Dissertation abstracts:

Scientific evidence related to teaching and learning mathematics

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Abstract

This study explores the potential for doctoral dissertation abstracts to add to scientific evidence relating to the teaching and learning of mathematics. Abstracts of all doctoral dissertations granted in 2004 to candidates affiliated with institutions offering doctoral degrees in mathematics education (n=115) were downloaded from *Digital Dissertations* on 6/30/06 to provide the data for this document analysis. Data offer answers to questions including the following: Is there really a shortage of mathematics doctorates? What can we learn from doctoral research in mathematics education (i.e., the representation of topics, context, and recommendations)? How may doctoral research in mathematics add to the information that is needed by our various educational communities? Descriptive methods summarize the data contained in the abstracts. For example, the approximate proportion of dissertations 1) authored by men and women is approximately 1 to 2, respectively; 2) employing qualitative, quantitative, or mixed research designs, 20%, 65%, and 75%, respectively; and 3) representing higher education, high, middle, and elementary school, 24%, 28%, 23%, and 19%, respectively. Other data suggest that carefully written abstracts offer researchers the best link to establishing scientific evidence relating to teaching and learning of mathematics.

Introduction

Although mathematics educators are engaged in a wide range of activities that may include the teaching of undergraduate- and graduate-level mathematics education courses as well as undergraduate- and graduate-level courses in mathematics (Reys, 2006, p. 268), many assume major responsibilities for building strong research strands in our discipline. In our work with doctoral candidates, we endeavor to identify and advance important, under-researched issues relating to undergraduate mathematics education and add to existing scientifically-based recommendations for policy and practice.

Various current events focus attention on our research in mathematics education. First, there are indications of an acute shortage of mathematics doctorates (Dubinsky, 1996; Glasgow, 2000; Reys, 2000, 2002, 2006). Secondly, a recent AERA commissioned report suggests that the preparation of

mathematics teachers is an under-researched topic (Cochran-Smith & Zeichner, 2005). Third, the National Council of Teachers of Mathematics notes the need to target "research to questions that are identified as key problems of importance to practice" (NCTM Research Committee, 2006, p. 76). Finally, through the 2006 US Department of Education creation of a National Mathematics Advisory Panel (NMP), mathematics educators are "examining and summarizing the scientific evidence related to the teaching and learning of mathematics" (para. 3, U.S. Department of Education, 2006b).

The current spotlight on mathematics research is certain to be affected by any shortage of doctorates in our field. We recognize the challenges of addressing the need to implement and/or contribute to 1) research on mathematics teacher preparation and 2) link research with practice. It is likely that the NMP final report, due to be ready by February 2008, will emphasize any existing challenges.

Given these circumstances, several questions arise. Is there really a shortage of mathematics doctorates? What can we learn from doctoral research in mathematics education (i.e., the representation of topics, context, and recommendations)? How may doctoral research in mathematics add to the information that is needed by our various educational communities?

This paper explores answers to these questions with the hope of strengthening the strands of research that support mathematics teaching and learning. Specifically, this paper addresses the growth in numbers of

dissertations completed in mathematics education and describes the research contained in the dissertations completed by 2004 doctoral candidates.

Related Literature

A review of literature relating to the quantity and content of doctoral research in mathematics education was conducted using the Educational Research Information Center [ERIC]. For example, on 2/19/07, a basic title search was conducted in ERIC using “research in mathematics education”; 50 citations were found. On 2/19/07, a basic keyword search was conducted in ERIC using “research on mathematics education”; 48 citations were found.

The documents found in ERIC contain several annual reports of dissertation research and other research studies relating to mathematics education. For example, a recent citation (Reed & Owens, 2000) illustrates the longstanding interest in the content of mathematics education dissertations. This report reviews all dissertations (n=295) that were abstracted in *Dissertation Abstracts International* in 2000, (p. 1). Included in the report are the dissertation title, author, grade level, and focus. The Reed and Owens report, sponsored by OERI, US Department of education, is representative of a sequence of similar annual reports that have been archived in ERIC since the early 70s. (Note: the numbers of dissertations contained in these annual reports may differ from those reported by other researchers for the same time period due to the fact that the database is active.)

