the mathematics education community, several have written with concern about the existing gap between research and practice. Steen (1999) pointedly stated, "Research has had essentially no impact on the practice of mathematics education" (p. 240). Malara and Zan (2002) noted that, "within the mathematics education community, it (research) tends to be treated as a purely scientific discipline with no connection to social reality and the most urgent needs of teachers" (p. 554). Bishop (1998) expressed a related concern about the "dangers of researchers just talking to each other, and thereby ignoring the practical concerns of teachers" (p. 34). Addressing these concerns is becoming increasingly urgent as calls have recently been made for teachers to implement "evidence-based" or "research-based" practices (Davies, 1999; U.S. Department of Education, 2002).

Several have stated that researchers themselves have partially caused the disconnection between research and practice in mathematics education. Silver (2003) argued that more mathematics education research studies should arise from practitioner-generated questions. Bishop (1998) stated, "Researchers need to take far more seriously than they have done the fact that reforming practice lies in the practitioner's domain of knowledge. One consequence is that researchers need to engage more with practioners' knowledge, perspectives, work and activity situation" (p. 36). Lester and Wiliam (2002) suggested that mathematics education research will only strongly influence practice when teachers play active roles in the creation of research questions and the design of investigations. All of these recommendations for bridging the gap between research and practice contain the common element of urging researchers to pay more careful attention to the perspectives of practicing teachers.

Unfortunately, within the ongoing academic discussion of reconciling research and practice, the voices of practitioners who engage in teaching but not in formal research are usually not heard. Part of this can be attributed to the fact that many practitioners not engaged in research do not read mathematics education research reports because they see them as irrelevant to practice (Lester & Wiliam, 2002). The result is that voices that could provide insight about fruitful directions for the academic community are often silent.

Purpose of the Study

In this paper, our goal is to give a group of practicing teachers a voice in the ongoing discussion concerning the relationship between mathematics education research and practice. Our focus is upon two primary research questions:

(1) What positive influences on practice do the teachers identify from mathematics education research reports?

(2) What negative critiques do the teachers make about mathematics education research reports?

We investigated the two research questions within the context of a university graduate-level course in which the first author sought to acquaint practicing teachers with a set of existing mathematics education research reports.

Describing the Relationship between Research and Practice

Since our first research question concerned the investigation of perceived positive influences on practice, we needed to choose a framework to help conceptualize the various dimensions of the practice of teaching mathematics. We chose Kilpatrick, Swafford, and Findell's (2001) model of mathematics teaching proficiency (MMTP) because it was formulated on the basis of an extensive review of existing empirical literature on the various dimensions of the task of

teaching mathematics. The MMTP takes the dimensions of general pedagogical models of teaching competence (e.g., Shulman, 1987) into account along with literature specific to the field of mathematics education. The MMTP is described further in this section along with its connection to the mathematics education literature.

Our second research question aimed to characterize negative critiques teachers would make about mathematics education research reports. In order to frame the investigation of this question, we began with Kennedy's (1997) discussion of reasons for the disconnection between research and practice in education. Like the MMTP, Kennedy's discussion is grounded in a thorough examination of existing empirical literature. Her categorization scheme illuminates reasons why educational research has historically failed to influence teaching practice. This categorization scheme, therefore, provided a plausible lens through which to examine teachers' comments. Kennedy's classification scheme and its connection to the field of mathematics education are described in more detail in this section.

Conceptualizing the Positive Influences of Research on Practice

The MMTP includes five broad, intertwined components. Each component illuminates potential avenues for research to influence teaching practice. The manner in which research may potentially influence teaching practice along each of the components is described below by making reference to relevant mathematics education literature.

Conceptual Understanding of Core Knowledge

The first MMTP component is "*conceptual understanding* of the core knowledge required in the practice of teaching" (Kilpatrick et al., 2001, p. 380). The core knowledge needed for teaching consists of mathematics content knowledge, knowledge of the development of students' mathematical thinking, and knowledge of effective pedagogical practices. Even (1999; 2003)

commented that mathematics education research can help teachers develop knowledge of students' thinking, since it illustrates the way mathematical knowledge is often constructed in ways teachers do not expect. Cognitively Guided Instruction (CGI) research showed that research can serve as a framework for helping teachers organize their knowledge of students' thinking (Fennema & Franke, 1992). Silver (1990) pointed out that research can help add to teachers' pedagogical resources by providing them with mathematical tasks to use with their own students. Therefore, research holds the potential to help teachers build the various facets of the knowledge base needed for teaching.

Fluency in Instructional Routines

The second component of the MMTP is "*fluency* in carrying out basic instructional routines" (Kilpatrick et al., 2001, p. 380). Basic instructional routines include effective classroom management procedures and approaches to personal interactions with students. They are vital to successful mathematics teaching, since perceived management and logistics problems can prevent teachers from implementing instructional methods they believe to be valuable (Thompson, 1992). Since what constitutes an effective instructional routine varies greatly by classroom, school, and teacher, CGI researchers largely left decisions about classroom management and organization to the discretion of individual teachers. (Carpenter, Fennema, Peterson, Chiang, & Loef, 1989). Some research reports attempt to bring instructional routines to the forefront by dealing with issues such as teaching while students work independently and teaching while leading a whole-class discussion (Lampert, 2001).

Strategic Competence

The third component of the MMTP is "*strategic competence* in planning effective instruction" (Kilpatrick et al., 2001, p. 380). A teacher with strategic competence can effectively

engage in the problem-solving activities of making lesson plans, carrying them out, and interacting with students. Silver (1990) noted that research results can play a role in shaping teachers' instructional plans by showing that some pedagogical practices tend to be more effective than others. While research results cannot necessarily "prove" that one type of instructional plan is better than another, they can help teachers make more reasonable decisions about courses of action to take in practice (Margolinas, 1998). Therefore, mathematics education research holds the potential to build teachers' strategic competence.

