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Doctoral Programs in Mathematics Education: Should Programs be Accredited?

Robert Reys
University of Missouri-Columbia

ABSTRACT Over several hundred different institutions in the USA have graduated people identifying a doctorate in mathematics education. Some institutions graduate people every year, other institutions graduate one person every 3-5 years. Some institutions have one faculty member, others have more than ten. There is no agreed upon common core of knowledge or requirements for a doctorate in mathematics education. This article discusses some pros and cons of accreditation, offers some direction, and hopefully will stimulate thinking about accreditation for doctoral programs in mathematics education.

KEYWORDS *mathematics education, doctoral preparation, core knowledge, accreditation*

What knowledge accompanies a Ph.D. in mathematics education? What is the nature of programs that prepare doctorates in mathematics education? Should an accreditation process for doctoral programs in mathematics education be established? Answers to some of these questions require research along with thoughtful discussion. It is worth noting that some academic disciplines, such as music education, require a doctoral program to be reviewed before their Ph.D. program is recognized by the National Association of Schools of Music Education (Reys 2017). Nothing similar exists for doctoral programs in mathematics education.

If someone has earned a Ph.D. in mathematics, it can be safely assumed that person has completed advanced graduate work in mathematics, including courses in advanced calculus and analysis. Surprisingly, there are no specific course requirements across all programs for doctorates in mathematics education. While a document entitled *Principles to Guide the Design and Implementation of Doctoral Programs in Mathematics Education* (AMTE, 2003) exists, each institution designs its doctoral program in mathematics education and it may or may not reflect components from the *Principles.* The goal of this paper is to stimulate discussion focused on the value of an accreditation process for doctorates in mathematics education.

Some Background on Doctoral Programs in Mathematics Education

The Survey of Earned Doctorates (SED) is annually reported by the National Science Foundation. It has been tracking earned doctorates from institutions in the United States since 1920, and mathematics education as a field of study since 1962 (Shih, Reys, & Engledowl, 2018). For more than 50 years there has been a growing number of doctorate-granting institutions that identify mathematics education as their primary area. More specifically, the SED data show that during the 20-year period from 1996 to 2015 there were 192 different institutions that reported mathematics education as their primary doctorate area (Reys & Reys, 2016). Table 1 shows that only three institutions (Teachers College of Columbia University, the University of Georgia, and the University of Texas) averaged over 3.5 doctorates in

Table 1

Name of institution along with the number of doctoral graduates in mathematics education from 1996–2015 according to the Survey of Earned Doctorates.

Institution	Graduates	Institution	Graduates
Columbia University (Teachers College)	181	George Mason University	18
University of Georgia	134	Pennsylvania State University	18
University of Texas, Austin	70	University of Arizona	18
Illinois State University	67	University of South Florida	18
Rutgers University	65	University of California, San Diego	17
Georgia State University	57	University of Illinois, Urbana-Champaign	17
North Carolina State University	54	Western Michigan University	17
Ohio State University, Columbus	51	Auburn University	16
Florida State University	50	University of New Hampshire	16
Michigan State University	37	University of Pittsburgh, Pittsburgh	16
University of Maryland, College Park	37	Boston University	14
University of Missouri, Columbia	36	Stanford University	14
University of Northern Colorado	36	University of California, Davis	14
Oregon State University	34	University of North Carolina, Chapel Hill	14
University of California, Berkeley	34	University of Southern Mississippi	14
University of Oklahoma	32	Oklahoma State University, Stillwater	13
Indiana University	31	Portland State University	13
Temple University	31	Purdue University, West Lafayette	13
University of Michigan	31	Texas State University, San Marcos	12
SUNY University at Buffalo	29	University of Florida	12
University of Tennessee, Knoxville	28	University of Iowa	12
University of Virginia	28	Montclair State University	11
University of Wisconsin	26	New York University	11
Arizona State University	25	University of Kentucky	11
Ohio University	24	University of Massachusetts-Amherst	11
University of Minnesota	24	Claremont Graduate University	10
Syracuse University	24	Southern University and A&M College-Baton Rouge	10
University of Delaware	23	University of Alabama-Tuscaloosa	10
Vanderbilt University	21	University of California-Los Angeles	10
Montana State University, Bozeman	20	University of Kansas-Lawrence	10
Texas A & M University, College Station	19	University of Nebraska-Lincoln	10
University of Central Florida	19	University of South Carolina-Columbia	10

mathematics education annually for the last 20 years. In general, the number of graduates from most institutions was very small. For example, less than one-sixth of the institutions (31) averaged at least one graduate a year from 1996-2015, and only two institutions (Teachers College of Columbia University and the University of Georgia) had at least one graduate during each of the 20 years. About two-thirds of the institutions (127) graduated less than a total of 10 doctorates in mathematics education over this 20-year period. It is hard to imagine that programs graduating so few students annually (i.e., about one every two years) can maintain a high level of quality.

