

Report to
The National Council of Teachers of Mathematics
Board of Directors

From
The Linking Research and Practice Task Force

Harnessing the Power of Research for Practice

January 2005

The Board of Directors of the National Council of Teachers of Mathematics (NCTM) commissioned a national Linking Research and Practice Task Force in 2004 with the responsibility of making recommendations for strengthening mathematics education research and its application to teaching and learning.

This report, *Harnessing the Power of Research for Practice*, represents our conclusions.

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Introduction

This report proposes an interconnected set of recommendations that will enable NCTM to become the most credible resource for research-based practices in mathematics education. These ambitious and far-reaching recommendations aim to set a new standard for educational organizations and to place NCTM at the forefront of the national movement for evidence-based practice. With the publication of its Standards, NCTM became the leader in providing both a vision and the essential support for standards-based education. The opportunity now exists for NCTM to reassert its leadership role, but this time by creating an integrated and sustainable system for linking research with practice. The time is right for launching this new initiative, an initiative that could rival the Standards in its impact for improving mathematics learning and teaching. In the words of NCTM President Cathy Seeley,

We cannot and will not ever again be caught unarmed for backing up our good work with evidence.

It is irresponsible and unacceptable to make uninformed decisions when we have the knowledge and information available to make informed decisions, but that information is not accessible.

We have a responsibility to the field and to the public to communicate what we know about how students learn mathematics and how we can best structure educational systems to help them learn it.

At present, the development of useful and credible links between research and practice in mathematics education occurs in haphazard and disconnected ways due to three major bottlenecks:

- 1) Access: Teachers cannot efficiently find, reduce, process, and implement research in the forms in which it is currently published;
 - 2) Relevance: The day-to-day, often politically determined interests of a teacher do not always coincide with the long-term programmatic interests of a professional researcher; and
 - 3) Knowledge: The variety and depth of research methods and disciplines that inform mathematics education are not well understood outside the research community.
- These bottlenecks have prevented the development of the needed links. If the Council does not step into this current void and serve its members by reducing these bottlenecks and creating and strengthening links between research and practice, then it risks becoming marginalized as a professional organization. Taking the lead is imperative and urgent—there are other people and organizations that will step in if NCTM does not. The stakes are high.

The profession needs an expeditious, fluid, sustainable process by which practitioners can quickly have access to research findings that can inform and support their classroom practices. Likewise, there is a need for a meaningful and effective process by which researchers can learn from practitioners and pursue research agendas that will positively influence practice. The bottom line is that NCTM can and must take the lead to improve the quality and raise the level of student learning through strategic application of what we know works.

Mathematics education is at a critical point. Many efforts to improve the teaching and learning of mathematics have succeeded in limited settings. It is heartening that some mathematics programs funded by the National Science Foundation have seen positive results. If the profession is to move beyond these and other “pockets of wonderfulness,” it must create a new vision for turning the best we know into common practice. We must learn how to gather and disseminate what has been learned to support local schools, districts, and states/provinces as they do the hard work of implementing new programs in their communities. And the research community needs to listen to the hard lessons practitioners are learning as they push forward against many challenges to implement what promises to be effective in helping students learn mathematics.

This means that existing models for conducting, reporting, and translating research must be challenged. New ground must be broken in the arena of linking research about mathematics teaching and learning, about schools, and about the change process with what actually happens in schools, districts, and states.

NCTM is uniquely positioned to create an integrated system that bridges arenas of research and practice, because it represents people and institutions engaged in both types of activities and because it has a track record for advancing mathematics, sometimes in dramatic ways. NCTM has both the responsibility and the opportunity to launch a transforming initiative at the beginning of the 21st century.

Answering Our Charge

In this report we respond forcefully to our charge by creating an *integrated system* to enable research to link with practice and to make NCTM a credible and timely resource for making research-based decisions in mathematics education. Our primary audience is educators-as-engineers¹—those who design teaching and learning systems, policy, and practices to enhance student learning and achievement in mathematics. This audience includes teacher leaders, curriculum supervisors, building level administrators, curriculum developers, and policymakers, generally referred to here as *practitioners*. It is also essential that classroom teachers, parents, mathematicians, and others interested in K-12 schooling have access to the information provided by this initiative. In turn, the system encourages and provides avenues for feedback to researchers from practitioners to improve the ways in which research addresses critical issues arising in the real world of classrooms and schools and the political arena in which schools exist.

¹ The term *engineering* refers to the creation, design, and implementation of products and processes to solve problems of societal value. The process is based on scientific knowledge, requires synthesis of knowledge, and takes into account issues of implementation. Engineering is also used to describe a way of working to create or improve an end product that is useful, reliable, and viable. Interestingly, engineering comes from the Latin word, “ingenium,” meaning something like brilliant idea, insight, or flash of genius. An engineer, therefore, is someone who utilizes evidence and scientific knowledge to generate solutions to important problems. We use the term “engineer” because it so aptly describes the audience for this report. However, we sometime shorten teacher leader/engineer simply to teacher leader.

We expect this initiative to be fully evaluated after three years so that the Board can make decisions on its effectiveness and on future plans. Evaluation criteria are suggested.

The Structure of the Linking Research and Practice Initiative

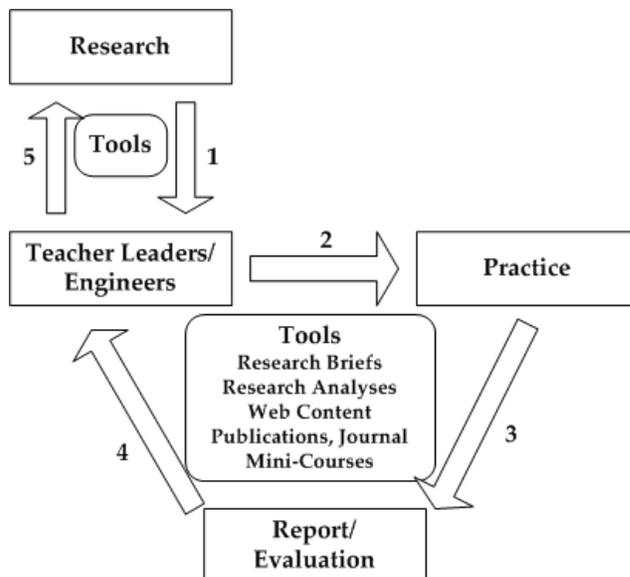
The structure of this initiative was developed to respond to the charge to the task force. The charge was as follows:

Charge to the Task Force: In support of the Council strategic priority on linking research and practice, make recommendations to the Board on the following:

1. How can NCTM make current research findings that are relevant to the teaching and learning of mathematics most useful to those involved in mathematics teaching and learning, including teachers and other practitioners, parents, and policymakers?
2. How can NCTM identify potential mathematics education research that would address issues of greatest importance to mathematics education practitioners?
3. How can NCTM set and promote a research agenda that responds to the questions of most importance in informing decisions at the classroom and district levels?
4. What ongoing structures (e.g., committees, personnel, publications, current or future resources) could the Council use and/or create to facilitate tasks 1, 2, and 3? (The Task Force should account for the roles of existing national structures such as the NSF-funded Centers for Learning and Teaching and the Science of Learning Centers as well as the work of the Standards Impact Research Group [SIRG].)

(NOTE: The rationale for this motion is contained in an appendix.)

The figure below provides a visual way of thinking about the structure of the initiative we have designed to address our charge.



This simple drawing is intended to convey several substantive points:

- We are responding to our charge through the creation of a *system* to enable linking research with practice. (Entire figure)
- We are targeting teacher leaders/engineers as our primary audience. (Arrow 1)
- We expect that teacher leaders will need to interpret information for their own context and design (engineering) strategies for using that information in practice. (Arrow 2)
- We expect that teacher leaders/engineers will need a variety of tools, created by researchers and teacher leaders working together, to help their constituents apply research to practice. We are recommending those that will be most helpful, in a variety of formats and levels of detail. (Center boxes)
- We know little about this engineering process beyond the personal knowledge held by on-site experts. Teacher leaders, curriculum developers, and other practitioners have a wealth of localized knowledge that can be consolidated to assist in the design of the feedback mechanism(s). (Arrow 3)
- Information regarding strategies that work well, under particular conditions, must be collected and fed back into the system (made available to teacher leaders and researchers). (Arrow 4)
- With information flowing back to teacher leaders and through them to researchers, we are designing a system that is expected to influence the very nature of research. (Arrow 5).