Adaptive Reasoning

The fourth component of the MMTP is "adaptive reasoning in justifying and explaining one's instructional practices and in reflecting on those practices so as to improve them" (Kilpatrick et al., 2001, p. 380). A teacher fitting Schön's (1983) description of a "reflective practitioner" would have well-developed adaptive reasoning. Teachers can become more reflective through discourse with peers and with teacher-educators (Valli, 1997; Manouchehri, 2002). Research reports appear to be one discursive tool for helping the development of reflection, since teachers in Even's (1999) study reported "that learning about research helped them make explicit things they already 'felt' but did not have the language to express" (p. 242). Hence, it appeared that research helped the teachers develop adaptive reasoning by bringing latent pedagogical issues to the surface and transform them into objects for reflection.

Productive Disposition

The final component in the MMTP is "productive disposition toward mathematics, teaching, learning, and the improvement of practice" (Kilpatrick et al., 2001, p. 380). It appears that teachers' study of research can help in the development of productive dispositions. Fennema et al. (1996) reported that CGI teachers, of their own accord, used their classrooms to evaluate the

research findings they studied in workshops. Franke et al. (1998) also illustrated that CGI workshops helped teachers engage in experimentation leading to the improvement of their own practices, and that this change in disposition toward instruction sustained itself outside of the formal workshops. Therefore, formal research, in at least some cases, can help motivate teachers to critically examine their own classroom practices and experiment with different approaches to improving them.

Conceptualizing Teachers' Possible Negative Critiques of Research

While research holds the potential to help teachers enhance practice, as described above, there are also factors that can lead teachers to view it in a negative light. Kennedy (1997) discussed reasons for the historically perceived lack of usefulness of education research:

> The reasons hypothesized for the apparent failure of research to influence teaching can be grouped into four general hypotheses: (a) The research itself is not sufficiently *persuasive or authoritative*…(b) The research has not been *relevant* to practice…(c) Ideas from research have not been accessible to teachers…(d) The education system itself is intractable and unable to change, or it is conversely inherently unstable, overly susceptible to fads, and consequently unable to engage in systematic change (p. 4).

The four identified barriers formed a starting point for categorizing and reporting teachers' negative critiques of mathematics education research in the present study.

Authoritativeness/persuasiveness of research

The first of the four identified barriers, the authoritativeness/persuasiveness of research, has been a recurring topic of conversation in the mathematics education community. It was thought that in the present study, teachers' critiques of the quality of mathematics education research would relate to criteria set forth by Lester (1996) and Simon (2004), since those sets of criteria

were studied in the graduate course providing the context for the study. Lester (1996) set forth the criteria of worthwhileness, coherence, competence, openness, ethics, credibility, lucid writing, and originality as important for evaluating mathematics education research. Simon (2004) identified coherent reasoning, justification of the research question, justification of methodology, justification of data analysis, and justification of conclusions as important criteria. The failure to meet any of these criteria could conceivably cause a mathematics education research report to be perceived as low quality.

Relevance of Research to Practice

The second of the identified barriers pertains to the relevance of research to practice. Research tends to produce theoretical knowledge, and teachers tend to value knowledge generated in concrete settings (Bromme & Tilemma, 1995). Leinhardt, Young, and Merriam (1995) noted that practitioners often have difficulty transforming theoretical knowledge into practical knowledge. This stems from the fact that professional knowledge acquired in practice tends to be procedural, specific, and pragmatic, while university-level knowledge tends to be declarative, abstract, and conceptual. A research report that is declarative, abstract, and conceptual is likely to be viewed as irrelevant to practice by a teacher who lacks tools for integrating the abstract and particular.

Accessibility

The third barrier to connecting research and practice, accessibility, has been recognized as problematic in the mathematics research community. Sowder (2000) identified conventions for reporting research as part of the cause for the gap between research and practice, stating, "The manner in which research is reported in journals…important as this style may be in convincing our peers that the research meets expected standards, is a turnoff for most teachers" (p. 3).

Bishop (1998) suggested that researchers should make it a priority to disseminate research results in media accessible to teachers, such as teachers' journals and newspapers.

Nature of Schools

In beginning her discussion of a fourth barrier, Kennedy (1997) noted, "The fourth hypothesis for the apparent lack of connection between research and practice suggests that the problem lies not in research but in the education system itself" (p. 7). Due to the nature of schools, sometimes even well-conceptualized and well-executed research studies can fail to have an impact upon practice. An example of this phenomenon in the mathematics education community is teachers' use of textbooks in the U.S. Even though research illustrates that traditional U.S. mathematics texts tend to present material in a fragmented manner, they still exert a great deal of control over the mathematics taught in schools because they provide somewhat of a stable de facto national curriculum (Mayer, Sims, & Tajika, 1995). Another example is that school-based concerns about classroom management and time management can prevent teachers from following research-based recommendations for mathematics teaching reform (Adams & Krockover, 1997). These examples, which are by no means exhaustive, illustrate that numerous factors within the educational system itself may influence teachers' perspectives about the usefulness of research.

Summary

Both the positive and negative interactions between research and practice are complex. The MMTP provided a way to begin to think about possible positive interactions, while Kennedy's (1997) discussion provided a way to begin to think about possible negative ones. Taken together, the two broad perspectives related to the research-practice relationship provided a working framework for the present study.

Methodology

The intent of the present study was to contribute to the ongoing professional discourse surrounding the relationship between research and practice in mathematics education. This study sought to inject new voices into the discourse by describing the perspectives of a particular group of practitioners not engaged in conducting formal research that is published in academic journals. With this in mind, we adopted a qualitative design, since qualitative studies provide a useful format for giving voice to underrepresented groups of individuals (Lincoln & Denzin, 2000). Our goal was not to make statistical generalizations about teachers' perspectives, but rather to help readers make naturalistic generalizations (Stake & Trumbull, 1982) that are grounded in their own experiences in working with practitioners, reading related papers, and conducting research studies. Toward that end, our research design focused on collecting and representing teachers' perspectives on a collection of published mathematics education research reports. The specific components of the study design are described in detail this section.