Research literature provides evidence of a critical need for mathematics doctorates (Dubinsky, 1996; Reys, 2000, 2002, 2006; Glasgow, 2000). Glasgow estimated that there were 120 graduates produced annually from 1993-1995. Reys (2000) cited the National Research Council (NRC) report of even fewer, a "yearly average of about 70" between 1982-1998 (p. 1269). Using the NRC summary report for 1998 as a source of his information, Reys adds that nearly "80% of current mathematics education faculty" in doctoral-granting institutions will be eligible for retirement within the next ten years" (p. 1269).

Reys (2000) and Glasgow (2000) suggest that the preparation of future graduates of doctoral programs in mathematics may need to be changed to meet the demand for mathematics education doctorates. Reys, noting that it is difficult to identify people who have completed doctoral studies, recommends that NSF, NRC, AMA, MAA, and NCTM work together to increase the numbers of doctorates in mathematics education. One of the three steps that Reys believes is essential is that of developing "a procedure (maybe similar to the Annual AMS Survey) that provides a valid measure of the number of doctorates in mathematics education that are awarded and the location of these programs" (p. 1270).

Increasing the numbers of doctorates in mathematics education focuses attention on issues relating to the quality of doctoral studies and the need to communicate the outcome of research. Schoenfeld (2000), for example, argues for and against using various forms of research in mathematics education;

Eisenhart and DeHaan (2005), suggest that "scientifically based" research implies the "need for more education researchers who can conduct scientifically based studies" (p. 3) and note that training is a critical part of the process.

The communication of the research findings is critical to the successful use of research findings, as noted by the NCTM Research Committee (2006). The Research Committee believes that roadblocks to communication are "cultural differences, methodological difficulties, governmental barriers, and insufficient bridges of communication between the community of practitioners and the community of researchers" (p. 79). The Research Committee suggests that the "practitioner with a working knowledge of both research and teaching may be of greatest help in brokering the grounds for communication" (p. 80). Consequently, the doctoral researcher and dissertation team are challenged to design meaningful research, expand and clarify existing research, and report the outcome of the research to the widest audience possible.

To be able to 1) successfully link new research to existing research or 2) design research to address recommendations forthcoming from research, it is essential to be able to search for, find, and evaluate related research. One of the major sections of a research report or dissertation is the literature review. For example, researchers state that "being intimately familiar with the professional literature in your general area of interest is a necessary prerequisite to problem identification" (Johanson & Brooks, 2002, p. 2). Boote and Beile (2005) note the centrality of the dissertation literature review to the production of useful research.

Fortunately, it is now easier than ever to read full text of dissertations and many research reports (published or unpublished) using electronic library resources. Keywords found in the abstracts of these research reports are invaluable to the process of finding and reviewing literature.

The information contained in dissertation abstracts offers students and researchers guidelines that may help others locate meaningful research. Since this study utilizes the abstract as a source of data, the review of literature included a review of documents that establish standards for writing abstracts. The following are some illustrations of that literature.

The fifth edition of The American Psychological Association (APA) manual offers suggestions for writing the brief and comprehensive summaries that are characteristic of a well-written abstract (2001, p. 12-14). The APA manual, for example, lists the components that should be included in the abstract of an empirical study (problem, subjects, method, findings, and conclusions). More detailed guidelines may be found in (Galvin, 2004; Pyrczak, F. 2005; Smith & Krathwohl, 2005; AERA, 2007). Recent publications (Boote & Beile, 2005; Hostetler, 2005) offer more illustrations of the important part the abstract plays in establishing and maintaining the qualities needed in order to find research meaningful.