This flow of information and the ultimate success of this initiative are dependent on the quality and success of the tools developed and the resources provided to develop the tools. NCTM must address the need to develop print and web-based resources that will support linking research and practice. The tools needed to do so include:

- The development of a Virtual Research Library that communicates what research offers, of varying lengths and formats, to serve a variety of purposes and audiences.
- A Rapid Response mechanism to provide quick turnaround responses to research questions addressed to the President and Council.
- Publications and conference sessions to support understanding and use of research.
- Structures that ensure alignment of current NCTM materials and activities with the new components of these recommendations.

We first describe these tools and the processes to put them in place in a series of four interrelated recommendations (with details about how each recommendation might be carried out). The resources need to carry out this work are then described. A three-year tentative budget and timeline are provided. A motion to accept this set of recommendations is then made.

Tools and Processes

Recommendation 1. Create a credible and successful Virtual Research Library in Web and print form that provides answers to questions of practice for a variety of audiences.

Actions: Engage the best researchers and teacher leaders in the field to produce Research Analyses (10-15 pages) that both address questions of practice to teachers and have strong empirical bases. Develop Research Briefs (2-3 pages) and Research Clips (a few paragraphs) based on the Research Analyses and other research documents such as chapters in the Research Handbook. Develop a process that will ensure that the products are reviewed rigorously before making them public. Ensure that the products are accessible and updated. Develop a both a Web-based Virtual Research Library and a corresponding print publication, Linking Research and Practice (LRP), to provide primary venues for the publication of the Research Analyses that link research and practice, the Research Briefs, and the Research Clips.

Processes

- 1.1 Identify a set of researchers and teacher leaders/engineers to write the initial set of Research Analyses that answer questions of practice. Researchers should represent different areas of expertise.² Identify important research questions and issues to be addressed.

The Research Director could gather names of researchers and teacher leaders from NCTM leaders such as past and present NCTM Presidents, Board members, committee members, the Executive Director, and staff members. Initial names of researchers might be selected, for example, from JRME past panel members, authors, and reviewers, past Research Committee members, and members of the Catalyst Conference Working Groups. Initial names of teacher leader/engineers will also be solicited from staff, Board members, and possibly NCSM and CPAM (Council of Presidential Awardees in mathematics) and SEPA (Society of Elementary Presidential Awardees). The teacher leader/engineers should be ones who can articulate important research questions, and the researchers should be people from different research areas who have sufficient expertise to know which questions can be addressed with research now available. All of these people could also be invited to suggest questions for practice that they feel are the most important ones to address. The Research Director will coordinate the process of preparing the lists of names and areas of expertise for the President, and the list of questions for the author team. These names can be used to select the author team and also to select members for the Review Panel (two researchers, two teacher/leader engineers). The President will then make appointments to this group of Research Analyses authors and to the Reviewer Panel.

- 1.2 Identify important research questions and issues to be addressed.

Topics for the Research Analyses that answer questions of practice will be selected through negotiations between those who have knowledge of important and frequently asked questions of practice and those who have knowledge of relevant research literatures. The questions identified by selected individuals in 1.1 will provide a starting point for developing such a list. (An example of a list of questions from a mathematics supervisor is provided in Appendix 5.) The goal is to identify an initial set of topics for Research Analyses that are important to practitioners and that have meaningful research-based answers. Negotiations between appropriate members of these two groups will likely be needed to select the first set of questions. Selecting an appropriate set of initial questions will be critical for launching the system of linking research with practice that we are proposing. The Research Director, working with the assistance of the LRP Editor, will be responsible for oversight of this process

² This Task Force Report identifies recommendations and the processes we determined necessary to carry out the recommendations. The small print below each identified process provides details to assist the Board in understanding how each process can be undertaken.

(Note: Processes 1.1 and 1.2 should happen simultaneously, to begin soon after a Research Director has been appointed. After two researchers and two teacher leaders have been selected, the process of determining questions should begin so that final researchers selected are those with expertise in the areas needed to produce the Research Analyses.)

1.3 Arrange for a meeting of the author team, with assignments, to result in high-quality Research Analyses that answer questions of practice identified above in 1.2 (10-15 pages). The LRP Editor and the Research Director (serving as staff liaison) should both participate in the meeting. These documents must undergo a rigorous review because they will set the tone for other work to come, and must be of high quality. Thus, soliciting critical reviews and feedback throughout the process is crucial for establishing and maintaining the high standard of credibility that is essential for the success of this effort.

The author team, with the LRP Editor and the Research Director will commit to a maximum of one summer week for each of two summers in a combination of on-site or virtual meetings (paid as in the manner for development of Standards). Prior to the first meeting, the researchers will prepare drafts of Research Analyses for discussion, then meet with the other members (researchers and teacher leaders) and the LRP Editor to discuss each draft in terms of its implications for practice, and get reactions and suggestions from the teacher leaders for needed changes and editing. The team would meet a second time (perhaps electronically) to discuss the reports. Between 12 and 15 Analyses documents should be prepared in this manner. The LRP Editor will send each document to the LRP Review Panel (see below 1.5), who will review it within one month. If other reviews are necessary due to lack of knowledge of particular bodies of research, the LRP Editor will seek additional reviews, but only if they can be returned within a month's time. After necessary revisions, the LRP Editor will then prepare the Research Analyses for the LRP publication (see 1.5). This process would be repeated during the second year of the project. The LRP Editor and Review Panel will suggest names to the President for authors for the second year, if the LRP Editor and Research Director decide that new authors are needed to ensure that the author team represents a strong cross-section of research interests. The net result of this process will be to produce between 24 and 30 high-quality documents that will be published in six volumes of LRP Research Series during the first three years of this work (see 1.4 below).

1.4 The Research Analyses that answer questions of practice will be used by the Research Director, in consultation with the LRP editor and authors, to prepare appropriate Research Briefs (2-3 pages) that are summaries of the Research Analyses, and appropriate Research Clips (1-2 paragraphs). Additional Research Briefs and Research Clips will be produced and will be based on other reviews of research, such as chapters in the Research Handbook.

The Research Director, in consultation with the authors and the LRP Editor, will be responsible for preparing Research Briefs and Research Clips that contain highlights of the Research Analyses documents, written in forms appropriate for a variety of audiences to include teachers, teacher leaders/engineers, administrators, and policymakers. Other staff members will be involved in the preparation of these documents as appropriate. The documents will be reviewed by the LRP Editorial Panel and/or authors (see 1.5) to ensure that the Briefs and Notes clearly represent the findings noted in the Research Analyses. As with the Research Analyses, soliciting critical reviews and feedback is crucial for establishing and maintaining the high standard of credibility that is essential for the success of this effort.

These documents could be used in multiple ways. The Briefs could, for example, be included in the *NCTM News Bulletin*, appear on the public part of the NCTM Web site, sold in bulk and distributed at professional development meetings or parent meetings, and reside on the Web sites of sister organizations. The clips could serve as "sound bites" that could be used in press releases or as inclusions in documents such the NCTM school journals and journals published by Affiliates. When possible and appropriate, Research Clips will be written to be used for Rapid Responses (described in Recommendation 2).

Appendix 2 contains an example of a Research Brief and Research Clips, written by Dave Barnes and Ken Krehbiel, based on information given to them by Jim Hiebert and based on the Research Handbook chapter written by Jim Hiebert and Doug Grouws.

- 1.5 Create a Linking Research and Practice serial publication for a three-year period. The primary potential audience will be individuals with leadership responsibility in K-12 mathematics education, including secondary school mathematics department chairs, instructional coaches, principals, assistant principals, central office curriculum people, and staff development people. The secondary audience will be teachers, researchers, mathematicians, and policymakers. The publication will be both Web based and in print at least for the three-year evaluation period. The LRP Editor (See the Resources section) will serve as the editor of this publication. An editorial panel of two researchers and two teacher leader/engineers would be appointed by the NCTM President. One issue will be published during the first year, two the second year, and three the third year.

