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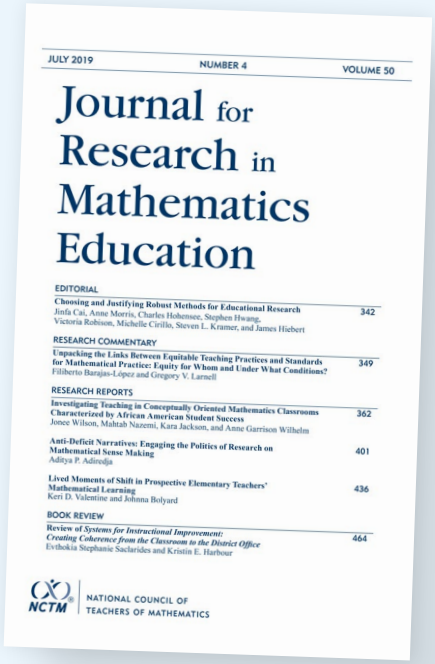

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Where Are the Special Niches in Doctoral Programs in Mathematics Education in the United States?

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Some people pursuing a doctorate in mathematics education are interested in specializing in a specific area within mathematics education. In addition, people considering postdoctoral appointments often choose institutions that have niches or specializations aligned with their long-term career goals. These specialty areas are typically the result of the foci of specific faculty members who are active in research and scholarship and have gained broad recognition for their work. This brief report offers information about specific areas of specialization within doctoral programs in mathematics education in the United States that are recognized by peer faculty at other doctoral institutions.

Keywords: Doctoral preparation; Niche; Specialization; Research; Doctoral programs; Survey study

Guest Editor's note: Like any other site of educational practice, doctoral programming can be a focus of academic research in its own right (e.g., Boaler et al., 2003). Doctoral programs also are of professional interest to mathematics education researchers as part of our collective responsibility for the continuity of the profession. The following brief report providing survey data concerning niches in doctoral education in the United States serves this latter purpose.

Specializations or niches within doctoral programs do not happen by chance, but generally result when several faculty members establish "an intellectual community formed around domains of knowledge and consisting of active faculty participation and leadership along with student apprenticeships" (Hiebert et al., 2008, p. 243). These specializations may be within a single institution or involve multiple institutions. They are typically aligned with the scholarship of specific faculty so they may be dependent on the mobility of those faculty members. Consequently, the specializations associated with an institution may change quickly as faculty members retire or move to a new institution. One challenge within the mathematics education community is to identify these specialty areas and communicate their existence to the pool of potential doctoral applicants. No previous research addressing specialties in doctoral programs in mathematics education has been reported (Kilpatrick & Spangler, 2016; Reys, 2017). This article is a first step in addressing this challenge by sharing information collected from

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a survey of faculty members actively involved in doctoral programs in mathematics education.

Methodology

Niches or specialization areas may exist in both doctoral- and non-doctoral-granting institutions. However, because our focus is on doctoral programs in mathematics education, we contacted faculty members only at institutions with doctoral programs in mathematics education. Several possible methods exist to identify niches or specializations in these institutions. One could try to identify niches by examining institutional funding from federal and private foundations that focused on specific areas of specialization. Another approach would be to identify scholarship reported in journals, use citation network analysis (Colicchia et al., 2018), and connect areas of specialization with institutions. Each of these approaches would serve as a lens to identify niches at specific institutions. Rather than use these secondary sources, we decided to survey faculty members who were actively involved in doctoral programs in mathematics education and gather information about niches or areas of specialization.

Procedure for Survey

The data collected by the Survey of Earned Doctorates (SED)[1] were used to identify institutions that graduated the greatest number of doctorates in mathematics education. The SED began gathering data in 1920 and added mathematics education as a discipline in 1962. The SED is conducted annually and gathers data from every institution in the United States that awards earned doctorates. Although the SED has some limitations (Shih et al., 2018), it offers the most comprehensive data available on doctorates in mathematics education.