Method

On 6/30/06, a search for dissertation abstracts with “mathematics education” as the subject (SU(0280)) was conducted using ProQuest’s archive of

UMI Digital Dissertations identified 7598 doctoral dissertations and masters' theses (http://proquest.umi.com). A subsequent search on 3/7/07 identified 7975 doctoral dissertations and masters' theses. Of the 7975, 7181 were doctoral dissertations. (More dissertations are added to this database as time passes, so a more recent search might yield more abstracts. The abstracts would most likely be those for 2006.) The 3/7/07 search produced 4495 doctoral dissertations within the last 15 years (1991-2005), approximately 300 annually.)

Because the archive of dissertations is active, abstracts from the dissertations of doctoral degrees awarded in 2004 were selected for review with the expectation that this sample would be relatively stable and suitable for description. To focus on dissertations awarded in a specific year, the code corresponding to the "degree date", for example DDT(2004), was added to the search.

A more focused search (UMI code: SC(XXXX)) was conducted using the school code of the specific universities that SIGMAA Research in Undergraduate Mathematics (RUME, 2004) lists on their web page (www.rume.org/phd.html). The universities on the RUME list was separated from the UMI archive to form a subset for analysis. The RUME list was last updated on 12/23/2004 and was retrieved for this study on 6/29/2006. It is described by the organization as a preliminary list of 46 institutions, two of which have joint programs with other listed institutions. This list of 46 institutions provides an approximation of the numbers of degrees awarded at institutions specifically designed to prepare

doctorates in mathematics education. Appendix A presents this list of RUME institutions and illustrates the numbers of doctorates awarded during this period.

Data

The abstracts of the each dissertation and the UMI archive of descriptive codes provide the information used in this study. Of particular interest is the dissertation's research methods and design, grade level, focus, unit of analysis and recommendations forthcoming from the dissertation abstracts written by doctoral candidates who were awarded doctoral degrees in 2004. A document analysis was conducted by this author to explore answers to the research questions:

- Is there really a shortage of mathematics doctorates?
- What can we learn from doctoral research in mathematics education (i.e., the representation of topics, context, and recommendations)?
- How may doctoral research in mathematics add to the information that is needed by our various educational communities?

The dissertation abstract was chosen for analysis because it provides readers with the critical information they need in order to complete a literature review for their own research studies or determine whether to read the entire research report. The abstract contains many keywords to help readers find dissertations on specific topics. Abstracts that are clearly written, well organized, and accurate help researchers and readers to access the information needed to

review and implement recommendations forthcoming from the dissertation research.

Analysis

Is there really a shortage of doctorates in mathematics education?

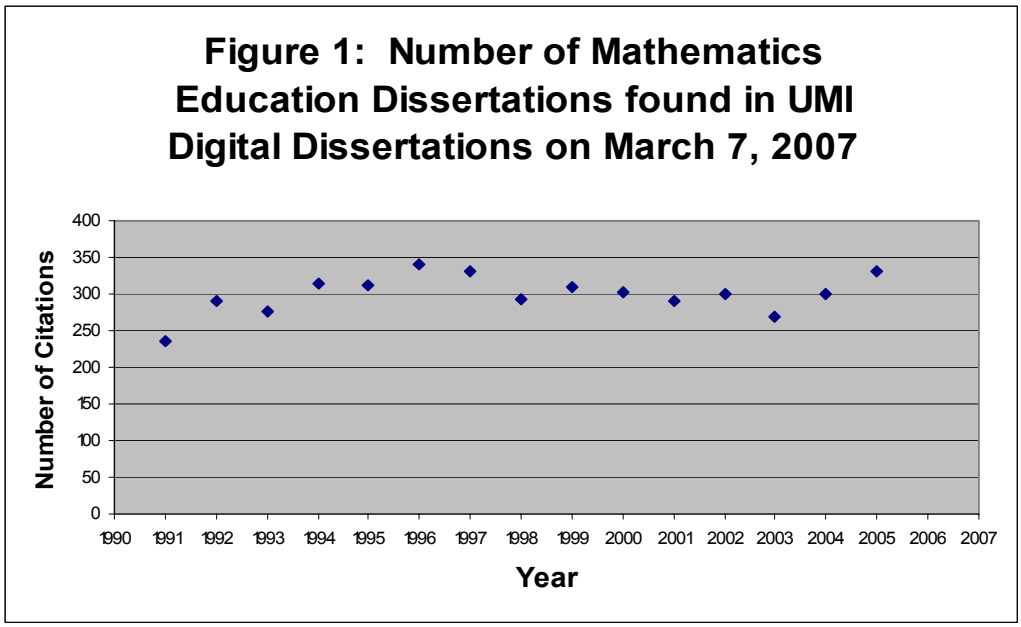
The data provide a good estimate of the number of "mathematics education" doctoral degrees awarded in the past 15 years, 1991-2005. The results are presented in Table 1, below.