At the end of three years the Board will evaluate the value of the publication and possible transition to a journal.

The LRP Editor and the Review Panel will have been named by the President. The LRP Editor will choose an associate editor to assist in the editing of this publication. The first issue/book will include at least five Research Analyses that answer questions of practice prepared during the first year. As Research Analyses are reviewed, revised, and completed, subsequent publications will be published. The Editorial Panel should review the work of the LRP Editor each year in a manner similar to the review of the JRME Editor.

- 1.6 Determine a process for continuing to solicit Research Analyses that answer questions of practice.

During the second year, a call for submissions to the Linking Research and Practice print publication and Web site could be published in all of NCTM journals and in the newsletter. Submissions could include Research Analyses that answer questions of practice, related Research Briefs, annotated lists of Web sites with research-related information on particular topics of interest to practitioners, presentation of published research reports with a discussion/review of that article for practitioners, reports of the classroom-based trials of the application of particular research results, evaluations of classroom trials of new curricula and new approaches to mathematics instruction, short articles on interpreting research results for use in practice, reports of research undertaken in classrooms by teachers and researchers, and perhaps editorials. A peer-review process will be initiated for all Research Analyses and submissions to the LRP Web site and print publication. *At least* one researcher and one practitioner on the review panel will review submissions, and other reviewers will be asked as appropriate. Reviewers will be given no more than one month to return reviews, which will then be prepared for publication and for the research Web site. During the third year, the viability of continuing this publication in series form or in journal form will be thoroughly explored and decisions made on continuation based on feedback from the field, quality of submissions, and other appropriate measures. (Note: No stipends will be provided for submissions beyond the initial two years.)

Rationale for Recommendation 1: In this age of accountability there is a focus on evidentiary decision-making. Evidence is the product of research, and its usefulness is determined by both the quality of the research and its accessibility to practitioners. Too often this evidence is presented to practitioners in the form of a single research study, sometimes misinterpreted and sometimes not, which is used to support changes in practice. There has been an increasing use of single studies as mathematics curriculum, and instructional practices have become targets of uncommonly vocal critics. By nature,

however, educational research results are the product of bodies of research rather than single studies. Teachers and administrators need to be able to assess the validity of the research cited, to recognize that each study is situated in a larger body of research, and to counteract, when necessary, with evidence from analyzing research from a number of valid studies.

The Research Analyses that answer questions of practice break new ground in education. They are a new kind of scholarship. Mathematics education, and education more generally, has not developed well the kinds of research-based analyses we have in mind. The Research Analyses that answer questions of practice are not simply translations of research into practice, nor are they syntheses of research in particular domains. These Analyses begin with significant and common questions of educational practice and require an intensive analysis of relevant research to provide the most specific evidence-based answers available. As in most fields of research (including medicine, for example), no research-based answers are unequivocal. Consequently, the Research Analyses will describe the conditions under which the effects are likely to be experienced and, if possible, an estimate of how confident the user can be. We are proposing these Research Analyses as the backbone of the system because we believe they provide the best chance of linking research with practice in a trustworthy and sustainable way, and we believe the research and practice communities are ready to develop new levels of capacity and expertise for building these links.

Determining what the larger body of research suggests about the questions of practice arising in mathematics teaching and learning is not an easy task, and analyses that would directly inform such decisions are not currently available. Such Research Analyses need to be targeted to answer important practice-based questions and need to be long enough to allow researchers to present a suitably comprehensive perspective accounting for the various sides of issues. The production of these Research Analyses is at the heart of the plan outlined in this report. The Research Analyses that answer questions of practice described here are intended to address the needs of the practitioner audience by allowing researchers to present a suitably comprehensive perspective. The Research Briefs will be derived by teacher leaders from the Research Analyses and will be the appropriate length and language that can be used with a practitioner audience. Because of their relationship to the Research Analyses, they offer the opportunity to return to the more detailed documents for additional information and references. The Research Clips, also derived from the Research Analyses, are a few paragraphs long and can be disseminated widely, such as in Affiliate newsletters. Briefs and Research Notes can also be written for a policy audience.

Key to encouraging scholars to write Research Analyses is a reputable outlet for their work. An LRP series publication can serve the reciprocal needs of the researcher and the practitioner. If research results are to be useful to teacher leaders, they must be available in a form that is written for practitioners and that is credible to the audiences that increasingly demand evidence-based education. A high-quality publication dedicated to the discussion, interpretation, and dissemination of high-quality research that has clear implications for mathematics teaching addresses this need. This publication can gather in one place print versions of the resources derived from the Research Analyses. Moreover,

if scholars from universities are to be encouraged to submit articles (of the type described), the strategy must tie into their reward structures—they must publish in highly regarded peer-reviewed publications. This LRP series publication could serve as a viable outlet for colleges and universities that increasingly are recognizing their responsibility to contribute positively to K-12 education. The LRP series publication will provide a vehicle for the continuation of researcher involvement in producing research analyses to answer questions of practice by providing a credible outlet for their work. Also, having this venue for publishing peer-reviewed articles will be attractive to researchers and should have an effect on how they think about and design their research. Finally, this will give teacher leaders a way of linking with researchers to examine practice and reporting on links between research and practice.

Additionally, there is currently no place in NCTM’s current portfolio for the kind of responsive reporting envisioned for the Research Analyses and the LRP research publication.

- JRME has too long a turnaround time, and it is not written for the non-researcher consumer. Its integrity and reputation as a research journal places it as one of the top mathematics education research journals in the world, and it cannot maintain this status if it adopts additional not entirely compatible goals.
- Many of the genres to be included in the LRP publication, including the Research Analyses, are not appropriate for publication in the Journal for Research in Mathematics Education (JRME) or other NCTM journals. These journals are highly successful in attaining their current goals, and it would not be possible to adapt their missions to the extent needed to serve the teacher-leader and researcher audiences.
- Mathematics Teacher (MT), Teaching Children Mathematics (TCM), Mathematics Teaching in the Middle School (MTMS), and ON-Math do not reach the middle-manager, principal, and curriculum audience because their articles are typically intended for use by the classroom teacher. The few research-oriented articles will not be enough in content or length to interest these audiences who have specific need for information about the results of research.
- The audiences reached by these products will be those who have the authority to implement findings. These audiences need a publication that is clearly research-based.

The actions recommended here are at the heart of our response to the charge we received.

Other recommendations proposed below will depend on elements described in this recommendation, which addresses all four parts of our charge.

Recommendation 2. Develop a Rapid Response Process for Presidential and Council Communication.

Actions: To establish a collection of Rapid Responses that can be used to provide answers to research questions of an urgent nature, to name Senior Advisors to the President on Matters of Research who will assist the President in answering urgent questions for which answers are not in the collection, and to produce “sound bites” that can be used to respond to questions for which there is no research answer. These three

measures allow the Council to provide rapid responses to research questions they receive or issues that need to be quickly addressed.

Processes: This rapid response strategy would have the following elements:

2.1 The present and past NCTM Presidents, Executive Director, and staff will generate a list of questions for which NCTM is likely to need credible (high-stakes) answers in the near future.

2.2 A Rapid Response Process will be initiated.

Senior Advisors to the President would be appointed for terms of two years (the first year with secondary responsibility, the second year with primary responsibility). Two advisors will be appointed in each of the major research areas that cover the most likely questions to be received by the President. The Senior Advisors will prepare brief responses to the questions identified in 2.1.

For urgently needed responses to questions not addressed by the statements in the initial collection of Rapid Responses, the Senior Advisors must make a commitment to respond to questions urgently in need of a response within 24 hours or less at the request of the NCTM President. The Senior Advisor with primary responsibility will receive questions and respond appropriately. When the response is difficult to compose or when the response is especially “high stakes,” both Senior Advisors in the relevant area will negotiate a consensus response. Senior Advisors with secondary responsibility will be copied on all correspondence to ensure continuity when they assume primary responsibility. The Communications Director and the Research Director will receive copies of requests and responses so that responses can be edited as necessary. RC, JRME Editor and Panel, the Research Director and the LRP Editor will provide the President with names of researchers as initial and replacement appointments are made. Responses will also be placed in the Rapid Response collection.