Participants

Twenty teachers from the Mid-Atlantic U.S. participated in the graduate course that was the focus of the study. Table 1 summarizes information about the participants. Fourteen were female and six were male. Three taught grade school (grades 1-5), five taught middle school (grades 6-8), eight taught high school (grades 9-12), two taught both middle school and high school, and two were college instructors. One of the college instructors taught remedial mathematics and the other taught personal finance. When the participants were asked to describe any past experiences with reading and/or applying mathematics education research on a questionnaire at the beginning of the semester, thirteen reported having "none," "not much," or "very little." Five said that they had read some research in conjunction with past graduate level courses they had taken. Two

mentioned reading teacher materials produced by NCTM. The 1-12 grade teachers received credit toward teaching certificate renewal for taking the course along with graduate credit.

<INSERT TABLE 1 HERE>

Procedure

At the beginning of the course providing the setting for the study, teachers were assigned readings from a text designed to make research articles accessible to practitioners (Sowder & Schappelle, 2002). Readings were grouped into three topics: motivation, NCTM Standards-based curricula, and reform-oriented vs. traditional instruction. There were two main factors influencing this particular choice of topics. First, they were chosen to be relevant to the various grade levels taught by the teachers in the study and not specific to just one grade level. The issues within each of the topics cut across various age groups. Second, the topics were chosen to challenge teachers and prompt them to reflect on commonly existing teaching practices. Research reports on motivation, for example, were chosen in part to challenge the common uncritical use of extrinsic motivators (Kohn, 1999). Research reports on NCTM Standards-based curricula and instruction were chosen to provide a pedagogical vision different from that of most classrooms in the U.S., where the study took place, and where reform-based pedagogy is rare (Stigler & Hiebert, 1999). It is important to note that given this topic choice, this study is far from being an exhaustive treatment of the teachers' perspectives on all possible categories of mathematics education research. The study is, nonetheless, a report on the teachers' perspectives on some commonly-encountered research topics.

In order to achieve methodological triangulation (Denzin, 1970), data on teachers' perspectives on the readings were gathered in three ways: (i) Reflections on each topic guided by a set of questions designed by King and Kitchener (1994) were sent to the instructor via e-mail

before each class discussion of the readings; (ii) Class discussions resembling focus group interviews (Morgan, 1988), where teachers were encouraged to share perceived strengths and weaknesses of each reading, took place for each topic; the first author took field notes and synthesized them into vignettes (Miles & Huberman, 1994) summarizing each session; (iii) Teachers completed a written questionnaire after the class discussions in which they were asked to comment on whether or not each reading would impact the way they operated as teachers and to explain their responses. Data from these sources were gathered and retained for analysis.

Data Analysis

To begin the process of data analysis, teachers' questionnaire responses for each article were coded based on the aforementioned schemes of Kilpatrick et al. (2001) and Kennedy (1997). Codes based on the MMTP categories were assigned to portions of responses that reflected a perception that the research article would positively influence practice, and codes based on the four Kennedy (1997) categories were assigned to portions of responses reflected a negative critique of the article. Email journals and written vignettes of classroom sessions were coded in the same manner. Throughout this process, perspectives that did not fit any of the categories specified by the frameworks were also sought, although none were discerned.

After codes had been assigned, a clustering procedure (Miles & Huberman, 1994) was used to gather data into categories. One set of categories described ways in which teachers perceived research would influence practice, and the other set described types of critiques the teachers made of the research articles studied. Refinements to the analysis of data continued throughout the representation of the study results in writing (Glesne, 1999). The results section represents the negotiated consensus of both authors in regard to how the gathered data should be coded and categorized.

Results

Results of the data analysis are reported in chronological order, by topic studied. The topical reporting scheme is intended to facilitate the connection of teachers' comments to the specific studies that prompted them. Direct quotes are used frequently, given that one of the purposes of the study was to give teachers voice in the academic discussions about the connection between research and practice. Quotes are drawn from teachers' written questionnaire responses, except where otherwise noted. The pseudonyms chosen for each teacher were based on the grade levels they predominantly taught. Elementary teachers' pseudonyms begin with the letter "e," middle school teachers' with "m," high school teachers' with "h," and college instructors' with "c."

Topic 1: Motivation

The assigned articles focusing on motivation were chapters 1 and 2 from the class text (Sowder & Schappelle, 2002). Chapter 1 was an adapted version of a literature review regarding motivation and mathematics education (Middleton and Spanias, 1999). Chapter 2 was an adapted version of the Stipek et al. (1998) study of the relationships among teaching practices, students' motivation, and students' learning of fractions. The types of comments teachers made regarding the articles and the numbers of teachers making each type of comment are summarized in the second column of Table 2. The same data are disaggregated by individual in Figure 1.

<INSERT TABLE 2 HERE>

<INSERT FIGURE 1 HERE>

Perceived Contributions of Research to Practice

Conceptual understanding of core knowledge. Teachers indicated that chapters 1 and 2 from the class text were useful in developing understanding of the knowledge base needed for teaching. One way the articles seemed to help in this respect was in developing knowledge of

students and how they learn. In reference to chapter 1, Harold remarked, "Motivation has been difficult for me as a new teacher. It was helpful to understand the five factors that influence motivation." In reference to chapter 2, Megan observed in her email journal, "For students with what the text calls 'performance or ego goals', grades are their candy. In both cases, students are not self-motivated to learn but are instead driven by some reward." A second way the articles were perceived to contribute to the knowledge base needed for teaching was that they helped develop knowledge of pedagogical practices. In discussing chapter 2, Hannah commented, "I found many useful things in this article. It gave suggestions or at least implied what I could do in my classroom." Teachers' comments therefore indicated that the research read helped build knowledge of students and of pedagogical practices. Both of these types of knowledge are part of the core knowledge for teaching identified by Kilpatrick et al. (2001).

Strategic competence. The second broad area in which teachers perceived contributions of research to practice was building strategic competence in planning instruction. Some of the evidence for this is found in an excerpt from Caleb's email journal:

> The chapter 2 research conducted by Kazemi and Stipek comparing "instructional practices suggested by researchers on achievement motivation" and "practices promoted on reform in mathematics instruction" both concurred that motivating students through "learning goals" versus "performance goals" (extrinsic rewards) proved students "learn better, are more attentive, and use more effective problem-solving strategies."