Doctoral programs are expensive to operate, and doctoral programs with a specific focus, such as mathematics education, often have only a few students. This means that many institutions cannot afford to offer specific courses unique to mathematics education. Instead, they offer more generic courses on curriculum, history, and the psychology of learning that serve graduates from multiple disciplines. This is one of the reasons why the academic backgrounds of graduates with doctorates in mathematics education vary greatly (Reys, et al., 2001; Shih, Reys, & Engledowl, 2016). Furthermore, criticism has been made of some doctoral programs in education whose faculty members are stretched thin by many demands and do not have the expertise to provide mentoring in research methodologies. In addition, the lack of availability of internships with faculty members actively involved in research projects is a limitation of many programs (Levine, 2007). While Levine was not focused on mathematics education in particular, he argues that too many marginal doctoral programs exist in education and some should be either upgraded or terminated. Perhaps a similar argument could be made for mathematics education. For example, opportunities to engage in ongoing research, including developing proposals for research, were frequently cited suggestions for improving doctoral preparation in mathematics education (Shih, Reys, & Engledowl, 2016). In order for this to happen, faculty members in doctoral programs in mathematics education need to aggressively pursue funding for research and involve their doctoral students in all phases of the research process.

Overall, there has been very little research reported on doctoral programs (Ostriker, Kuh, & Voytuk, 2011; Golde & Walker, 2006), and there has been no systematic examination of doctoral programs in mathematics education (Reys, 2017). Some data on the number of faculty, types of courses, and number of doctoral students in mathematics education have been obtained via surveys (McIntosh & Crosswhite, 1973; Sonnabend, 1981). More recently there have been two national conferences on doctoral programs in mathematics education and each of them documented the multiple pathways to complete a doctorate in mathematics education (Reys & Kilpatrick, 2001; Reys & Dossey, 2008). These conferences also addressed different components essential to the doctoral preparation of mathematics educators. In fact, the first conference resulted in the development of core knowledge and experiences essential for doctoral programs in mathematics education as highlighted in the Principles (AMTE, 2003) including the following: mathematics content; research; learning; teaching and teacher education; technology; curriculum; assessment; and history of social, political, and economic contexts of mathematics education.

Discussion at these conferences focused on the need to strengthen doctoral preparation in mathematics education and the challenges of improving complex systems. For this purpose, the following remarks are suggested:

> "…Improving doctoral programs in mathematics education is a continuing process that yields small changes over time. But those changes can accumulate to yield lasting and fundamental improvements rather than quick and temporary fixes. We believe that it is important for the mathematics education community to take the initiative and begin a rational long-term process of improving its programs for training coming generations of doctoral students" (Hiebert, Kilpatrick, & Lindquist, 2003).

A common recommendation from both conferences was the need for doctoral programs to be reviewed and revised periodically to reflect the changing times and needs of doctoral graduates in mathematics education (Reys & Reys, 2017). For example, technology has provided opportunities to offer courses and share expertise across institutions that were impossible prior to 2000 (Burke & Long, 2008; Jonassen, 2004). Additionally, demands for more collaborative investigations across multiple disciplines provide fresh opportunities, but this also presents new challenges to allow doctoral students in mathematics education to engage in activities that promote and reward interdisciplinary outreach.

Identifying Institutions with High Quality Doctoral Programs in Mathematics Education

One effort to identify strong doctoral programs in mathematics has been reported (Reys, et. al., 2007). That study asked a faculty member in each of 70 institutions that were on the AMTE list of doctoral programs in mathematics education (see amte.net) to "Identify six institutions that you think are particularly strong and that you would currently recommend to a potential doctoral student in mathematics education (other than your own institution)." No specific criteria were identified (such as scholarly publications, or graduation rates), so responses most likely reflected their overall perceptions of doctoral programs. Responses were received from 90 percent (63) of the mathematics educators. No institution was listed by every respondent, and only two institutions (the University of Georgia and Michigan State University) were listed by a majority of the respondents.

There were some common traits of institutions cited most frequently. They each had a core of at least five established and nationally recognized mathematics education faculty members who were engaged in research and scholarly writing as well as making presentations at professional meetings; they had a critical mass of at least 10 full-time doctoral students; they had sustained records of success in gaining external funds that supported many doctoral students; each institution annually graduated doctorates in mathematics education.

At the national level, there are several groups that review, report, and often rank specific programs. For example, the *U.S. News and World Report* annually ranks academic programs based solely on surveys sent to department chairs and directors of graduate studies. Doctoral programs in mathematics are also reviewed based on data gathered from an Annual Survey organized by joint professional organizations (e.g. AMS-ASA-IMS-MAA-SIAM). The resulting information is used to group Ph.D. granting mathematics departments (Cleary, Maxwell & Rose, 2012). However, none of these national review efforts include mathematics education.