2.2 A set of Rapid Response messages will be collected and will reside in the Virtual Research Library.

The brief responses prepared by the Senior Advisors as described in 2.1, and the Research Briefs and Research Clips developed in response to Recommendation 1 will be available through the Virtual Research Library. They will be used to create “sound-bite” size research findings. The NCTM Research Director and LRP Editor will approach individual researchers for assistance in preparing other quick responses as new questions are received by the President and NCTM staff. The Communications Director will assist with format and wording of responses that will be used in public arenas.

2.3 Some general responses will be developed by the Research Director in consultation with the LRP Research Editor that could be used for a variety of questions for which we do not have research clips. For example, if the President is asked whether children receive a better mathematics background in charter schools, she or he might respond by saying: “Research on the effects of charter schools is mixed. There is no evidence that students will or will not receive better mathematics instruction in charter schools. But there is evidence on the kinds of instruction that facilitates students’ mathematics learning, whether it occurs in a charter school or in any other kind of school. If you want students to develop solid conceptual understanding of mathematics, research says that instruction should spend some time discussing and investigating the key concepts and should challenge students to grapple with significant mathematical concepts and procedures.”

Rationale for Recommendation 2: The President and staff receive many requests for information about research for which they do not have answers. The President, in particular, receives high-stakes questions that need immediate answers. The need to respond in a timely manner to requests about research, or to proactively make research-based claims, depends upon having research available in a form that can be used without delay.

Recommendation 3. Undertake initiatives that will support practitioners' understanding and use of research.

Action: Two new books are to be published. The first book would be a practitioners' guide to reading and interpreting mathematics education research, the other would focus on linking policy and administration with teaching and learning mathematics. The books could be viewed as the potential beginning of a new series of books about research.

A day-long Conference Minicourse will be developed for each of the next three Annual Meetings and Expositions that focuses on the topics in the books and in the analyses papers. Finally, a special session will be offered at the Research Pre-session, offered by teacher leaders/engineers, to focus on the research questions that are needed to improve classroom practices.

Processes

- 3.1 A new book (approximately 64 pages) will be written to focus on helping practitioners read and understand mathematics education research. The authors to be selected should include a researcher familiar with the contents outlined here, and a practitioner who would ensure that the contents are in a form helpful to the audience for this publication. This publication would include information about research that practitioners need to better understand the role of research in their work. The Research Committee will advise on authors for this book and will serve as reviewers to ensure that the book meets the needs of its audience.

This book would include topics such as:

- The types of questions research can and cannot answer,
- A description of research models and methods,
- The means of developing a critical lens needed to ascertain the validity, reliability, and more generally the credibility of research reports,
- Examples of studies that provide different ways of using research (e.g., interpreting findings, using research tasks in one's own classroom, developing new constructs helpful in one's work such as Skemp's relational and instrumental understanding of mathematics),
- Responses to frequently asked questions such as: If a study is 10 years old, are the findings still valid? What does it mean to be "peer reviewed"? What does it mean to be a peer-reviewed journal? Are these studies more trustworthy than those in non peer-reviewed journals?
- Knowledge of how to respond to administrators, parents, and others who bring in requests to change practice based on research they have read,
- Information on how to search for research on a particular topic, and
- Last but not least, a glossary of terms used in research reports.

3.2 A new book (approximately 64 pages) will be written to focus on the use of research within the confluence of policy and administration with teaching and learning, as related to mathematics education. Authors should include a researcher whose primary interest is in the nexus of teaching and learning of mathematics, a researcher whose work focuses on policy and how it is developed and interpreted, and a teacher leader who can work with the researchers to ensure that the book is written in a manner as to speak to its intended audience. The Research Committee will advise on authors for this book and will serve as reviewers to ensure that the book meets the needs of its audience.

The book would include topics such as:

- How research gets translated into practice;
- Effectively communicating ideas about linking research with practice for teachers, to administrators, to school boards, to parents, and to the community;
- Why changes in practice should be made on the weight of evidence over time rather than on the results of one study;
- Examples of ways in which research and practice are linked, such as the study of curriculum effectiveness in the Pittsburgh Public Schools;
- How textbooks have been evaluated by national groups and reasons for disparate evaluations;
- Promising research-based practices in mathematics education;
- The need for evidence-based answers to questions of practice;
- Data-driven decision making;
- Ways that teachers can undertake research in their own classrooms, and
- How to take advantage of the NCTM Virtual Research Library.

3.3 A Research Minicourse on finding, reading, and using research to change practice will be developed and offered at the 2006 Annual Meeting and Exposition. Two more additional minicourses will be offered at the 2007 and 2008 Annual Meetings and Expositions. The minicourses would be based on the products of our previous recommendations. Topics will vary depending on new information available in the Virtual Research Library and information published in the two books. After the third year, the minicourses will be evaluated for continuation.

3.4 Teacher leaders/engineers (perhaps those involved in the writing of the books or in the development the Research Analyses that answer questions of practice) will design and present a session at each of three Research Presessions, beginning in 2006, that provides researchers with information on what types of research questions need to be addressed to improve teaching practices and student learning.

Rationale for Recommendation 3: The first book would deal with issues that will help teacher leaders deal with basic questions regarding research.

- Teachers are receiving more questions about research and being asked (often told) to change practice based on research. They need to be able to access information that may either support or refute the research cited.
- The ways in which teachers view themselves professionally change over time, and one of the ways this is exhibited in later years is through an interest in research. Conference sessions dealing with research have been well attended. But teachers can become discouraged when reading research reports due to the detail and language used; they need help in knowing how to find, read, and interpret research reports.

- Opponents and proponents of standards-based research tout research and teachers, and administrators need to be able to weigh sides.
- The placement of parts of this text on the public Web site might entice principals and other administrators to use the NCTM Web site and to join NCTM, particularly if these resources are advertised in journals read by administrators.
- The publication of this book would assist teachers in using research and in making informed decisions, and thus relates primarily to the first and third charges.

The second book would be a follow-up to the first book, and would deal more with issues that teacher leader/engineers need to understand to do their work:

- To do their work this audience must be able to interpret research for the teachers with whom they work.
- Demands of NCLB create a need to support teachers in raising scores while simultaneously not giving up on good mathematics teaching practices.
- This type of resource does not now exist.
- NCTM is best positioned to produce such a publication.

Judging by current teacher interest in the Research Pre-session and in conference sessions on research, there should be no problem in offering and filling such a session, with an additional conference cost. The Research Minicourse could be built around the products recommended here: the two books described, the Research Web site with access to our products but also to linked Web sites, and the LRP research publication. It should not overlap any National Council of Supervisors of Mathematics (NCSM) conference offerings if possible, and could, in fact, be jointly offered by NCTM and NCSM.

The Research Pre-session provides a venue for researchers to hear from teacher leaders/engineers the questions they need answered. There is also the opportunity to link particular researchers with particular practitioners to seek answers to these questions.

All four parts of the charge are addressed by the development of these initiatives.

Recommendation 4. Create structures that ensure alignment of current materials and activities with the new components of these recommendations.

Actions: Design a fully coherent process to ensure alignment of NCTM research activities. Design a Research Web site and other mechanisms to carry out research activities in a friendly, usable, and coordinated manner, intended to serve current members and attract new members. Outcomes of this alignment would include providing consistent and reinforcing information on research-to-practice links across the range of NCTM publications and activities, and coordinating the timing of the release of information through a variety of outlets.

Processes:

- 4.1 To develop a process by which all of NCTM's research-related activities are aligned. All of the above processes, including the development of Research Analyses that answer

questions of practice, the Research Briefs and the Research Clips, the rapid responses, the messages in the books and minicourses, the research articles in the school journals, the newsletters, and research sessions at conferences—should be aligned so that the various forums in which NCTM publishes “research to practice” information are coordinated. For example, if TCM has an article on what research says about teaching place value, and the NCTM annual meeting has a series of planned research sessions on young children’s arithmetic, and a research analysis has been written on strategies for teaching multi-digit addition and subtraction, all three forums should be coordinated to build on each other where possible.