The excerpt indicates that he used the research article as a tool for comparing different pedagogical strategies for the purpose of deciding upon practices likely to result in gains in students' learning. The research helped him progress beyond attaining new ideas for pedagogical strategies to making a thoughtful decision about which strategy was more likely to be effective.

Adaptive reasoning. Teachers felt the topic 1 readings helped them develop adaptive reasoning in three different ways. The first way was by justifying existing beliefs or practices. Henry, for example, stated, "I use intrinsic motivation anyway and it [chapter 1] reinforced this for me." The second way was by making teachers rethink existing practices. Melanie remarked, "I will now reconsider the motivating factors I use in my classroom; when, what, and how I reward will probably change a bit" in reference to chapter 1. A third type of comment indicated that teachers would monitor existing practices, but not necessarily change them. For instance, commenting on chapter 2, Haley stated, "I will consciously monitor my external praise of students." In each instance, the research either validated existing practices, made teachers rethink them, or become more conscious of them. Each can be categorized as development of adaptive reasoning, since adaptive reasoning can involve justifying one's practices, monitoring them, and/or improving them (Kilpatrick et al., 2001).

Negative Critiques of Research

Authoritativeness/persuasiveness of research. One type of negative critique, related to the authoritativeness of research, seemed to extend past the specific articles themselves to a discussion of what one can and cannot hope to accomplish through research. These critiques were most pronounced in the email journals for the topic. Several teachers expressed the sentiment that one cannot use research to settle the intrinsic vs. extrinsic motivation issue. When asked to compare intrinsic and extrinsic motivation, Mandy remarked, "I'm sure that if a person looked hard enough they could find enough evidence to support their opinion either way." In response to the same question, Esther said, "We can find examples to support both sides of this issue. So much depends on the instructional practices, the teacher's personality and teaching style, and the attitudes of the students." The thought inherent in these types of responses was that

we can not hope to arrive at general conclusions about the given topic through the act of reading educational research.

Negative critiques pertaining to the persuasiveness of the research arose during class discussion of the motivation chapter. In particular, an aspect of the methodology of chapter 2 was criticized in large group discussion after teachers had discussed the article in small groups. Maggie reported that her group thought the study was weak because it focused only on 20 students. Not all teachers agreed that this was a weakness, as Herman commented that the authors of the study were not trying to make claims about a larger population outside the study. Further, no teachers made written critiques of the persuasiveness of the research.

Relevance of research to practice. Some of the negative critiques of research read for the first topic stemmed from the perception that the article was focused on declarative knowledge that would have little or no impact on practice. Teachers making this critique felt that the research would not influence their practice since it simply stated things perceived to be obvious or because they were already putting its recommendations into practice. Colleen, for example, commented on chapter 2, "Teachers should be 'nice' and display enthusiasm and interest in mathematics. [sic] Should not need research to tell us that." In regard to the same chapter, Maggie stated, "I can't say that I was too impressed with this article. I've always tried to use positive motivation in my classroom as a driving force," indicating that she was already doing what the article recommended. The comments resonated with the Leinhardt, Young, and Merriam (1995) discussion, since they theorized that reports concerned with disseminating declarative knowledge are likely to be viewed by as irrelevant to practice by teachers.

Accessibility. Some teachers also stated that aspects of the research were not accessible. Heather felt that a diagram used in chapter 2 to summarize the research made the article less

accessible. During class discussion of the article, several others agreed with her point of view. Some of the confusion about the diagram was seemingly resolved when Haley spoke up during class discussion to say that she thought the diagram was helpful for summarizing the main points of the article. She then summarized her interpretation of the diagram for the whole class. While the perception that the diagram made the article less accessible emerged in discussion, it was only critiqued in writing by one teacher.

Summary

The categories of perceived positive impacts on practice and negative critiques of research for the first topic can be classified in terms of the frameworks proposed at the outset of the paper. Positive impacts identified fell into three of the MMTP categories of enhancing adaptive reasoning, conceptual understanding of core knowledge needed for teaching, and strategic competence. Negative critiques fell into three of Kennedy's (1997) categories: relevance of research to practice, accessibility of the research, and persuasiveness and authority of research.

Topic 2: NCTM Standards-based Curricula

The assigned articles focusing NCTM Standards-based curricula were chapters 5, 20, and 21 from the class text. Chapter 5 was an adapted version of Fraivillig, Murphy, and Fuson's (1999) analysis of a teacher using the *Everyday Mathematics* curriculum. Chapter 20 was adapted from Huntley, Rasmussen, Villarubi, Sangtong, and Fey's (2000) study comparing the *Core-Plus Mathematics Project* curriculum to conventional curricula. Chapter 21 was adapted from Lubienski's (2000) study of the experiences of how students of low socioeconomic status (SES) interacted with the *Connected Mathematics Project* curriculum. The types of comments teachers made regarding the articles and the numbers of teachers making each type of comment are summarized in the third column of Table 2. The data are disaggregated by individual in Figure 1.

Perceived Contributions of Research to Practice

Conceptual understanding of core knowledge. Teachers once again identified an increased grasp of the knowledge base needed for teaching as a positive impact of the articles. In some cases, they felt that the research articles helped build their knowledge of students and how they learn. Eileen, for example, remarked, "This (chapter 21) will help me see why the students are completing the math the way they are. I will better understand their thinking." In regard to the same chapter, Harold noted, "This chapter was very useful because of the demographics and SES of my school and helped to understand the different problems these students face in mathematical education." A second perceived way the research articles helped build the base for teaching was by adding to existing repertoires of pedagogical practices. In regard to chapter 20, Herman noted, "I like the idea of new way to teach the old subject of Algebra such as the CPMP method which may help to revitalize teacher and student." As with topic 1, some teachers felt that their knowledge of students and/or knowledge of pedagogical practices were strengthened.

Strategic competence. The second broad category of perceived positive impact on practice was the development of strategic competence. In particular, the research articles appeared to make some teachers carefully think through strategic issues involved in implementing an NCTM Standards-based curriculum. An excerpt from Henry's journal illustrated this type of thinking:

> The researchers in chapter 20 stated that they were not try to answer the question of which method was better, 'just to show the kinds of trade-offs that might be expected when one allocates time to topics in ways that differ from the allocation in typical U.S. high school curriculum.' Students are going to learn different things from each curriculum so we must figure out what we want them to learn before we decide what method is best.