We examined SED data on institutions during a 20-year period, from 1996 to 2015. The total number of doctorates in mathematics education awarded at a single institution during this period ranged from one to 181. We decided to identify institutions that had awarded at least 10 doctorates in mathematics education during this 20-year period, which produced 67 institutions. This study was focused on active doctoral programs in mathematics education, so we made a further review of the institutional data to identify those that did not award at least one doctorate in the last 5 years. Four institutions were removed for this reason, with the remaining 63 institutions constituting our sample.

In the fall of 2017, we contacted a faculty member at each of the 63 institutions and asked them to identify all tenured or tenure-track faculty members involved in their doctoral program in mathematics education. Retired faculty and part-time faculty members were excluded. Some institutions had only one faculty member, whereas several institutions had more than 10 faculty members contributing to their doctoral program in mathematics education. We ultimately compiled a list of 297 names and emails of faculty members in mathematics education. In January 2018, we sent them a letter providing background and rationale for the survey along

[1] Information about the Survey of Earned Doctorates (SED) is available at https://www.norc.org.

with an invitation for them to complete the online survey. We sent two follow-up emails to anyone not completing the survey.

We received partial or complete surveys from 262 (89.7%) of the mathematics educators. Of the remainder, two were on medical leave, two declined to complete the survey, and another reported their doctoral program had been changed to STEM and chose not to complete the survey. We received a response from at least one faculty member from every institution. All the mathematics educators from 45 of the institutions completed the survey.

This represents the largest survey of faculty members in doctoral programs in mathematics education that has been done (Kilpatrick & Spangler, 2016; Reys, 2017). Some findings from the survey have previously been reported (Reys et al., 2019; Shih et al., 2020).

Instrument

We designed the survey to collect information from faculty members involved with doctoral programs in mathematics education. It included questions about niches available within their doctoral program, and their knowledge of niches in other institutions. More details about the entire survey have been reported elsewhere (Reys et al., 2019).

In regard to intellectual communities and niches, we intentionally did not supply a formal definition in the survey. Our reasoning was that we want the field to define the term; the intent is for a bottom-up definition rather than a top-down definition. Using different grain sizes for the definition is purposeful—perhaps some doctoral programs want to be known for broader categories such as curriculum, technology, or assessment, whereas other programs may want to be known for very specific content. However, the survey did offer some context for questions related to intellectual communities or niches. Figure 1 shows the verbatim text from the survey along with the three specific survey questions addressing niches.

We collected survey data on a spreadsheet to determine the frequency of responses for each question. We sorted responses to the open-ended questions into specific categories. Often respondents used different words to describe niches—for example, "curriculum," "design curriculum," "focus on curriculum," "teachers[’] use of curriculum," and "undergraduate mathematics curriculum"—and these were clustered together, in this example under "curriculum."

Most of the niches identified in the survey instrument were reflected in the Centers for Learning and Teaching that had been a major initiative of the National Science Foundation to support doctoral students in mathematics education as well as enhance and promote research in doctoral programs in mathematics education (Reys, 2017, p. 945). Additionally, these niches were reflected in the common core knowledge described in the *Principles to Guide the Design and Implementation of Doctoral Programs in Mathematics Education* (Association of Mathematics Teacher Educators, 2002).

Survey Findings

Table 1 reports results from two niche questions and suggests that a majority of faculty members in doctoral programs in mathematics education agree that

Figure 1

Survey Instrument

A recommendation (Hiebert et al., 2008) was made that some institutions with a doctoral program in mathematics education should identify intellectual communities organized around the expertise and research of two or more faculty members. This would create specific niches within mathematics education for doctoral study, such as teaching, curriculum, equity/social justice or technology.

1. Do you think specific program niches are a good idea: Yes No Not sure
2. Does your doctoral program in mathematics education have one or more niches?
   Yes No Not sure
   If yes, please describe the niches within your doctoral program in mathematics education.
   [ ]
3. If a potential doctoral student in mathematics education expressed an interest in enrolling in a doctoral program with a particular research niche, are there one or more institutions that you would identify with the following research niches?
   Technology Yes No
   If yes—please identify institution(s) that have the listed niche
   [ ]

Similar questions were asked for the following research niches:
Content knowledge for teaching
Mathematics curriculum
Diversity/Equity
Teaching collegiate level mathematics

specific niches in doctoral programs are a good idea. Further, about one half of the faculty members reported that their institution did indeed have one or more niches. Notably, about one third of the faculty members were "not sure" whether niches are a good idea.