The Research Director would be primarily responsible for coordinating this alignment activity through work with school journals, conference planning, the publication of the Research Analyses, and the development and dissemination of Research Briefs and Research Notes. The work could also include assisting in the selection of Research Briefs in the NCTM newsletters, sending Research Clips to Affiliates for publication in their newsletters, and working with RC to design research sessions at conferences around specific Research Analyses that have recently been developed.

4.2 To develop a Research Web site, linked from NCTM’s home page. This site would serve a clearinghouse function, and will contain a searchable database around questions of practice. This Web site would contain the following:

- The items in our Virtual Research Library, including the Research Analyses, Research Briefs, and Research Clips, all aligned as in 4.1
- Links to external sites.
These links would be carefully selected, and would be organized and described in ways that would focus on specific questions or topics. All links must contain research-to-practice information, and be aligned with NCTM research activities and messages as described in 4.1. These linked Web sites fulfill a clearinghouse function for users, and would *de facto* represent endorsements by NCTM. Links might include, for example, selected pages on sites for
- NSF funded Centers for Learning and Teaching, which have as their primary function the development of new researchers through their doctoral programs and of linking the research undertaken at the Centers with important questions of practice.
- Other NSF and Department of Education Centers, such as the Center for Teaching and Policy.
- Links to sites of sister organizations, such as the American Educational Research Association (AERA).
- Links to internal sites, as appropriate, to include
 - JRME, particularly the Commentary section, when appropriate
 - RC activities
 - Journal articles linking research and practice
 - Catalyst Conference proceedings
 - Catalog of NCTM research publications

Rationale for Recommendation 4: Current materials and activities that convey research implications and link research with practice must be re-conceptualized to find ways of reinforcing messages that are developed through building the Virtual Research Library. Aligning all NCTM current resources to reinforce and convey consistent messages that are generated through the system we are proposing will greatly amplify the impact of

indicated by Arrow 4, and would primarily address the flow of information indicated by Arrow 5

Recommendation 4. Create structures that ensure alignment of the different components of these recommendations. All parts of the diagram will be affected by this last recommendation.

The system we are proposing is intended as a coherent and aligned system, not a list of activities from which to pick and choose. It is comprehensive and bold because the prevailing political climate has placed research at the forefront of practitioner needs. NCTM has an opportunity to take advantage of this current sea change in the education climate and become the leader in providing this much-needed information to practitioners. Simultaneously this effort will influence the questions addressed by researchers. Because it is an interrelated system, its effectiveness depends on all components being maintained.

Essential Resources for Carrying Out This Initiative

1. A full-time Research Director staff position should be created with a search to begin as soon as possible.

The responsibilities associated with this position could include the following:

- Develop processes to assist the Council in aligning activities and products for research-related work.
- Oversee the development of the Virtual Research Library.
- Coordinate the Rapid Response process.
- Prepare/edit Research Briefs and Research Clips based on Research Analyses and other research summaries such as Research Handbook chapters, with appropriate consultation with authors and LRP Editor, and with other headquarters staff such as the Communications Director.
- Become a liaison to RC and to the LRP Panel.
- Work with LRP Editor to ensure the timely flow of Research Analyses manuscripts.
- Manage Web site research content and links.
- Coordinate products, activities, and the research Web site with other departments.
- Determine ways of making research more visible during conferences.
- Work collaboratively with RC in coordinating NCTM research efforts.
- Explore and recommend relationships/partnerships with sister organizations, Centers for Learning and Teaching, centers that focus on policy, and other centers and organizations as they develop.
- Work with funding agencies to promote funding for projects that link research and practice.
- Play a research advocacy role within NCTM.
- Work with the Board and staff to ensure that decisions made regarding teaching, learning, assessment, curriculum, and professional development are, when possible, research-based.
- Coordinate budget for research activities that result from the work described in this document
- Strategic planning
- The Research Director may also be involved, as appropriate, in the design and implementation of evaluation strategies for products and activities.

Preferred qualifications for Research Director include

- Advanced degree in mathematics education or a related area emphasizing mathematics education
- Well acquainted with the mathematics education research field
- Active participant in mathematics education research community
- Knowledge of NCTM activities, mission, and organization
- Communication skills

- Knowledge of schools and of mathematics teaching, learning, and curriculum
- Experience working with teacher leaders
- Understanding of the work of various funding agencies
- Project management experience

The search process could begin by soliciting applications for this position through advertisements on the NCTM Web site, in the NCTM newsletter, and through the AERA Special Interest Group for Research in Mathematics Education. An announcement of this position could be made at the Research Presession. The hiring should take place according to NCTM headquarters procedures. The Executive Director can, if he or she so wishes, ask members of the mathematics education research community to review applications and make recommendations.

Rationale for this position: The Research Director's position is well defined here in terms of all aspects of this initiative. To establish NCTM as the national leader in linking mathematics education research and practice, the research initiative needs to be carefully coordinated so that it permeates all of NCTM's work. This need precludes being able to distribute the responsibilities of the Research Director among other staff members and necessitates the Research Director working across current departments at NCTM Headquarters. There is far too much work involved for other staff members to undertake in addition to their other responsibilities. In addition, creating this position at the Director level will enhance the image of NCTM as serious about the manner in which research undergirds its activities. Finally, the initiative described here can flourish only if there is continued attention to the activities described here, with an evaluation process, and new initiatives undertaken as need arises.

2. An off-site Linking Research and Practice Editor (LRP Editor) will be hired 100% for one semester, 25% for each academic semester thereafter. The Editor's institution will be expected to provide some matching time for this work. The Research Editor would also receive some funding for secretarial support.

(NOTE: It may be necessary, because of time constraints and university regulations for early requests of a one semester leave of absence, to hire the LRP Editor 50% for the first year, and 25% thereafter.)

The responsibilities associated with this position include

- Assist in the identification (see Recommendation 1) of topics/questions/problems for evidence-based Research Analyses for the initial development of these documents.
 - Take primary responsibility for the development and editing of Research Analyses that address questions of practice.
 - Work collaboratively with headquarters staff, the Research Director in particular, in developing the Linking Research and Practice series publication.
 - React to Research Briefs and Research Clips prepared by the Research Director
 - Develop a process for solicitation and submission of additional (after Year 2) Research Analyses that address questions of practice, including identification of authors and invitations to write (with the understanding that all submissions will be rigorously reviewed).
 - Oversee and manage refereed process and editing for LRP Publication Series.
 - Serve as ex-officio member of the Research Committee.
- The LRP Editor would serve for a renewable three-year term.

Preferred qualifications for Research Editor include

- Earned doctorate in mathematics education or related area
- Editorial experience
- Research record in mathematics education

- Active participant in mathematics education community
- Knowledge of NCTM activities and mission and organization
- Ability to communicate research to practitioners
- Organizational and writing skills
- Knowledge of schools and of mathematics teaching, learning, curriculum, and assessment
- Ability to communicate broadly across communities

The search process for the LRP Research Editor can begin by soliciting applications for this position through advertisements on the NCTM Web site, in the NCTM newsletter, and through the AERA Special Interest Group for Research in Mathematics Education. An announcement of this position could be made at the Research Pre-session if possible. For the first LRP Editor, the applications should be reviewed by the members of RC and members of the JRME Panel and recommendations made for two (perhaps three) candidates to be interviewed. A special meeting of RC should be held in the late spring/early summer of 2005 during which top candidates could be interviewed and a recommendation made to the NCTM President for filling this position.

The necessity of timely production of research analyses that answer questions of practice to allow for associated Research Briefs and Research Notes, and timely publication of the Research Series, requires that the LRP Research Editor agree to a schedule of production of Research Analyses. The Advisory Board/Review Panel (see 1.4) should review yearly the work of the LRP editor in this regard and, when necessary, make recommendations to the President for changes.

Rationale for Linking Research and Practice Research Editor: It is vitally important that the Research Analyses to address questions of practice, and the associated Research Briefs and Research Clips, be credible and written well to gain respect from the research community. This cannot happen without a respected researcher in this position. We suggest 100% time for one semester so that the development of the research analyses papers can begin immediately,

We anticipate that a researcher from a university could work full time for one semester by taking a leave or sabbatical from the university for that period of time, then have 25% of her or his salary bought out by NCTM, with additional university support, similar to what occurs with the JRME editor. The LRP Editor would receive some support to be used toward secretarial assistance.