Table 1: Number of Mathematics Education Doctoral Dissertations Source: Digital Dissertations, 8/1/2006

Degree date	number citations
1991	235
1992	290
1993	277
1994	314
1995	312
1996	341
1997	331
1998	294
1999	310
2000	302
2001	290
2002	299
2003	268
2004	301
2005	331

Table 1 illustrates that there were 301 doctoral dissertations archived in 2004 at the time of the 3/7/07 search. Although the 331 archived in 2005 may be under-reported due to the time of the search, the numbers of doctoral awards between 1991 and 2004 appears relatively stable while reflecting a decline from the 1996 high of 341 and recent annual increases of 301 and 331 (2004 and

2005, respectively). For the 15 years, 1991-2005, the mean average annual number of dissertations with a "mathematics education" focus is nearly 300. Figure 1, shown below, is a graphical representation of the data contained in Table 1.



While the data in Table 1 and Figure 1 illustrate the 301 "mathematics education" doctoral dissertations awarded in 2004, only 115 were awarded by the 46 institutions posted by RUME. This number (115) is similar to the numbers reported by Glasgow (2000) for 1993-1995. In this study, Glasgow estimated that there were between 120-147 degrees awarded annually from 1993-1995 by institutions with doctoral programs in mathematics. Although Glasgow's estimates are higher than those presented in this analysis, a more accurate comparison of data gathered for this study and for Glasgow is difficult due to the limitations in the data available. Based on this study of 2004 doctoral awards

and the research of Glasgow, it appears that the numbers of doctoral degrees awarded in mathematics education has remained stable and may even be declining. (The production of doctorates in science and mathematics education is viewed from 1972-1982, appears to have fluctuated. For example, the Survey of Earned Doctorates (Science Resources Studies Highlights, 1983) reports that "although doctorates with specialization in science/mathematics education peaked at 364 in 1972, they declined to only 136 in 1982" (abstract).)

What can we learn from doctoral research in mathematics education?

Abstracts of the 115 mathematics education doctoral degrees awarded in 2004 were downloaded and reviewed to answer this question. This is the number of dissertations of the 2004 doctorates awarded to candidates who attended institutions posted on RUME (2004). RUME lists the U.S. Doctoral Programs in Mathematics Education and notes which programs are supported by a school or department of mathematics (n=21), and which are housed in a school or college of or department of curriculum and instruction (n=31). Of the 46 institutions listed, six institutions offer a focus on research in undergraduate (collegiate) mathematics. Two programs are listed as "joint" programs, reducing the number of programs to 44.

Of the 44 institutions, 10 (23%) institutions did not have 2004 dissertations archived in UMI. However, 115 dissertations relating to mathematics education were found. The UMI archived five or greater digital dissertations for eight

institutions. See Table 2. Illinois State University reported 10 dissertations, the greatest number, for 2004. The mean average number of dissertations per institution was 2.6 (115/44). See Appendix A for a list of all RUME institutions and the numbers of dissertations found in *UMI Digital Dissertations*.