The excerpt indicates that Henry saw the research article as a tool for helping decide between standards-based strategies for teaching mathematics and traditional ones.

Adaptive reasoning. Adaptive reasoning again surfaced as an area the teachers felt the research helped them develop. As with topic 1, some of the teachers mentioned that the articles justified pre-existing beliefs or practices. Maggie commented "It (chapter 5) supported my feelings of using a NCTM curriculum in my teachings." Elmer expressed similar feelings, stating, "I feel that these articles cumulatively strengthened my position on a standards-based teaching." Also as with topic 1, in some cases teachers noted that the articles prompted them to rethink instructional practices. Heather, for example, said, "This (chapter 20) was another article that helped me see how I may make changes in my teaching practices - helping students to make their own ways to solve problems." Harry thought along a similar line, stating, "It (chapter 20) will cause me to review the NCTM Standards and try to incorporate them more."

Negative Critiques of Research

Authoritativeness/persuasiveness of the research. One category of critique for topic 2 stemmed from the perceived persuasiveness of the research. Heidi remarked in regard to chapter 20, "I understand the point of the article, but it failed to convince me that the approach worked best. The results were not as strong as I thought they should have been." In discussing the same chapter, Haley said, "This research didn't seem to be too credible. It probably won't affect me one way or the other." Megan remarked, "I don't believe that the depth of this study (chapter 21) was adequate. It will probably influence my instruction very little." In each case, the critiques reflected a feeling that the research was not as persuasive as it should have been, although specific reasons for lack of persuasiveness were sometimes not reported.

Some critiques associated with topic 2 were related to the perceived authoritativeness of research. As with topic 1, several comments made in email journals questioned the ability of research to provide authoritative answers to educational problems. Haley's email journal comments illustrate this type of critique, and also closely resemble a similar critique made by others within the context of studying the articles for topic 1. When asked to compare traditional curricula to standards based curricula, she stated,

> I suppose experts in the field can disagree by citing research that supports their side of the issue and not feeling the evidence supporting the other side is significant enough to sway them. There always seems to be a way to discount a study that doesn't show your point of view. Then you can feel confident that you are right.

Hence, skepticism about the act of research itself extended through the study of topic 2.

Relevance of research to practice. As with topic 1, some teachers viewed the research articles for topic 2 as irrelevant to practice because they centered on declarative knowledge perceived to be obvious. In commenting on chapter 20, for instance, Melanie stated, "Obvious research findings and they conclude by asking the very question we all want to know – What mathematics is most important for students to learn?" In a journal entry, Heidi expressed a similar sentiment, stating, "In chapter 5, the concept of "elicit, support and extend" is treated as some novel idea that supports ACT. But really, that is just good, common sense teaching." In the class discussion, Macy said that she did not think the research reported in chapter 21 was necessary, since it just repeated what they saw in their classrooms each day. These comments show that each of the three chapters was critiqued negatively because of a perceived preoccupation with declaring the "obvious," just as with topic 1.

Two types of critiques about relevance of the research to practice emerged in the context of topic 2 that did not emerge in the context of topic 1. First, some teachers felt the research was not relevant to practice because it did not mirror the specific circumstances under which they taught. In regard to chapter 20, Eileen stated, "This article doesn't relate to my current grade. However, if I ever make it to middle school I might use it." In a journal entry, Heidi observed that some of the research did not seem to support the specific instructional goals she valued for algebra:

> Huntley and Rasmussen made a good case for CPMP in chapter 20, but when you think about it, what good is any program when, in the end of an Algebra course, the child still has trouble with Algebraic Symbol [*sic*]manipulation?

A second type of critique about the relevance of research to practice that emerged was that the research did not give procedural instructions for carrying out its recommendations. Colleen, for example, remarked in regard to chapter 5, "The eliciting/supporting/extending methodology is very good but the author does not tell one <u>how</u> to do these creative techniques." Mallory gave a similar assessment of the pedagogical ideas in chapter 21, stating, "I like this idea – but I'm not sure how to implement it – it scares me to think some students will be off task – however lower SES needs this type of instruction!!" Teachers making critiques about the relevance of the research in topic 2 seemed to lack the tools for integrating the abstract and the particular. They apparently did not see how to implement the classroom visions provided by the research in their particular classroom situations.

Accessibility. The accessibility of the research reported in the articles read in connection with topic 2 was also critiqued, just as with topic 1. Once again, diagrams meant to clarify the message of the articles were critiqued, as Herman noted that he found the diagram explaining the teaching model presented in chapter 5 to be confusing. Others made less specific critiques about

accessibility. Hannah and Haley, for example, simply stated that they found chapter 5 to be confusing without elaborating upon particular problematic aspects.

Summary

The perceived positive impacts of research on practice for topic 2 fell into largely the same categories as those for topic 1. In each instance, teachers identified the building of adaptive reasoning, conceptual understanding of core knowledge, and strategic competence as positive impacts. Three categories of critiques from topic 1 appeared once again for topic 2: that the research was concerned mostly with declarative knowledge, the research was not accessible, and that research itself is not especially useful for answering questions in the field of education. New categories of critiques also emerged within existing broad categories, including criticisms that the research was not specific to instructional settings or goals, and that the research did not give procedural directions for carrying out its recommendations.

Topic 3: Reform-oriented vs. Traditional Instruction

The assigned articles focusing on reform-oriented vs. traditional instruction were chapters 12 and 16 from the class text. Chapter 12 was an adapted version of Pesek and Kirshner's (2000) comparison of instrumental instruction in geometry to relational instruction. Chapter 16 was adapted from Boaler's (1998) comparison of traditionally-structured classroom instruction to reform-oriented classrooms. The types of comments teachers made regarding the articles and the numbers of teachers making each type of comment are summarized in the fourth column of Table 2. The data are disaggregated by individual in Figure 1.

