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Mathematics Education Graduate Students' Thoughts About Becoming Researchers

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Abstract The preparation of graduate students to become independent researchers is a central goal of all doctoral programs. In this paper, I present the results of a study looking at how this move to independence is viewed by graduate students enrolled in a mathematics education master's or PhD program. Results indicate that graduate students have very different views and experiences between the doing of research and the writing up of research. Results also indicate that membership in a community of researchers is central to the transition to independence.

Abstrait Former les étudiants de troisième cycle afin qu'ils deviennent des chercheurs indépendants est. l'un des objectifs principaux de tous les programmes de doctorat. Dans cet article, je présente les résultats d'une étude qui analyse comment ce parcours vers l'indépendance est. perçu par les étudiants inscrits à un programme de maîtrise ou de doctorat en didactique des mathématiques. Les résultats indiquent que ces étudiants ont des conceptions et des expériences très différentes lorsqu'ils passent de la réalisation d'une étude de rechercher au compte-rendu écrit de cette recherche. Les résultats indiquent également que l'appartenance à une communauté de chercheurs est. cruciale pour la transition vers l'indépendance.

Keywords Graduate students · Doctoral students · Research preparation

Introduction

Much work has been done in an effort to first understand, and then improve, graduate student education both within education in general and within mathematics education in particular (Reys, 2016; Reys & Reys, 2017). The bulk of this work can be organized into three main foci: the program of study, supervision and supervisory relationships, and the graduate student experience. The first of these has traditionally looked at the knowledge and skills graduate students need to acquire in their graduate program in order to become researchers (Middleton & Dougherty, 2008). However, Boaler, Ball, & Evan (2003) point out that "[r]esearch, after all, is not *knowledge*. Research, whether empirical, theoretical or philosophical, is an *active process of investigation*, one that relies on strategic use of knowledge, in context" (p. 495).

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A focus on the second of these—supervision—has produced an abundance of supervisory practice guides (Egan, Stockley, Brouwer, Tripp, & Stechyson, 2009; Pyhalto, Stubb, & Lonka, 2009). The guides tend to focus on more general aspects of supervision such as the relationship between the student and the supervisor, management of expectations, and setting and keeping of deadlines (Krauss & Ismail, 2010).

The third focus—graduate student experience—has tended to focus on the "transition to independence" (Baker & Pifer, 2011, p. 5) and an "emerging membership to the scholarly community" (Nardi, 2013, p. 2398). This has included, but is not limited to, a focus on helping graduate students' "decisions on what to focus on [and] the move from appropriating to creating knowledge" (ibid, p. 2398).

On their own, each of these three foci is insufficient in preparing graduate students to become independent and contributing members of the mathematics education research community. Consideration of the three aforementioned foci together in an integrated manner has, however, produced some results. Lovitts (2005), for example, looked at graduate education in two stages—dependent and independent work. The dependent stage contains the acquisition of disciplinary knowledge through coursework, participation in ongoing research projects, and the building of relationships within the graduate community. Meanwhile, the independent stage is signaled by the student independently doing and writing up research. Albold (2011) found that the degree to which a graduate student is able to transition to the independent stage is closely related to both their self-efficacy and identity as a researcher.

Gardner (2008) argues that becoming an independent researcher (or not) is a product of the socialization process embedded within a doctoral program. Schoenfeld (1999) feels this socialization process is contingent on the student being part of a research community and that this will help the student to develop useful research habits and perspectives. In particular, Schoenfeld (1999) argues that students should, right from the beginning of their studies, participate in ongoing research projects so as to be mentored and apprenticed within a research community.

In the research presented here, I look closely at this transition from dependent to independent researcher within one mathematics education graduate program which embodies many of the characteristics argued for by Lovitts (2005), Gardner (2008), and Schoenfeld (1999). And like Gardner (2008), I approach this work through graduate student experiences of becoming independent researchers by using their emerging views of research as a lens into this transition. That is, rather than looking at what this transition *could* or *should* be, I am looking at what it *is* and how it *is* shaped by their experiences.