Table 2: Universities with Greatest Number of Dissertation - U.S. Doctoral Programs in Mathematics Education Listed on MAA - SIGMAA RUMI Web (6/29/2006) and Number of Dissertations Dated 2004 Archived in UMI Digital Dissertations (June 30, 2006),

Ranking	University Name	Number Dissertations
1	Illinois State University	10
2	Pennsylvania State University	7
3	Arizona State	6
4	North Carolina State University	5
4	Ohio State University	5
4	Oregon State University	5
4	University of Illinois	5
4	University of Wisconsin	5

As indicated earlier, 115 dissertations were found as a result of searching Digital Dissertations using the keywords “mathematics education.” Based on commonly used names for males and females and where it is possible to determine, the ratio of male to female dissertation authors appears to be 1 to 2, respectively. In contrast, the ratio of male to female dissertation advisors was nearly equal. Thirteen percent of the studies were guided by two advisors.

The research focused on college, high school and middle school mathematics issues in approximately equal proportions (24%, 28%, and 23%, respectively). Fewer studies focused on the preschool (4%) or elementary

school level 15%. (Twelve percent of the studies did not report the level.) When the dissertation codes were used to identify the focus of the dissertation, one may get an idea of the variety of topics addressed in the 115 dissertations found. See Table 3.

Table 3: UMI Digital Dissertation Subject Codes

Code	Name	Number
0280	Ed mathematics	115
0533	**Secondary Ed**	23
0727	Curriculum & Inst	17
0530	teacher training	16
0525	Ed. Psychology	13
0745	**Higher Ed**	13
0710	Ed Technology	13
0524	**Elem Ed**	12
0529	Special Ed	7
0714	Ed Sciences	7
0275	**Community College**	5
0514	Ed Admin	5
0633	Psychology Cognit	5
0340	Ed Sociology	3
0325	Black Studies	3
0288	Tests & Measure	3
0405	Mathematics	2
0518	Early Childhood	2
0453	Women's' Studies	2
0984	Computer Science	2
0535	Reading	2
0291	Modern Languages	1
0463	Statistics	1
0519	Guidance & Counsel	1
0537	Engineering-Gen	1
0516	Adult & Continuing	1
0413	Music	1
0631	Soc Ethnic & Racial Studies	1
0459	Speech Communication	1
0617	Political Sci & Pub Adm	1

Of the 115 dissertation abstracts reviewed, approximately 75% report the size of the research population; approximately 21% provide recommendations based on the outcome of the research. Approximately 20% appear to be

quantitative; 65%, qualitative; and 15% mixed method. The length of the dissertations averaged slightly over 200 pages each.

Using the search features on Digital Dissertations, it is estimated that approximately 24% of the advisors were chairing a dissertation for the first time (2004); 58%, chaired dissertations between 1990 and 2003; and 18%, chaired dissertations as early as 1987, 1988, or 1989.

How may doctoral research in mathematics add to the information that is needed by our various educational communities?

I believe there are three interesting features of the data described. First, it appears that we are dependent upon estimates to identify the numbers of mathematics education doctoral programs and the focus of doctoral dissertations. Second, and as to be expected, the abstracts often offer a restricted view of the content of the dissertation research. Third, faculty with many experiences as a dissertation chair may be shrinking over time with newer faculty assuming greater responsibility for guiding dissertation research.

Individual mathematics educators have limits on what they may do to support and communicate doctoral research in mathematics education. However, individuals who serve on dissertation teams may support those who use information contained in dissertation abstracts by encouraging authors to include descriptions of the major features of the research in the abstracts of the dissertation. In this way, the abstract becomes an essential part of the bridge

between research and practice and a critical part of the communication of research outcome.

For reference and future application, a well-written abstract may take this form:

> This study examined the (*problem statement*). (*Description of data used*) was gathered from (*sources*) and (*quantity and description of data*) were used to (*answer the question or for the analysis).* The (*name type of research methods*) were used to produce (*outcome*) that suggest (*findings*). The findings (*support or do not support*) the (*earlier research, theory, assumption, etc.*). Recommendations for additional studies include (*recommendations*).

Recommendations

Based on the literature reviewed and the information contained in the abstracts of all of the dissertations completed by 2004 doctoral candidates who were affiliated with RUME institutions, the following recommendations are made.

- Develop a common language to describe methods and research designs used to research mathematics education issues. Also, suggested, by Reys (2000).
- Develop a taxonomy or coding scheme to document the research that has already been done.
- Identify under-researched topics.