3. Additional ways will be discussed and planned by RC to make research a more central focus of annual and regional meetings. For example, the last day of the Pre-session/first day of the regular meeting could be set aside for research activities that may be a part of the mini-courses, or may be other types of activities, such as meeting with a teacher undertaking classroom research (action research) or lesson study. Also, RC can offer sessions during the Research Pre-session for researchers interested in linking their work to practice.

Rationale: This type of activity is already being considered by RC, but the system described here will present more options.

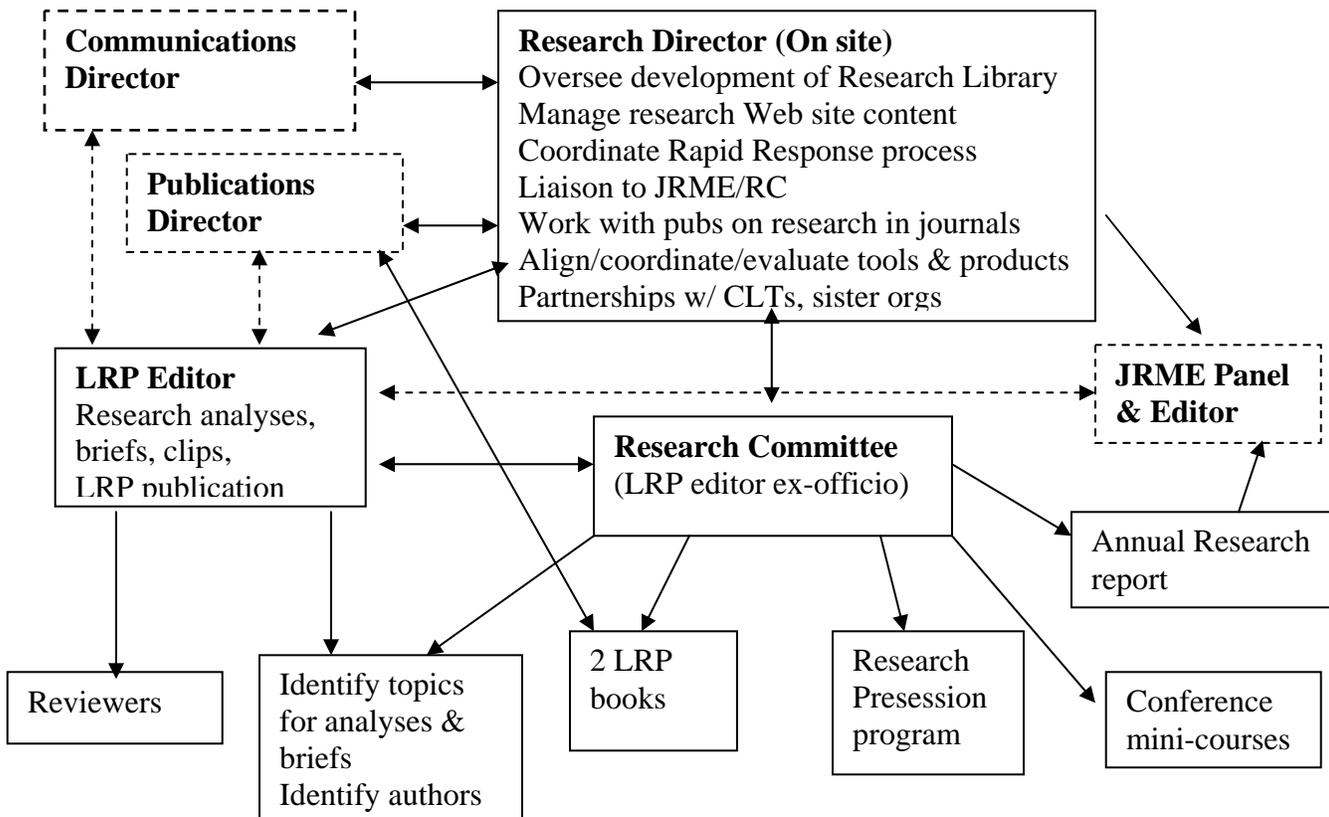
4. The responsibilities of the Research Committee should be revised to undertake the work outlined here to include: identifying research questions and issues to be addressed as described above, identifying authors of Research Analyses and Research Briefs as described above, assisting in the selection of book authors and serving as reviewers of the books described in Recommendation 3, and selecting a teacher leader/engineer to speak

to researchers during the Research Pre-session. RC will work closely with the Research Director to undertake the recommendations listed in this initiative.

Rationale for new RC responsibilities: The Research Committee already exists, and the responsibilities outlined here are appropriate for this committee. The work during the first year will be demanding, and we thus request funding for an additional meeting for RC.

5. The Research Director should work in an advisory capacity with other NCTM Directors. For example, the Research Director could work with the Communications Director in preparing Research Briefs and Research Clips for policymakers, as in the manner that Ken Krehbiel and Dave Barnes worked with Jim Hiebert to prepare the briefs and notes that are contained in the first appendix. The Research Director could serve the Publications Department by pointing to particular analyses, briefs, and notes that might be appropriate for publication in journals by providing information and names of authors, and by reviewing research reports. The Research Director could meet regularly with other staff to discuss issues of alignment of research messages as described in Recommendation 1.
6. Dissemination to a broad variety of audiences will depend on staff work. The type of efforts we recommend will be relevant to sister organizations and policymakers, and those connections will need to be made.

This diagram shows how the various components of the recommendations and resources are linked.



Evaluation of Research Initiative

The success of a research-based initiative, of any kind, is fully dependent on continuing and relentless evaluation and revision. Just as improvements in the research-based recommendations for practice depend on gathering new and updated empirical data, so do the improvements in the initiatives we propose depend on evaluating their success and feeding the information back into the system. Beginning in Year 3, at the latest, we suggest that a task force be named to evaluate all aspects of this initiative, and make recommendations to the Board of Directors regarding improvements in the system. Improvements might come in the form of the structure of the system outlined in our recommendations, in the processes used to implement particular components of the system, in the reallocation of resources in order to readjust the emphases given to different components, and so on. Over the long run, we expect this kind of evaluation to take place on a regular and continuing basis.

Criteria for evaluations will include:

- Preparation of at least 20 Research Analyses that answer questions of practice. That is, these documents must represent the best thinking in the field on questions of practice and have been carefully reviewed. Preparation of Research Briefs and Notes based on the Analyses.
- Appropriate dissemination of above documents.
- Publication of at least two books in LRP publication series, with two additional books in preparation.
- Two books in press that focus on teachers' understanding of research.
- One successful minicourse at Annual Meeting and Exposition and another in planning stage.
- Success of Rapid Response process, based on analyses by Presidents and Executive Director.
- Development of Virtual Research Library as a link on the NCTM Web site.
- Success of the Research Publication Series. Should this series be continued? If so, in a journal or in a book format?

Task Force Motion: That the interrelated set of recommendations described here, and viewed as an integrated system that links research and practice within the mathematics education community, be accepted.

Rationale: The system we are proposing is intended as a coherent and aligned system, not a list of activities from which to pick and choose. It is comprehensive and bold because the prevailing political climate has placed research at the forefront of practitioner needs. NCTM has an opportunity to take advantage of this current "sea change" in the education climate and become the leader in providing this much needed information to practitioners. Simultaneously this effort will influence the questions addressed by researchers. Because it is an

interrelated system, its effectiveness depends on all components being maintained.

Systems that change cultures, that launch and sustain initiatives that place NCTM into new positions of leadership, do not come cheap. We thus argue for adopting this plan as a whole.

NOTE 1: The books and the minicourses should increase revenue. Documents on the Web site, unavailable to non-members, could be obtained at cost. If this venture is successful there will be an increase in membership.

NOTE 2: The decisions about what information should be available on the public part of the NCTM Web site and what should be restricted to members will be a decision of the Board with staff input. But the task force members think that as much information as possible should be available to the public. Perhaps, for example, Research Briefs could be public, but the Research Analyses on the member site.