Methodology

Participants for this study are drawn from the pool of graduate students enrolled in either a Master's or PhD program in Mathematics Education offered at a university in Canada. The Master's program is a cohort-based program consisting of six courses taken one at a time over the course of 2 years. Among these six courses are two courses focusing on mathematics content knowledge, two courses focused on the teaching of mathematics, and two courses dealing with research in mathematics education. Being a cohort program, the students take all their courses together. Each cohort enrolls between 14 and 18 students and is taught by four to six tenure track faculty. Admission into the program requires an undergraduate degree with significant attention to either mathematics or mathematics education.

After completion of these six courses, the students who have opted to complete a Master's of Education (MEd) write a comprehensive examination and the students who have chosen to complete a Master's of Science (MSc) complete a thesis. The decision as to which stream to follow is made by the beginning of the third course. To follow the MSc stream requires consensus between the student and the three instructors they have so far encountered. Of those students admitted into the MSc stream some begin their thesis research only after they have completed their coursework, others begin the process during their coursework. Some of the students who complete our master's program continue on, either immediately or after some years, to do a PhD.

The PhD program is comprised of four courses also taken one at a time over a 2-year period. These four courses include one course on the history of mathematics education, one course on contemporary research in mathematics education, one fieldwork course where students gather and analyze data, and one course which looks at what it means to be a contributing member of the mathematics education research community. Like the master's program, this is also a cohort program where the students take all four courses together with the cohort of students admitted at the same time. Unlike the master's program, however, each course will have students from two different cohorts—the cohort admitted that academic year, and the cohort admitted the previous academic year. That is, the program has an annual intake with courses offered biennially. Each cohort is comprised of two to four students and courses are taught by four tenure track faculty.

Admission into the program requires a master's in mathematics or mathematics education, preferably with a thesis as a capstone. In rare circumstances, students who have completed a master's without a thesis capstone are admitted. There is a provision for admission with only a bachelor's degree with a very high GPA and exceptional experience, but this option has never been exercised in the 14 years the program has existed.

Upon completion of the coursework, the students write a comprehensive examination which looks at their readiness to proceed into the final stages of their PhD thesis research. Although some PhD students wait until they finish their coursework before they begin to do their thesis research, the vast majority begin thinking about their research as early as their first term.

Although the MSc and PhD students have the option of doing a theoretical- or philosophical-based thesis, all but a very few choose to do empirical research. And of these, the majority choose to gather their own data (as opposed to using secondary data from their supervisor or some publically available repository). In addition, most of the PhD students participate in at least one, but often multiple, ongoing faculty-led research projects.

The participants were selected from the aforementioned pool of MSc and PhD students so as to represent a diversity of research experience from a brand new MSc student all the way up to a completed PhD student. Sixteen graduate students were selected so as to maximize this diversity (see Table 1). These 16 students were contacted via email and asked to participate in a research study looking at their research experiences as a graduate student. Fifteen of the 16 students contacted agreed to be participants in the study—six MSc students and nine PhD students.

Instrument

Each of these participants was asked to complete an online questionnaire designed to probe their experiences and conceptions about research. But research can be both the process of doing research (a verb) and the products of research (a noun). For a graduate student, this distinction exists in the tensions between the doing of their research and the writing up of the results of that research. Although the literature on becoming an independent researcher does not explicitly make this distinction, I wanted to capture the participants' views of both of these. As such, the questionnaire was designed around these two phases—*doing research* (the verb) and *writing up* research (the noun). I also wanted to capture their conceptions of discrete aspects of research such as methodology, literature, theoretical frameworks, and analysis. Finally, I wanted to understand how the participants' views about research developed, in general and within their graduate studies. As such, the questionnaire was designed around a developmental frame so as to probe for the aspects of the participants' experiences that have helped to develop their research prowess and to learn what further help is needed. At the same time, I wanted all of these experiences and conceptions to emerge naturally, without explicit provocation from specific questions.