- Craft abstracts that clearly address all of the major components of a research study.

Limitations

Data for this study are limited by the fact that Digital Dissertations is an active archive and the fact that not all dissertations may be archived in this database. It is possible that some doctoral degrees in mathematics education to be awarded to institutions not listed by RUME. A review of one year (2004) of dissertations limits our ability to estimate changes in the numbers of degrees awarded over time. Furthermore, changes in institutional policies may influence the numbers of mathematics education doctoral candidates and the programs that support these candidates.

Summary

This paper presents the findings of a review and analysis of the dissertations archived in *Digital Dissertations,* http://proquest.umi.com. The review complements the current focus on scientifically-based research. As we are aware, the National Mathematics Advisory Panel (NMP), created in 2006 by the U.S. Department of Education, is engaging in a thorough review of existing empirical literature (U.S. Department of Education, 2006a, 2006b).

As a part of this national focus, mathematics education faculty with appointments as dissertation or thesis advisors, undergraduate faculty who teach pre-service teachers and undergraduate mathematics instructors, practitioners and policy-makers, researchers who hope to build a ladder of meaningful

research or develop an agenda for future research may able to use the information found in the dissertation work of others.

Presented in this paper is a limited review of related literature, description of the methods used to review the dissertations, the findings, and recommendations for consideration. However, this descriptive study suggests that 1) the numbers of doctoral dissertations in mathematics education is stable, yet may be inadequate to meet the current need, 2) the discipline may be supported by the development of measures that will help index, track, and trace the work contained in dissertations, 3) the senior faculty supporting dissertation research may be diminishing, and 4) refinements made to dissertation abstracts may enhance the ability of dissertation research to link the outcome of research to practice.

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Appendix A: U.S. Doctoral Programs in Mathematics Education Listed on MAA - SIGMAA RUMI Web (6/29/2006) and Number of Dissertations Dated 2004 Archived in UMI Digital Dissertations (June 30, 2006) (N=44)

Record	University Name	Number Dissertations	UMI University Code
1	Arizona State	6	0010
2	Auburn University	2	0012
3	Boston University	3	0017
4	Central Michigan University	0	6006
5	Teachers College of Columbia University	3	0055
6	Florida State University	3	0071
7	George Mason University	0	0883
8	Georgia State University	4	0079
9	Idaho State University	0	0320
10	Illinois State University	10	0092
11	Indiana University, Bloomington	0	0093
12	Michigan State University	2	0128
13	Montana State University	2	0137
14	New York University	1	0146
15	North Carolina State University	5	0155
16	Northern Illinois University	0	0162
17	Ohio State University	5	0168
18	Oregon State University	5	0172
19	Pennsylvania State University	7	0176
20	Portland State University	0	0857
21	Purdue, Calumet, Indiana - Joint with Indiana University	3	0183
22	Rutgers University	3	0190
23	San Diego State University - Joint with U. CA., San Diego	0	0220
24	Stanford U	2	0212
25	Syracuse University	0	0659
26	Texas A & M University	4	0803
27	University of Arizona	2	0009
28	U. of California, Berkeley	0	0028
29	U. of California, San Diego - Joint with San Diego State U.	0	0033
30	University of Georgia	2	0077
31	University of Illinois (Chicago & Urbana Champaign)	5	0799/0090
32	University of Iowa	2	0096
33	University of Maryland, College Park	1	0117
34	University of Michigan	2	0127
35	University of Minnesota	2	0130
36	University of Missouri	2	0133
37	University of Montana	0	0136
38	University of New Hampshire	2	0141
39	University of Northern Colorado	1	0161
40	University of Oklahoma	1	0169
41	University of Pittsburgh	4	0178
42	University of South Florida* (n=5)	4	0206
43	University of Texas, Austin	3	0227
44	University of Tennessee	4	0226
45	University of Wisconsin, Madison	5	0262
46	Western Michigan University	3	0257

Source: http://www.rume.org/phd.html