Should an Accreditation Process be established?

Accreditation of doctoral programs was addressed in the second national conference and it stimulated thoughtful discussion on both sides (Lappan, Newton & Teuscher, 2008). It was agreed that an accreditation process would require guidelines and standards that could be used to develop and evaluate the quality of doctoral programs in mathematics education, and to better define what is meant by a doctorate in mathematics education. Furthermore, it was agreed that external reviews from an accreditation would encourage more regular self-examination and thoughtful discussions by faculty members leading the doctoral program.

On the other side, some argued that an accreditation process might limit institutional control and perhaps stifle creativity in preparing doctoral graduates in mathematics education. Concern was also expressed about who would conduct the accreditation and how the accreditation process would be carried out.

Accreditation—A Proposed Action Plan

A systematic review of a Ph.D. program should identify critical components or characteristics of a high-quality program. For doctoral programs in mathematics education, some examples follow: a core of mathematics education faculty, minimum number of doctoral students, regular course offerings related to core topics in mathematics and mathematics education, resources to support faculty and students, etc. These issues were addressed in some detail in the *Principles (AMTE, 2003)*. The *Principles* is now over a decade old and needs to be updated. Nevertheless, it could provide a starting point for the field to discuss critical features and core elements related to doctoral preparation in mathematics education.

If a process for accreditation were to exist, each institution would need to decide if its doctoral program in mathematics education should apply for an accreditation review. If an institution chooses to have an accreditation review, then there should be clear directions for how to prepare for said review.

What might institutions do to prepare for an accreditation review?[1]

- Provide a brief history of the institution's doctoral program in mathematics education, highlighting expansion and/or contraction over time.
- Identify short and/or long-term goals for the doctoral program in mathematics education.
- List titles of all required and optional doctoral level courses for mathematics education doctoral students along with their course syllabi, and the number of times these courses have been taught over the last 5 years.
- Identify full-time tenured faculty members who contribute to the doctoral program in mathematics education.
- Identify tenure-track faculty members who contribute to the doctoral program in mathematics education.
- Identify adjunct/clinical faculty members actively involved in the doctoral program in mathematics education.
- Describe the application process for the doctoral program in mathematics education, along with the number of applicants and acceptances for the last two years.
- Identify the number of doctoral graduates in mathematics education during each of the last 5 years.
- Report dissertation titles and major advisors for doctoral students graduating during the last 5 years.
- Report the current positions/placements of doctoral graduates.
- Identify any unique niches, foci, or intellectual communities within the mathematics education doctoral program.
- Describe active research projects involving faculty members and/or graduate students in mathematics education.
- Describe research projects (not counting dissertations) completed by faculty members and/or graduate students during the last 5 years.
- Have current faculty members involved in the doctoral program in mathematics education self-reflect on program strengths and weaknesses.
- Have current doctoral students in mathematics education self-reflect on program strengths and weaknesses.
- Summarize survey results from recent doctoral graduates in mathematics education regarding their suggestions on ways to strengthen the doctoral program.

How might the review be carried out?

A review team from other institutions, composed of mathematics educators, and possibly educators of other disciplines, such as mathematics, would be invited to do the following:

- Review the information prepared for the accreditation several weeks prior to the on-site review;
- Visit the institution and meet with faculty, doctoral students and administrators chosen by the host institution;
- Examine and synthesize the data provided prior to the visit as well as information gathered from the on-site visit;
- Prepare an oral exit report highlighting program strengths and weaknesses; and
- Prepare a more detailed written report within an agreed upon time frame at the conclusion of the site visit.

What might be gained from accreditation?

The ultimate goal of reviewing and accrediting doctoral programs in mathematics education is to strengthen doctoral preparation. The accreditation process should be constructive and it could also provide a pathway to help new doctoral programs become established. The oral and written report that summarizes program strengths and weaknesses could be used by faculty members to develop an action plan going forward. Such information could be used by faculty members to gain support from administrators to strengthen their doctoral program. It might also be used to denote accreditation status for their doctoral program in mathematics education.

What's next?

While some research has been cited in this paper, it is recognized that research into and about doctoral programs in mathematics education is very limited and remains an area in need of much additional work by the

[1] These suggestions are based largely on experience gained by the author's on-site reviews of doctoral programs. Some on-site reviews were made of established doctoral programs in mathematics education, and others of new programs that were being considered by their coordinating boards of higher education.

mathematics education community (Reys, 2017). Research carefully examining components of doctoral programs in mathematics education would be enlightening and potentially useful to all institutions involved in doctoral preparation. Establishment of accreditation of doctoral programs would allow for examination of the impact of an accreditation process for doctoral programs in mathematics education, by comparing the programs before and after receiving accreditation.