Perceived Contributions of Research to Practice

Conceptual understanding of core knowledge. A recurring category of perceived impacts on instructional practice was that the research was perceived to strengthen the knowledge base

needed for teaching. Some teachers felt that the articles helped add to their existing repertoire of pedagogical practices. Colleen said in regard to chapter 16, "I like the idea of open ended projects and I may try to supplement my teaching with one to start off with and then maybe increase the number later." Commenting on the same chapter, Harold stated, "This chapter allowed me to see further into the different types of teaching mathematics. I have been a closed type teacher but with experience and further knowledge will use the open style." In such cases, teachers noted that the articles gave them ideas for instructional approaches that they had not previously considered.

Strategic competence. Another recurring category of perceived impact was the ability of the research to strengthen strategic competence. Teachers cited both articles as useful in the process of reasoning about the best course of action to take in planning mathematics instruction. Eileen felt that chapter 12 helped her compare instrumental approaches to mathematics instructions to relational ones, stating, "This research helped me see that relational instruction helps child attack problems from different ways, whereas the instrumental only lead down one path." Megan thought that chapter 16 helped illustrate that reform in traditional methods of approaching mathematics instruction was needed. In her email journal, she stated, "I think that Boaler's findings were significant. In two schools with very similar demographics, a school with a progressive program clearly outperformed the traditional program." Both articles studied for topic 3 helped teachers think through the two different approaches to instruction.

Adaptive reasoning. The ability of research to facilitate adaptive reasoning was again cited by teachers in regard to the topic 3 articles. Hilda rated chapter 16 highly on its ability to impact practice, stating, "This study backed what I believe." Heather rated chapter 12 highly not

because it reinforced existing beliefs and practices, but because it made her think about changing them. She stated,

> This article really struck me. I almost always do instrumental instruction before relational instruction and this article showed how this way is ineffective and probably a waste of time. Students will learn from relational instruction without the instrumental and in less time.

Others said that the research would make them more aware of existing practices, even if they did not necessarily change them. In regard to chapter 12, Haley noted, "I will be more aware of the limitations the students would be developing by my teaching solely in an instrumental method."

Productive disposition. A new category of perceived positive impact that emerged in the context of topic 3 was that the research articles helped spark teachers' curiosity and hence fostered a productive disposition to continue to use research outside the context of the course to help improve practice. In commenting on chapter 12, Esther stated, "This is interesting to me because I have heard and read much about teaching skills vs. allowing students to construct meaning and therefore knowledge. I will continue to look at this type of research." Megan made similar comments about chapter 16, stating, "I found the Phoenix Park/Amber Hill comparison very interesting. It may influence further research." Herman went beyond looking up research for immediate classroom use to include sharing research with administrators. In discussing chapter 16, he said,

> The Phoenix Park and Amber Hills schools were very interesting in the style the classes were taught and the results that were achieved. To get administrators to agree may be a problem but I may have to have them read the study.

In each case in this final category, teachers indicated a positive disposition toward the use of research to help inform practice.

Negative Critiques of Research

Authoritativeness/persuasiveness of research. Skepticism about the authoritativeness of educational research in general continued to color some of the comments made by teachers in the context of studying topic 3. Heather expressed this sentiment in her email journal for topic 3:

> I think the results can be shown any way someone wants them to. If I decide that student-centered instruction is better, than I will use the data that I find to support this, even though I could get data that says differently if I set up my research another way.

These types of comments indicated a distrust of the ability of research to help in coming to firm conclusions. Interestingly, however, some teachers who distrusted research to inform instruction related to the previous two topics felt that research would be of some use in settling the question of which type of instruction is ultimately more desirable. When asked in her email journal if she could ever be sure that her position on standards-based vs. traditional instruction was correct, Mandy responded,

> In the last two journal prompts I've said "no" to this question, however, for this particular journal topic I believe I could be sure my position is correct. I believe that classroom observations, pre and post tests, student interviews, teacher interviews, etc. could prove that relational learning helps student to retain concepts longer than the traditional relational learning classroom.

Therefore, for some teachers, the general distrust of the authoritativeness of educational research did not extend across all types of research questions. Mandy, in particular, thought that comparative research could help "prove" that one type of instruction is better than another.

A perceived lack of persuasiveness in the research again surfaced in connection to the topic 3 chapters. In critiquing chapter 16, Henry said he was not persuaded by the research "because it based so much on qualitative data." The distrust of qualitative data did not extend across all members of the class, however, as Caleb said during class discussion that he was impressed by the data gathered for the same study. Others said that they were not persuaded by the research without mentioning specific reasons why. Colleen, for example, said that chapter 12 was "interesting research, but I prefer a combined approach," hence brushing aside the article's warning that combining instrumental and procedural approaches to instruction can do more harm than good without commenting on the methods employed in the study.

Relevance of research to practice. The feeling that the research was not relevant to practice surfaced once again. Some felt the research lacked procedural directions for implementing its recommendations. Caleb criticized both articles for a lack of procedural instructions. In connection with chapter 12, he stated, "I did not gain any insight on how to teach anything from this article." Commenting on chapter 16, he said, "This is of somewhat interest from an educational standpoint, but I don't see how to apply it in the classroom if I were teaching math." The concern about lack of procedural directions was less pronounced than with previous articles, since for topic 3, Caleb was the only one to voice concerns about relevance to practice.

Nature of schools. The nature of schools was the final category of reasons teacher identified to explain why the research studied would not impact practice. This category of concern arose for the first time in connection with topic 3. Several teachers felt that constraints in the school setting, due mainly to students and administrators, would prevent them from implementing the recommendations of the research articles. During class discussion, Herman said that teachers would be constrained from implementing the type of problem-solving oriented instruction

described in chapter 16 because of discipline problems that would arise. Heather's evaluation of chapter 16 echoed this sentiment, "I enjoyed the study done in this article [chapter 16] and I particularly liked what the author discovered about 'time on task.' It won't change a lot of what I do because administrators would hate to see students not working." Macy perceived further constraints in her school setting that would prevent her from implementing the relational approach to instruction recommended by chapter 12, "I still think there is a place in education for a balance in teaching. If we are to get through all of our county's curriculum, there must be a compromise. Some kids are not ready for 100% relational learning." These negative critiques were considered to be indicative of Kennedy's (1997) category pertaining to the nature of schools because they were grounded in factors within school settings rather than within perceived flaws in the research.