In the end, I came up with seven questions that seemed to succinctly and comprehensively capture the participants' thoughts and experiences around the two phases of research (doing and writing), the discrete aspects of doing and writing research (methodology, literature, theoretical frameworks, analysis, etc.), and the development of these thoughts. The specific questions are as follows:

1. What is research?
2. What does it mean to do research?
3. How is doing research similar and different to writing up your research?
4. What do you know now about doing research that you didn't know when you started the program?
5. What has helped you the most in doing research?
6. What has helped you the most in writing up your research?
7. What more help do you feel you need around doing and writing research?

At the beginning of the questionnaire, the participants were told that they would be given each question one at a time and that when they were finished responding to a question, they would click the *NEXT* button and the current question and response would disappear and the next question would

Table 1 Summary of the participants

PHD STUDENTS									MASTER'S STUDENTS					
Marnie	Donna	Mandy	Jennifer	Stephanie	Maureen	Richard	Veronica	Samantha	Marcus	Mathew	Nicole	Charley	Nancy	Barb
✓	✓	✓	✓	✓	✓						✓	✓	✓	✓
✓	✓	✓		✓	✓				✓	✓	✓	✓	✓	✓
✓	✓	✓			✓				✓	✓	✓	✓	✓	
✓	✓	✓	✓	✓	✓				✓	✓	✓	✓		
✓	✓	✓	✓	✓	✓		✓		✓	✓				
	✓	✓		✓			✓	✓						
	✓	✓	✓		✓									
✓														

BEGAN TO GATHER DATA WHILE DOING COURSE WORK

COMPLETED DATA COLLECTION

COMPLETED DATA ANALYSIS

BEGUN THESIS WRITING

COMPLETED A MASTER'S THESIS

WORKED ON A RESEARCH PROJECT OUTSIDE THESIS

HAS PUBLISHED RESEARCH FROM THESIS

COMPLETED THE PHD THESIS

appear. They were also told that they would not be able to go back to a previous response to modify their answers. This structure was chosen so as to prevent the prompting that comes with later questions from influencing their expressed conceptions on questions where prompting was absent or ambiguous. The first question is an example of the need for this questionnaire structure. As mentioned, research is an ambiguous term which can refer to either the act of conducting research or the products of research. I did not want the phrasing of the second question to bias their response on the first question. Likewise, for the second question, I wanted to see if the participants included the writing up of research as part of doing research. Thus, I did not want them to see the third question until they had completely responded to the second question.

The aforementioned seven questions, along with the questionnaire structure, seems to be a rather simple and unsophisticated instrument. However, the richness of the responses shows that this questionnaire provoked responses that were neither simple nor unsophisticated.

Analysis

These data were then analyzed using a framework of analytic induction (Patton, 2002). This process, like grounded theory (Charmaz, 2006), relies on the use of a constant comparative method (Creswell, 2008). Unlike grounded theory, however, analytic induction begins with codes drawn from theory and/or literature (Taylor & Bogdan, 1984). In the case of the data analyzed here, these a priori codes came from the aforementioned literature and focused on community and socialization (Egan, Stockley, Brouwer, Tripp, & Stechyson 2009; Gardner, 2008; Nardi, 2013; Pyhalto, Stubb & Lonka, 2009; and Schoenfeld (1999), guidelines (Krauss & Ismail, 2010), the doing of research (Boaler et al., 2003), and transition to independence (Albold, 2011; Baker & Pifer, 2011; Lovitts 2005). These codes were used recursively to analyze the data in two different directions—within the responses to each item on the questionnaire (with the grain[1]) and across all the responses to all the items (across the grain[1]). As the analysis progressed, new patterns began to emerge and were assigned new codes.[2] When saturation had been reached and no further patterns were emerging, the codes were examined more closely and similar codes were collapsed together to form themes.