A closer examination of the individual responses showed that faculty members from 15 institutions did not identify any niches at their institution. At least one faculty member from all the other institutions identified one or more niches associated with their doctoral program in mathematics education. An examination of responses from institutions with two or more faculty members often revealed multiple niches that seemed to be aligned with the number of faculty members actively involved in the mathematics education doctoral program. In general, the greater the number of faculty members, the greater the number of niches self--reported at that institution.

Table 1

Response to Two Niche Questions (N = 262)

Question	Yes	No	Not sure
Do you think specific program niches are a good idea?	57.3%	8.8%	33.9%
Does your doctoral program in mathematics education have one or more niches?	49.6%	31.3%	19.1%

Many different niches were self-reported by faculty members from 48 of the institutions represented in the survey. Their descriptions were brief but offer a reminder of the wide variability of grain size of niches identified at different institutions. Figure 2 identifies the niches most frequently reported by faculty members, which we have classified into some broad categories.

Additional study would be required to determine the nature and scope of the self-reported niches identified in Figure 2, but that was beyond the reach of the survey. Nevertheless, the range of niches in Figure 2 offers potential doctoral students in mathematics education a smorgasbord of areas for special in-depth study. Additionally, learning about these areas of specializations may prompt faculty members to reach out to their colleagues at other institutions to learn more about the nature of specific niches. Learning about the niches addressed in one institution could help strengthen the ways niches are developed in other institutions.

Question 3 asked respondents to identify institutions, other than their own, with specific intellectual communities or areas of specialization. Tables 2–6 summarize the results for each of the niches. Respondents were asked to identify other institutions with a specific niche, and self-nominations were not included in the tallies reported in Tables 2–6.

Figure 2

Niches Self-Reported by Faculty Members From at Least Five Different Doctoral Programs in Mathematics Education

Calculus & precalculus—research, visualization, representation, teaching

Cognition—student reasoning, issues in learning and teaching

Content knowledge for teaching mathematics—elementary, middle, secondary, geometry-measurement.

Curriculum—development, textbook analysis, teachers use, problem based

Diversity/equity—identity, access, social justice

History of mathematics, school mathematics, mathematics education

Learning trajectories—algebra, measurement

Modeling—applications

Problem solving—problem-based curriculum, problem-based instruction, problem posing

Proof—reasoning, proving

Research—student learning, teaching, curriculum, equity

Research in undergraduate mathematics education (RUME)

Teaching collegiate level mathematics—mathematics content

Statistics education—probabilistic thinking

Teaching and learning—K–6, middle, secondary and content areas: algebra, calculus, geometry

Technology—research, use of technology in teaching and learning

Note. The niches in bold were specifically addressed in our survey and are discussed below.

Technology

Technology has been an emerging area in mathematics education for several decades, and faculty members at 31 different institutions identified technology as a niche. The institutions' intellectual communities may focus on a range of possibilities related to technology, such as research on the use of technology to assist mathematics learning or on the development of technology to support and promote mathematics curriculum and development. Table 2 lists the institutions recognized by their peers as having a niche focusing on technology.

That only five institutions appear in Table 2 is surprising in our current technological era. Returning to our hypothetical situation, a faculty member could contact these institutions to learn how technology is reflected in their mathematics education doctoral program as well as in their preparation of PK–12 teachers. Also, worth noting is that the two most cited institutions, North Carolina State University and Penn State University, were substantially separated from the other institutions as well as from each other in the number of mentions.

Content Knowledge for Teaching

Content knowledge for teaching mathematics has also been a major area of discussion in mathematics education (Ball et al., 2001, 2005). In most cases, the focus is on teachers acquiring a sufficient level of understanding of mathematics and how students think to ensure that different levels of student learning are reflected in teaching practice. Content knowledge preparation sometimes focuses at a particular grade range, such as elementary school. Alternatively, content knowledge preparation may focus on specific mathematical topics, such as algebra or calculus.