Summary

The perceived positive impacts of research on practice for topic 3 fell into some of the same categories as those for previous topics. The categories of conceptual understanding of core knowledge, adaptive reasoning, and strategic competence were all represented. A new category of fostering productive dispositions emerged. Two categories of critiques from previous topics were again represented: the research was not authoritative or persuasive, and that it was not relevant to practice. A new category of critique that the research would not impact practice due to the nature of schools surfaced as well.

Discussion

At this point, it is fitting to stand back and consider how this injection of teachers' voices fits into the existing scholarly discourse about the relationship between educational research and practice, since introducing practicing mathematics teachers' voices into the conversation was the

stated purpose of the study. In order to achieve this, it will be helpful to conceptualize the current state of the scholarly discourse about the connection between educational research and practice. The teachers' perspectives can then be located within the existing conversation. Hammersley (2002) provided a useful conceptualization of the discourse surrounding the relationship between educational research and practice, identifying three models describing views about how research should relate to practice: the engineering model, the strong enlightenment model, and the moderate enlightenment model.

Proponents of the engineering model believe that research should provide "specific and immediately applicable technical solutions to problems, in the manner that natural science or engineering research is assumed to do" (Hammersley, 2002, p. 38). Policymakers frequently are portrayed as endorsing this model. In the field of mathematics education, mathematicians fall into this category so often that considerable effort has been made to help them understand the limitations of the engineering model (McKnight, Magrid, Murphy, & McKnight, 2000; Schoenfeld, 2000). Teachers also frequently expect this sort of immediate applicability from teacher preparation programs (Ball, 1990).

Some of the perspectives voiced by teachers in the current study could be said to fit the engineering model view. Among the teachers criticizing the relevance of research to practice were those who did so because the research did not provide specific instructions on how to carry out its recommendations. Colleen, Mallory, and Caleb, for example, all complained about this perceived deficit at various points in the preceding narrative. Hints of the engineering model view were also among the positive perspectives voiced. Some comments pertaining to conceptual understanding of core knowledge seemed to uncritically embrace the research reports as algorithms or recipes for success. Collen's comments on chapter 16 of the class text provide

an instructive example of this phenomenon. She stated, "I like the idea of open ended projects and I may try to supplement my teaching with one to start off with and then maybe increase the number later." Her remarks did not provide evidence that she had considered how the open-ended projects described in the research report might need to be adapted to fit her own students and school setting. Hence, the engineering view surfaced in at least two types of comments about the research: those that lodged criticisms about the lack of procedural directions and those that seemed to uncritically accept the research as an algorithm for successful teaching.

A second commonly-cited model in the discourse concerning the relationship between educational research and practice is that of "strong enlightenment." The strong enlightenment view "implies that policymakers and practitioners are normally in the dark, and that research is needed to provide the light necessary for them to see what they are doing, and/or what they ought to be doing" (Hammersley, 2002, p. 39). There is considerable overlap between the strong enlightenment and engineering models, since each hold that scientific knowledge must necessarily replace and govern over practical knowledge. The strong enlightenment model is unique from the engineering model because it holds that science or philosophy "can produce a comprehensive perspective on the world; rather than just specific items of knowledge, or perspectives useful for particular purposes" (Hammersley, 2002, p. 40). It is also unique in assuming that "practical conclusions can be derived from factual evidence, either directly or by reliance on a naturally produced value consensus" (Hammersley, 2002, pp. 39-40).

Perspectives aligned with the strong enlightenment model were evident among the teachers in the present study. Some of them stated that the research reports being read were not relevant to practice because they stated things that they already knew. For example, Heidi stated disappointment with the research-based model of reform-based teaching described in chapter 5

of the class text because she felt it was nothing more than "good, commonsense teaching." Others in the preceding narrative lodged similar criticisms, seemingly arguing that a research report is only valuable insofar as it dislodges apparent misconceptions or misunderstandings held by the reader. Views consistent with the strong enlightenment model also surfaced among those who criticized research reports for not providing a comprehensive perspective on the world. Several, for example, expressed disappointment that the research did not "prove" anything, or that one could not rely upon the research to guide the field of education toward consensus because of the seemingly contradictory results of some studies. Mandy's comments exemplify this part of the strong enlightenment position, since felt that some strands of mathematics education research could never "prove" anything conclusively, while other strands, such as studies comparing one type of instruction to another, could possibly produce such proofs.

The moderate enlightenment model stands in contrast to the engineering and strong enlightenment models. It holds that "research is one among several sources of knowledge on which practice can draw. Moreover, the use made of it properly depends on practical judgements about what is appropriate and useful" (Hammersley, 2002, p. 42). Knowledge produced through research is seen as fallible and often narrowly focused on single issues. Conclusions forwarded by research reports must necessarily be filtered through the readers' cognitive and value systems before they can be acted upon. Teacher educators who hold this type of perspective on research see it as their task to help teachers develop the pedagogical reasoning necessary to critically evaluate research and its relationship to contextual concerns rather than to indoctrinate them into believing transcendent pedagogical "truths" produced through research (Fenstermacher, 1986; Sparks-Langer, Simmons, Pasch, Colton, & Starko, 1990).

Some evidence of the moderate enlightenment view was apparent among the teachers studied. The view surfaced in teachers' perspectives on chapter 1 of the class text, which described research related to students' motivations to learn mathematics. Melanie and Haley's adaptive reasoning remarks, for example, recognized the potential of the research report to help them monitor and reflect on their existing practices for motivating students. Hence, the research was seen as a source of knowledge to be taken into account in practice and not as an absolute prescription about what sort of action to take (engineering view) or as a scientific document that dislodged existing misconceptions they held (strong enlightenment). Another example of a moderate enlightenment view can be found in Henry's strategic competence remarks about chapter 20 in the class text. He quoted and agreed with a line from the study stating that its findings must be considered in light of what a particular school values in terms of goals for mathematics education. The "productive dispositions" category for topic 3 provides further examples of moderate enlightenment views, as comments in that category mentioned interest in further exploring the topics brought to light by the reports in classroom contexts or using them as one part of an argument to support school-wide instructional reform.