Appendices

1. Rationale for Charge to Task Force
2. Example of a Research Brief and Research Clips prepared by James Hiebert, Dave Barnes, and Ken Krehbiel.
3. Example of a Research Brief from the American Educational Research Association Web site.
http://www.aera.net/uploadedFiles/Journals_and_Publications/Research_Points/RP_Summer04.pdf
4. Example of a Research Brief from the National Center for Improving Student Learning and Achievement in Mathematics and Science Web site.
http://www.wcer.wisc.edu/ncisla/publications/briefs/InBrief01_04.pdf
5. Examples of types of questions of practice that would be the subject of Research Analyses documents. (This sample list was generated by Matt Larson, a member of this Task Force, and a mathematics coordinator a teacher leader/engineer.)
6. Three-Year Timeline

Appendix 1

Rationale for Charge to Task Force

The prevailing patterns of curriculum, teaching, and assessment in school mathematics are shaped by a combination of traditional practices, experience-based judgments by teachers, advisory standards from professional organizations, and guidelines based on theoretical and empirical research in mathematics education and cognate disciplines (including psychology, anthropology and sociology). The past decade has seen a significant increase in efforts to transform the balance of these influences so that educational practice is more commonly based on principles that have been validated by empirical research.

The mathematics education research community has responded to this demand for research-based guidance of practice with unprecedented levels of research activity that addresses basic questions about the effects of various curriculum, teaching, and assessment practices. Support from the National Science Foundation and the Institute for Education Science has enabled a broad program of research studies that promise useful insights for practice in mathematics teaching, assessment, and teacher development.

However, translation of research findings into advice for day-to-day practice in classrooms is a daunting challenge. The American mathematics education enterprise is a loosely-coupled community that includes tens of thousands of schools and hundreds of thousands of teachers. Those schools and teachers are so busy with regular teaching responsibilities that they have little time for or experience in reading scientific research on teaching and learning—much less translating those findings into reforms of everyday practice. Yet, more so than ever before, teachers and schools feel the need for research-based recommendations to enhance their abilities to provide high-quality mathematics education for all students.

Current and recent efforts have begun the work of informing teachers and schools about research in mathematics education. These efforts include sections in NCTM practitioner journals as well as NCTM research-based publications, but these efforts have fallen far short of addressing the need for a viable strategy for informing practice with research. Instruction-based personnel (in schools, at district levels, and in state department) find it difficult to find out what research has to say about the questions of greatest concern to them. The uneven quality of advice available on the Web and the incomplete nature of advice available in “research into practice” publications contribute to the feeling that there is no current feasible strategy for building instructional decisions on a reasonable research base. Government efforts to provide such a research base have been far too narrowly focused to be useful to classroom teachers. The “What Works Clearinghouse” is aimed at identifying studies that result in improvements in student achievement. Having examined 70 studies to date and focusing on randomized trial experimental designs, the WWC has identified only one study (an unpublished dissertation) that met its criteria for inclusion.

If the substantial national investment and promising results from recent and current research are to have payoff in improved mathematics education practice and student learning, strategies need to be developed for synthesizing and communicating research results in ways that can be used by school practitioners. The most natural organization to assume that responsibility is the National

Council of Teachers of Mathematics. The NCTM membership includes nearly 80,000 classroom teachers, teacher educators, school system program leaders, and educational researchers. Service to schools and teachers is central to the NCTM mission, and the Council's publications and professional meetings reach a significant number of North American and international mathematics teachers.

Coupled with the problem of translating research into practice is the problem of defining research problems that are likely to be of ultimate use in mathematics classrooms. In order to achieve this practice-into-research goal, teachers and researchers (those whose primary responsibility it is to teach and those who have a primary responsibility for research) need to collaborate in the development of researchable, generalizable, and useable questions on which research might focus.

To enable NCTM to significantly enhance its role in the translation of research into practice and practice into research as well as the improvement of school mathematics, the Council should create and operate a Linking Research and Practice structure.

Timeline: The Task Force will meet two times (in Reston to maximize the opportunity for staff input as needed). Report to the Board by January 15, 2005

Appendix 2

Example of a Research Brief and Research Clips prepared by James Hiebert, Dave Barnes, and Ken Krehbiel

Teaching Strategies for Developing Student Understanding

Understanding important math concepts and skills is a key to student learning. A solid foundation of understanding supports students' future learning through

- Greater retention of what they have learned,
- Greater ability to learn new information and skills, and
- Increased flexibility in using what they know in new situations.

Taking time with students to help them to develop their understanding of key math concepts, along with practicing and applying procedures, while initially requiring additional time, ultimately results in significant direct benefits to learning and time savings (Hiebert & Carpenter, 1992; National Research Council, 1999, 2001).

When people really understand something, which is to say they see how it works and how it fits together with other things they know well, they are much less likely to forget it. This means less time needs to be spent on review and improving retention. This understanding also allows people to adjust what they know to fit new situations. In such cases students do not need to be taught a new procedure to solve every kind of problem, especially those that are actually related but look different on the surface.

What research-based strategies are available to develop student understanding?

Two key instructional strategies are linked to the development of students' mathematical understanding:

- Taking time during lessons to intentionally and explicitly talk about and work on the key *ideas* or *concepts* of the lesson.
- Engaging students to grapple on their own with at least some aspect of the important mathematical ideas.

Intentionally and explicitly talk about and work on the key *ideas* or *concepts*.

Some class time should be spent on the following types of activities.

- **Examining relationships between facts, procedures, and ideas within a lesson and across lessons.**

Examining Problems: How are problems that are being solved similar to and different from each other? Is one problem a special case of the preceding problem? Is it a general

case of a preceding problem? How are the problems today similar to and different from the problems yesterday?

Examining Representations for the same idea: If manipulatives are used to represent arithmetic problems, how are manipulatives similar to and different from the written process? How do the various forms of linear equations and the graphical representation communicate different information?

- **Examining the reasons *why* procedures work like they do.**

Have students spend some time discussing why the procedures work. For example, why do we usually add from right to left? Could we add left to right? What would happen? Would that work for some problems, or for all problems? When we solve an equation, why must we do the same thing to both sides?

Discussing the answers to questions like these can help students remember the procedures better and apply them more accurately. Understanding why procedures work can also be facilitated by examining the connections between procedures that are carried out with physical materials (or other alternative representations) and written symbols.

- **Examining similarities and differences in procedures that can be used to solve the same problems.**

Most math problems can be solved in more than one way. While asking students to solve problems using more than one procedure can, itself, help students understand the problem and its solution more deeply, spend time examining how the procedures are similar to and different from each other. Through this analysis students gain a better understanding of how the procedures work, as well as the math problem they are working to solve.

Using these types of instructional strategies will help develop students' understanding by connecting what students are learning with what they already know and fitting the content together in ways that make sense. Creating these kinds of relationships is one of the surest paths to building understanding (Brownell, 1935; Hiebert & Carpenter, 1992).

These strategies are supported by a variety of studies on different mathematical topics with different ages of students (including Brownell & Moser, 1949; Fawcett, 1938; Fuson & Briars, 1990; Good & Grouws, 1979; Heid, 1988; Hiebert & Wearne, 1993). One noteworthy point from these studies is that no single instructional style is required. Both teacher-centered and student-centered approaches can facilitate understanding if students are regularly engaged in the kinds of activities described above.

Grapple with some aspect of the important mathematical ideas.

Engaging students to grapple with at least some aspect of the important mathematical concepts and procedures to try to figure out how things work and to make sense of things changes the learning process. This means creating situations where students do serious mathematical

thinking. This complements settings where students are presented the information with all the problematic aspects of the mathematics removed.

Allowing students to work hard to make sense of mathematics means providing time during the lesson when students are allowed to work on problems they don't immediately know how to solve, and it does mean resisting the temptation always to jump in and tell students how to do something at the first sign of uncertainty. It does not mean standing by while they become unnecessarily frustrated and confused, nor does it mean presenting problems that are well beyond their reach. Grappling with important mathematics is the opposite of being presented with information to memorize or practice.