Faculty members involved in preparing future K–12 mathematics teachers spend considerable time helping their students develop content knowledge for teaching mathematics. Our survey respondents connected 27 different institutions with some aspect of content knowledge for teaching. Table 3 shows the institutions most frequently recognized. The results document that the University of Michigan is widely recognized for its faculty members' extensive research on and development of content knowledge for teaching.

Table 2

Institutions Associated With a Technology Niche and Named by at Least Five Faculty Members From Other Institutions

Institution	Number of times named
North Carolina State University	33
Penn State University	10
Northwestern University	5
University of California–Berkeley	5
University of Massachusetts Dartmouth	5

Table 3

Institutions Associated With a Niche for Content Knowledge for Teaching and Named by at Least Five Faculty Members From Other Institutions

Institution	Number of times named
University of Michigan	107
Michigan State University	22
University of Georgia	11
University of Delaware	7
Arizona State University	6
Harvard University	6

Curriculum

Curriculum was another niche identified at multiple institutions. Survey respondents identified 26 institutions with a curriculum niche. Institutions in Table 4 may focus on different aspects of curriculum, such as curriculum development, implementation of curriculum, or analyzing mathematics curricula. The widespread attention to Common Core State Standards and their implications for teaching mathematics in elementary, middle, and secondary schools underscores the role of mathematics curriculum in teacher preparation.

Diversity/Equity

Survey respondents identified diversity/equity as a niche for 34 different institutions. Table 5, which lists the most frequently named institutions, shows a greater number of different institutions than any other specific niche in our survey. Clearly, many different institutions are attending to diversity/equity as a niche, and their efforts are being recognized by the mathematics education community.

Teaching Collegiate Level Mathematics

Teaching collegiate level mathematics has long been a niche for some institutions, such as Teachers College, Columbia University, where the first doctoral program in mathematics education was established. That early program was

Table 4

Institutions Associated With a Niche for Mathematics Curriculum and Named by at Least Five Faculty Members From Other Institutions

Institution	Number of times named
University of Missouri–Columbia	61
Michigan State University	43
Western Michigan University	13
Penn State University	9
University of Georgia	8

Table 5

Institutions Associated With a Diversity/Equity Niche and Named by at Least Five Faculty Members From Other Institutions

Institution	Number of times named
Michigan State University	35
University of Illinois Urbana-Champaign	24
University of Arizona	23
University of Illinois at Chicago	21
University of Wisconsin–Madison	21
Vanderbilt University	16
University of California–Berkeley	11
University of California–Los Angeles	11
Stanford University	6
University of Maryland	5

modeled after the PhD in mathematics except that its research focused on teaching and learning mathematics (Donoghue, 2001). Today, doctoral students in mathematics education in institutions with a focus on teaching collegiate level mathematics acquire a solid foundation in mathematics (typically a masters' degree or more in mathematics) and have a strong commitment to teach mathematics at the postsecondary school level. These doctoral graduates are primarily interested in teaching instead of doing research in mathematics, and graduates from these programs are in high demand by mathematics departments in junior college, private baccalaureate colleges/universities, and regional state-supported institutions where teaching is the primary mission.

Table 6

Institutions Associated With Teaching Collegiate Level Mathematics and Named by at Least Five Faculty Members From Other Institutions

Institution	Number of times named
San Diego State University/University of California–San Diego (joint program)	45
Arizona State University	32
Portland State University	22
Rutgers University	16
University of Northern Colorado	14
Virginia Tech	11
Oklahoma State University	9
University of Oklahoma	8
Teachers College, Columbia University	5

Our survey respondents identified 22 different institutions as having a teaching collegiate level mathematics niche, but only the nine institutions shown in Table 6 were cited by at least five faculty members from other institutions. Arizona State University has a long history of a specific focus, calculus, as part of its teaching collegiate level mathematics program. Notably, the doctorates in mathematics education at every institution in Table 6 except Rutgers University and Teachers College, Columbia University, are offered in a mathematics department. Some institutions, such as Oklahoma State University and the University of Oklahoma, also offer a doctorate in mathematics education in their College of Education. However, the latter paths to a doctorate are typically less demanding in mathematics than those for students pursuing a doctorate focusing on teaching collegiate level mathematics.