In summary, the perspectives on research reports evident among the group of teachers in the present study were far from monolithic. Alignments with engineering, strong enlightenment, and moderate enlightenment models were evident. Of course, the perspectives of teachers in the present study may well have been influenced by the course in which they were engaged, and may not have been as diverse otherwise. This suggests that if researchers take the advice to increasingly base their research questions on practitioner-generated questions (Bishop, 1998; Lester & Wiliam, 2002; Silver, 2003), they should not abandon injecting elements of formal research into practitioners' discourse. Just as injecting practitioners' perspectives into the

discourse of formal research can help rejuvenate the field, injecting perspectives from formal research into practitioners' discourse may help teachers pose reflective and pertinent questions that in turn can provide the focus for research.

Concluding Remarks

The fact that the present study was intended to be just one piece of the conversation about the relationship between educational research and practice betrays the authors' orientations toward the moderate enlightenment model. It does not claim to be exhaustive in terms of types of mathematics education research considered by the teachers or teachers' possible reactions to research reports. We believe that any research report will necessarily be only a partial view of the world. In light of this orientation toward research, it would be tempting to close by simply stating that a goal of teacher education should be to move teachers away from the engineering and strong enlightenment models of research toward the moderate enlightenment model. Although the engineering and strong enlightenment models do seem to distort the nature, purpose, and goals of sociological research, it is nonetheless important to pause to consider what sort of contributions teachers espousing these models might make toward the ongoing discourse about the relationship between educational research and practice.

The overall process of mathematics teacher education is, for better or worse, a system that extends well outside university boundaries. Mathematics teachers learn outside university boundaries by studying teaching materials and interacting with colleagues and students (Ma, 1999). It is frequently lamented that they also learn through an "apprenticeship of observation" (Lortie, 1975) by spending numerous hours being exposed to traditional teaching practices before they ever reach the university. Given these various influences on teacher education, it does not seem reasonable to make it a goal for teacher educators to extinguish all vestiges of the

strong enlightenment and engineering models. Influences of the strong enlightenment and engineering models are readily apparent in these teacher education settings that fall outside the boundaries of the university.

Instead of looking at the engineering and strong enlightenment models as nuisances or obstacles, they might be more productively viewed as sites for productive disagreements (Matusov, 1996). For example, a teacher holding a moderate enlightenment view might sharpen and focus the view as a result of engaging in discourse with proponents of the engineering model. Teachers holding an engineering model view might alter it as a result of conversations with those endorsing moderate enlightenment. Among the teachers in the present study, opportunities for such productive disagreements were plentiful, as evidenced by the diversity of perspectives voiced. Such opportunities are likely to be available in similar settings where practicing teachers engage in the study of accessible research reports. While one model may never be completely extinguished, individuals may refine their perspectives as a result of engaging in such settings.

It is hoped that this report has contributed to increasing teacher educators' awareness of some of the diversity likely to be present among teachers' views of research and puts them in position to elicit various conflicting views and capitalize upon disagreements as learning sites. It is also hoped that the report has served the purpose of injecting fresh voices into the scholarly discourse surrounding the relationship between mathematics education research and practice. As we become more aware of teachers' perspectives on research, our actions in the areas of teacher education and research can be based on increasingly stronger empirical ground.

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Table 1

Summary of study participants

Pseudonym	Gender	Grade level taught	Self-reported experience with mathematics education research before the course
Eileen	F	1	None
Elmer	M	3-5	One previous course in education research
Esther	F	5	Research project for previous course
Macy	F	6-8	One previous course in education research
Maggie	F	7	Not much
Mallory	F	6-8	Research projects for two previous courses
Mandy	F	7	Very little
Megan	F	8	None
Melanie	F	8	Very little
Haley	F	9-12	None
Hannah	F	9-12	Not much
Harold	M	9-12	None
Harry	M	9-12	Read NCTM material as an undergraduate
Heather	F	9-12	One previous course in education research
Heidi	F	9-12	None
Henry	M	8-10	None
Herman	M	9-12	Very little
Hilda	F	9-12	None
Caleb	M	Personal finance college courses	None
Colleen	F	Remedial college mathematics courses	Read NCTM magazines, research projects for previous courses

Table 2

Number of teachers making written comments fitting each category

	Topic 1: Motivation	Topic 2: Standards-based curricula	Topic 3: Reform-oriented vs. Traditional instruction
Positive impacts			
Conceptual understanding of core knowledge	7	17	3
Instructional routines	0	0	0
Strategic competence	6	8	9
Adaptive reasoning	15	12	10
Productive disposition	0	0	5
Negative critiques			
Research not sufficiently persuasive or authoritative	11	7	9
Research not relevant to practice	6	15	1
Research not accessible	1	3	0
Nature of schools prevents implementation	0	0	6

Figure 1

Summary of Written Comments for Each Topic by Individual Teachers

	Positive Perspectives					**Negative Perspectives**			
	Conceptual Understanding of Core Knowledge	Instructional Routines	Strategic Competence	Adaptive Reasoning	Productive Disposition	Not Persuasive or Authoritative	Not Relevant to Practice	Not Accessible	Nature of Schools
Eileen	2		3	1,2,3			2		3
Elmer	2		2	2,3	3		1		
Esther	2			1,2	3	1,3	2		
Macy	1,2		1			3	1,2		3
Maggie	2			2		1,3	1		3
Mallory			3	1,2			2		
Mandy	1,2		2,3	1,2,3		1,3	2		
Megan	1,2		1,3	1,2,3	3	2	2		3
Melanie	2		1,3	1,2		1	2		
Haley	2		1,3	1,3		1,2		2	
Hannah	1,2,3			1,3		1,2	1,2	2	3
Harold	1,2,3			3			2		
Harry	2		2	1,2,3		1,2,3	2		
Heather	2		1,2	1,2,3		1,3		1	3
Heidi	2		3	1,2		2	2		
Henry	2		2	1,2	3	1,3	2		
Herman	1,2		3	1	3			2	
Hilda			2	1,3		1	1,2		
Caleb	1		1,2,3			1,2,3	2,3		
Colleen	2,3		2	1		2,3	1,2		