Results and Discussion: With the Grain

In what follows, I present the themes that emerged as a result of the analysis on the responses to each question in turn. I use excerpts from the data to either represent multiple responses, highlight nuance, or signal uniqueness. When relevant, I link these responses to relative stages within the participants' graduate experience.

Question #1: What Is Research?

Although the question, as stated, could be referring to the processes of research (verb) or the products of research (noun), all 15 participants responded to this question as a process (verb) with the majority stating that it was a formal process. More interesting, however, was that, while all of the participants talked about this process as being centered on answering a question, only the doctoral students, and all the doctoral students, talked about that question as being something specifically of interest to them.

[1] Watson (2000) distinguishes between patterning activities as either reading with the grain or across the grain. Reading with the grain means to read with the pattern—to determine the next term by previous terms. Reading across the grain involves looking across the direction of the pattern and determining the term based on the position the term is occupying. I have coopted this terminology to refer to the similar ways in which data can be analyzed.

[2] Analytic induction, through its constant comparative method, allows for this.

Research is an in-depth study of an area one is interested in learning more about. (Samantha, PhD)

Research is an inquiry into a phenomenon of interest. (Veronica, PhD)

Research is a formalized and systematic way of pursuing curiosity. (Richard, PhD)

Question #2: What Does It Mean to Do Research?

Doing research was generally described by the participants as a process involving identifying a research question, reading literature, the selection and use of theory, the selection and use of methods, the collection of data, analysis of data, and/or the arrival at some sort of conclusion. However, identifying a research question was the only aspect of doing research mentioned by all of the participants (see Table 2).

After identifying a research question, analyzing data and coming to a conclusion were the next most frequently mentioned.

It involves searching for answers, analyzing data, generating generalizations or conclusions which may lead to further questions. (Samantha, PhD)

And reading literature and using a theory were the least frequently mentioned.

Table 2 Aspects of doing research identified by participants

		IDETNIFYING RESEARCH QUESTION	READING LITERATURE	IDENTIFYING AND USING A THEOREY	IDENTIFYING A METHODOLOGY	COLLECTING DATA	ANALYSING DATA	ARRIVING AT CONCLUSIONS	TOTALS
MASTER'S STUDENTS	Barb	✓							1
	Nancy	✓				✓	✓	✓	4
	Charley	✓	✓	✓			✓		4
	Nicole	✓						✓	2
	Mathew	✓				✓			2
	Marcus	✓							1
PHD STUDENTS	Samantha	✓	✓				✓	✓	4
	Veronica	✓			✓			✓	3
	Richard	✓							1
	Maureen	✓					✓		2
	Stephanie	✓			✓			✓	3
	Jennifer	✓			✓	✓	✓	✓	5
	Mandy	✓							1
	Donna	✓		✓	✓		✓		4
	Marnie	✓				✓	✓		3
TOTALS		15	2	2	4	4	7	6	39

> It involves studying previously completed research Information that has been published and can involve further exploration into that area in order to answer unknown questions. (Samantha, PhD)

> To do research involves setting a clear goal for what you are wanting to investigate and then setting out a plan (method) to follow to seek answers. It also involves identification of how you will interpret the data that you obtain. (Donna, PhD)

The participant with the most comprehensive articulation of research, mentioning all aspects except reading literature or identifying a theory, was Jennifer

> Research is inquiry. It is a systematic approach to developing an understanding of a given phenomenon of interest. It encompasses everything from formulating a question to convincing others of one's findings. It includes identifying a phenomenon of interest, developing a method for inquiry, collecting artifacts and data, and pulling and viewing the data in various ways to emerge results. (Jennifer, PhD)

It should also be mentioned that two of the participants, both master's students, viewed research exclusively through the lens of action research involving varying some aspect of their own teaching practice and observing the changes in the students.