Reflection on the Findings

We conducted this survey to gather and share information that could strengthen doctoral preparation in mathematics education and also teaching and learning for future K–12 mathematics teachers. The results offer current information regarding specific intellectual communities or niches available in mathematics education at institutions in the United States. Although we recognize limitations from a survey, the results prompt several reflections.

Respondents included 262 faculty members in 63 institutions graduating the most doctorates in mathematics education in the United States. Results revealed that the majority of faculty members working in these doctoral programs thought niches were a good idea and identified a wide range of specific niches available in their doctoral programs. It also showed that about one third of the faculty members were unsure whether niches were a good idea. Equally perplexing is that about 9% said no, niches were not a good idea. The size of the latter two groups suggests that more discussion is needed within the mathematics education community to better understand the role and value of niches or areas of specialization in doctoral programs in mathematics education.

The faculty members of 15 institutions agreed that they did not have a niche in their doctoral program. Among the other institutions, multiple niches were reported, and generally the number of niches was directly related to the number of faculty members in mathematics education at that institution.

Given that 262 faculty members responded to the survey, and that the greatest frequency cited for any niche was 107 for the University of Michigan in Table 3 and the next greatest was 61 for the University of Missouri in Table 4, one could argue that we set a low bar for recognition of a niche (five mentions) from peers at other institutions with a doctoral program in mathematics education. If your institution has self-identified one of the niches in Tables 2–6 and is not mentioned in a table, then perhaps this omission will encourage your faculty members to be more proactive in increasing the visibility of your niches. These results may also encourage faculty members engaged in developing a niche not reflected in this survey to seek more recognition across the mathematics education community.

Survey respondents identified a total of 31 different institutions as having a niche (Tables 2–6). Twenty-six institutions appeared in these tables once; four institutions,

twice (Arizona State University, Penn State University, University of California–Berkeley, and University of Georgia); and one institution, three times (Michigan State University). However, the general infrequency of mentions for any particular institution suggests that, for the most part, specific niches are not overwhelmingly aligned with specific institutions in most faculty members' minds.

Some exceptions did exist with respect to the five niches reported here, with one or two institutions appearing more frequently among peers' mentions: the University of Michigan (content knowledge for teaching), North Carolina State University (technology), University of Missouri and Michigan State University (curriculum), and the joint program at San Diego State University/University of California–San Diego (teaching collegiate level mathematics). A general consensus seems to exist about intellectual communities in these institutions. The niche of diversity/equity did not have a clear institutional leader; five different institutions received mentions from at least 10 faculty members.

As noted earlier, only one institution, Michigan State University, was associated with three different niches. That doctoral program in mathematics education is, notably, embedded in multiple units, including the Department of Mathematics and the College of Education. Furthermore, the doctoral program in mathematics education is supported by more than 10 faculty members with a wide range of research interests and expertise.

Information about these intellectual communities may be helpful to faculty members who are interested in enhancing their preservice K–12 mathematics education programs to ensure they reflect issues such as technology, diversity/equity, mathematics curriculum, or content knowledge for teaching mathematics. Such information may also be useful to doctoral students interested in studying at an institution with a particular niche.

We recognize that niches in doctoral programs in mathematics education are fluid—that is, they will come and go. They depend on many factors, including funded research initiatives, faculty interest and experience, faculty mobility, and the time required to develop specializations that are widely recognized.

This brief report is a first step toward identifying academic areas of specialization in doctoral programs in mathematics education. We hope that sharing this information will stimulate more interaction among faculty members within the mathematics education community. For example, faculty members within similar intellectual communities could engage in additional collaborative work. Faculty members who are not currently in any of these intellectual communities may want to initiate conversations to learn more about these niches and perhaps collaborate in some activities of mutual interest. Finally, we hope our article will promote discussion that will help to characterize areas of specialization and their value in preparing future generations of mathematics teachers.

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