No claim is made that the above discussion is exhaustive, but at the least this narrative raises some foundational issues related to doctoral programs in mathematics education that need to be addressed. The goal has been to provide a narrative to stimulate thoughtful discussions related to the accreditation of doctoral programs in mathematics education. What happens in the next few years will determine whether this is a voice crying in the wilderness, or the start of a rallying cry for action by the mathematics education community that has the responsibility of preparing future generations of mathematics educators.

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References

Association of Mathematics Teacher Educators. (2003). *Principles to Guide the Design and Implementation of Doctoral Programs in Mathematics Education.* San Diego, CA: Author.

Burke, M. & Long, V. (2008). On-line delivery of graduate courses in mathematics education. In R. Reys & J. Dossey (Eds.) *U.S. doctorates in mathematics education: Developing stewards of the discipline* (pp. 155–162). Washington, DC: American Mathematical Society/Mathematical Association of America

Cleary, R. & Maxwell, J. (2012). Annual survey doctoral department groupings. *Notices of the American Mathematical Society, 59*(9), 1262–1264.

Golde, C. & Walker, G. (2006). *Envisioning the future of doctoral education: Preparing stewards of the discipline.* San Francisco, CA: Jossey-Bass.

Hiebert, J., Kilpatrick, J., & Lindquist, M. (2001). Improving U. S. Doctoral programs in mathematics education. In R. Reys & J. Kilpatrick (Eds.), *One Field, Many Paths: U.S. Doctoral programs in mathematics education* (pp. 153–162). Washington, DC: American Mathematical Society/Mathematical Association of America.

Jonassen, D. (2004). *Handbook of Research on Educational Communications and Technology* (2nd ed.) Mahwah, NJ: Lawrence Erlbaum Associates, Publishers.

Lappan, G., Newton, J., & Teuscher, D. (2008). Accreditation of doctoral programs in mathematics education: A lack of consensus. In R. Reys & J. Dossey (Eds.) *U.S. doctorates in mathematics education: Developing stewards of the discipline* (pp. 215–219). Washington, DC: American Mathematical Society/Mathematical Association of America.

Levine, A. (2007). *Educating researchers.* Princeton, NJ: The Education Schools Project.

McIntosh, J. & Crosswhite, F.J. (1973). *A survey of doctoral programs in mathematics education.* Columbus, OH: ERIC Information Analysis Center for Science and Mathematics.

Ostriker, J., Kuh, C., & Voytuk, J. (Eds.) (2011). *A data-based assessment of research-doctorate programs in the United States.* Washington, DC: The National Academies Press.

Reys, B. & Reys, R. (2016). A recent history (5 decades) of the production of doctorates in mathematics education, *Notices of the American Mathematical Society, 63*(8), 936–939.

Reys, B. & Reys, R. (2017). Strengthening Doctoral Programs in Mathematics Education: A Continuous Process. *Notices of the American Mathematical Society, 64*(4), 386–389.

Reys, R. E. (2017). Doctorates in mathematics education-How they have evolved, what constitutes a high-quality program, and what might lie ahead? In J. Cai (Ed.). *Compendium for Research in Mathematics Education.* (pp. 934–948). Reston, VA: National Council of Teachers of Mathematics.

Reys, R. E. & Dossey, J. A. (Editors). (2008). *U.S. Doctorates in Mathematics Education: Developing Stewards of the Discipline,* Washington, DC: American Mathematical Society/Mathematical Association of America.

Reys, R., Glasgow, R., Ragan, G., & Simms, K. (2001). Doctoral programs in mathematics education in the United States: A status report. In R. Reys & J. Kilpatrick (Eds.), *One Field, Many Paths: U.S. Doctoral programs in mathematics education* (pp. 19–40). Washington, DC: American Mathematical Society/Mathematical Association of America.

Reys, R., Glasgow, R., Teuscher, D. & Nevels, N. (2007). Doctoral programs in mathematics education in the United States: 2007 Status report. *Notices of the American Mathematical Society, 54*(10), 1283–1293.

Reys, R. E. & Kilpatrick, J. (Editors). (2001). *One Field, Many Paths: U.S. Doctoral Programs in Mathematics Education,* Washington, DC: American Mathematical Society/Mathematical Association of America.

Shih, J. Reys, R., & Engledowl, C. (2018). Issues of validity in reporting the number of doctorates in mathematics education. *Investigations in Mathematics Learning, 10*(1), 1–8.

Shih, J. Reys, R., & Engledowl, C. (2016) Profile of research preparation of doctorates in mathematics education in the United States. *Far East Journal of Mathematical Education. 16*(2), 135–148.

Sonnabend, T. (1981). *A survey of doctoral programs in mathematics education.* Columbus, OH: ERIC Information Analysis Center for Science and Mathematics.