Mathematics problems of many kinds can be posed in ways that allow students to grapple with, and explore, the underlying mathematics. First graders can be presented with simple arithmetic story problems and allowed to work out sensible solution procedures. Second or third graders who have learned to subtract numbers like $385 - 157$ can be presented with problems like $305 - 157$ (a zero in the minuend) and asked to solve the problem based on what they already understand. Seventh graders can be asked to measure with a protractor to find the sum of interior angles in a triangle, in a quadrilateral, in a pentagon, and then asked to predict the sum of angles for a hexagon and for an n -gon. The point is to identify the key mathematical ideas in a lesson and consider structuring the lesson or part of a lesson to allow students to explore some of these without providing immediate rules and answers.

Developing understanding through resolving perplexities or dilemmas that cannot be immediately sorted out is supported by many learning theories (Dewey, 1910; Festinger, 1957; Hatano, 1988; Skemp, 1971). Grappling with perplexing situations often results in rethinking ideas and creating new and better explanations for how things work. Mathematicians, not only cognitive theorists and educators, also have noted the importance of struggling with key mathematical ideas in order to understand them more deeply (Polya, 1957). The benefit of this instructional strategy on students is supported by a number of research studies (Boaler, 1998; Hiebert et al., 1996; Stein & Lane, 1996). Teachers who have had considerable experience promoting students' understanding have described the details for guiding students as they wrestle with key mathematical ideas (Heaton, 2000; Lampert, 2001).

Research conducted over the past 75 years, which spans a wide range of math topics, age groups and class settings, indicates that the proper implementation of these strategies by effective teachers will result in better student learning with a deeper mathematical understanding. Unfortunately, these two teaching strategies are largely absent from most mathematics classrooms in the United States (Hiebert et al., 2003; Rowan, Harrison, & Hayes, 2004; Weiss, Pasley, Smith, Banilower, & Heck, 2003).

Note: For a more complete development of these research-based recommendations, see Hiebert and Grouws (in preparation).

Next steps

1. Train teachers, math coordinators, teacher educators, and preservice teachers to develop concepts explicitly and to pose appropriate problems and structure lessons so students can grapple with mathematical ideas.

2. Use curriculum materials which provide sufficient opportunity for concept development and engagement of students in mathematical thinking.
3. Promote the development of mathematics curriculum materials at all grade levels which consistently address these strategies
4. Create learning environments in schools and with teachers, students and parents which values understanding of mathematics concepts.

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Research Clip 1.
**What Research Says on
Developing Student Understanding**

Research points to two strategies to increase students' mathematical understanding.

- **Intentionally and explicitly talking about and working on the key *ideas* or *concepts* during lessons.**
- **Supporting students in grappling with some aspects of the important mathematical ideas.**

Time needs to be spent during math classes on the key mathematical ideas and concepts, including developing why procedures work, connecting ideas across lesson, examining and developing the relationship between facts, procedures and concepts, and analyzing similarities and differences among problem types and solution procedures.

Students also need to be given regular opportunities to grapple with some math ideas—to figure out how things work and to make sense of things. While counter to the process of laying out all the steps for students, grappling with important mathematics results in better understanding.

These strategies provide students with the opportunities and expectations to think about and make sense of the mathematics. These strategies are not dependent on a specific teaching style, and they can work for both teacher-directed and student-centered instruction.

These strategies are supported by research conducted over the past 75 years, which spans a wide range of math topics, age groups, and class settings.

For more information see #####

Research Clip 2.
**What Research Says on
Time Spent on Concept Development**

Taking time with students to develop their understanding of key math concepts, along with practicing and applying procedures, while initially requiring additional time, ultimately results in time savings and direct benefits to learning.

While it may be counterintuitive, expanding the focus from skills development to include conceptual understanding positively affects skill development and retention. *Understanding* important math concepts and skills is a key to student learning and supports students' future learning through

- Greater retention of what they have learned,
- Greater ability to learn new information and new skills and
- Increased flexibility in using what they know in new situations.

When students really understand something, which is to say they see how it works and how it fits together with other things they know well, they are better able to remember it. This means less time is needed on review and improved retention. Understanding also allows students to adjust what they know to fit new situations. This supports the learning process because students can consistently build on their previous knowledge.

Research supporting these findings can be found in Hiebert & Carpenter, 1992 and National Research Council, 1999, 2001.

For more information and related topics see #####.

Appendix 5

Questions for Research Analyses

Questions that Apply to All Levels

1. How should students be grouped for instruction?
2. How much time should be devoted to instruction (length of a period)?
3. Is cooperative learning an effective strategy?
4. Should teachers use direct instruction?
5. What instructional strategies will encourage mathematical reasoning and problem solving?
6. What questioning techniques are most effective in the classroom?
7. How do you motivate students to learn mathematics?
8. How often should student learning be assessed?
9. How does teacher content knowledge affect student learning?
10. How can assessment be used to improve student learning?
11. How does U.S. student achievement compare to that of other countries?
12. What role do reading and vocabulary skills play in mathematics learning?
13. What role does writing play in mathematics learning?
14. What role does discussion play in mathematics learning?
15. Are basic skills still important in mathematics instruction?
16. What factors contribute most to students learning mathematics?
17. What are characteristics of effective homework practices in mathematics?
18. What amount of instructional time should be devoted to skills, concepts, and problem solving?
19. Are all-girls or all-boys mathematics classes more effective than mixed groups?
20. Should gifted and talented students receive an accelerated or enriched curriculum?

21. How do you effectively teach students to solve word problems?
22. What are the effective instructional strategies of Japan and Singapore? Can they be implemented here?
23. Why do U.S. math books seem to have so many errors?
24. What role do manipulatives play in mathematics instruction and at what level?
25. What mathematics is important for students to learn beyond arithmetic?
26. How can parents most effectively help their students in mathematics?
27. How can you reduce math anxiety?

Questions that Primarily Apply at the Elementary Level

1. Should elementary students be allowed to use calculators? If so, at what grade level?
2. Should elementary schools have mathematics specialists?
3. Do early interventions make a difference? What types of interventions?
4. Do students need to master skills before solving problems?
5. Do students need to master all skills before proceeding in the curriculum?
6. Should students learn traditional algorithms?
7. Do manipulatives/hands-on activities improve student learning?
8. How important are mental math skills?

Questions that Primarily Apply at the Middle Level

1. How should teachers be organized, interdisciplinary teams or disciplinary teams?
2. Are interdisciplinary projects effective in learning mathematics?
3. Is there a difference in student achievement if the student has a teacher with a math major versus a teacher with a middle level endorsement?
4. What is the appropriate use of calculators in the middle grades?
5. When should students take a formal algebra course?

Questions that Primarily Apply at the High School Level

1. What does the research say about block scheduling versus traditional scheduling?
2. Which is more effective, traditional curriculum or integrated curriculum?
3. When should students use graphing calculators?
4. How much math should high school students take?

Approximate Timeline for Task Force Recommendations

	YEAR 1						YEAR 2						YEAR 3							
	F/M	AP/M	J/J	A/S	O/N	D/J	F/M	AP/M	J/J	A/S	O/N	D/J	F/M	A/M	J/J	A/S	O/N	D/J	F/M	A/M
Search/hire Research Director	→	→																		
Search/hire LRP Editor	→	→																		
Select R Analyses authors		→	→																	
Select RA Analyses questions		→	→																	
Writing RA, RB, RC				→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→
Website Design of Virtual Reseach Library				→	→	→	→	→	→											
Virtual Reseach Library																				
First Series Vol			→	→	→	→	→	→	→											
Second Series Vol						→	→	→	→	→	→	→								
Third Series Vol								→	→	→	→	→	→							
Fourth Series Vol									→	→	→	→	→	→						
Fifth Series Vol										→	→	→	→	→	→					
Sixth Series Vol														→	→	→	→	→	→	→
Indentify book authors and prepare outlines			→	→																
Writing/publishing books					→	→	→	→	→	→	→	→	→							
Identify leaders/topics for Minicourses			→	→					→	→					→	→				
Design and offer Minicourses				→	→	→	→	→	→	→	→	→	→			→	→	→	→	→