> Conducting a thought out and planned series of actions amongst potential subjects of study (i.e. students) and noting the reactions or behaviors that it induces. (Charley, MSc)

> Asking a question and investigating by making some alteration to typical practice. This may be simply making note of something already happening, or making a larger change altogether. (Barb, MSc)

Question #3: How Is Doing Research Similar and Different to Writing Up Your Research?

Despite the fact that the question asked the participants to articulate similarities and differences between doing and writing research, the majority focused solely on the differences, often in dichotomous ways, between these two parts of doing research (see Table 3).

No participant embodied this dichotomous view more so than Nicole.

> Doing the research is exciting, like a game by my own rules. Writing the research: as fun as a visit to the dentist, followed by bad news and a car accident on the way home.

Table 3 Dichotomy conceptions between doing and writing research

	Doing research is …	Writing up research is …
Mathew	Collection of data	Formalizing the process
Marcus	Messy and unclear, full of bumps and bruises, falls and getting ups	Also messy, but it is a structured mess
Samantha	In answer to questions that you as a researcher have	Organizing it in a way to share with others
Veronica	Data collection process is fun and messy	Where the cleanup kicks in
Stephanie	An ongoing process where there is a constant need to find out how or why something operates the way it does	A finite process reporting on how the investigation was carried out to achieve the necessary findings
Donna	The findings are usually unknown	The findings may not be clear, but they are usually known

> Doing the research: although not every day is a good day, every day is a different day. Writing the research: for the most part, tedium.
> Doing the research: being authentic. Writing about the research: adopting a foreign persona, keeping the real me under lock and key so she doesn't say something silly.
> Doing the research: feeling that you learn something. Writing the research: realizing you know nothing, and you probably never will.
> Doing the research: having the illusion that you contribute to the sum of human knowledge. Writing the research: forget it, it's all been done before. (Nicole, MSc)

The emotionally charged dichotomy expressed by Nicole was also echoed by Mandy and Veronica.

> … it's definitely a love-hate relationship. (Mandy, PhD)

> Data collection process is fun and messy. It makes me think of unstructured play time with toys being everywhere and everyone enjoying the process. The writing up part is where the cleanup kicks in [..] Cleanup is no fun. (Veronica, PhD)

Emotions aside, the polarization between doing and writing research also revealed that four of the participants viewed analysis as belonging strictly to the writing up of research and that two of the participants believed the reading of literature on the topic of the research question also belonged to the writing up phase. Although the first of these revelations had no correlation to whether the participant was a doctoral or master's student or how long they had been in the program, the later was a view held only by masters' students.

On the positioning of analysis, Samantha saw analysis as being part of both the doing and the writing up of research and Richard, expressed research as having three phases—doing, analysis, and writing up—with the writing of research as the telling of one possible story about the research.

> Data analysis is a part of research that straddles the doing and writing up of research. It happens during the process of doing research and can inform the researching in regards to needing more data or having enough to stop and move to the next stage. The data can be looked at in depth for patterns or generalizations. This can be done prior to as well as during the writing up of the research. (Samantha, PhD)
> To use the analogy of travelling, doing research is like planning and taking a trip. The researcher, for example, takes the trip, writes journal entries and takes photographs and videos. After the researcher returns and looks back on the trip and the artifacts collected, they reflect on the experience and analyze the data collected for observations no one has made before. Writing up the research is like the traveller/researcher writing a particular short story about the observations made on the trip by choosing a genre, a theme, a voice, and a narrative. The written version of the trip is not the trip itself but one possible story about the trip. (Richard, PhD)

Jennifer was the only participant to resist the splitting of research into separate phases and views doing and writing research as dynamic and conjoined activity.

> Writing up research is a process of reflecting on and reifying the research process. It is a point at which a researcher takes "stock" of what has occurred. It can be considered distinct from doing research because it typically happens after one has engaged in the research. However, writing up research can be an extension of the research because through writing, research questions are clarified, data is selected, analysis becomes more robust and meaningful, and conclusions are written with the intention of being subject to public critique. This in turn makes the research stronger, and can prompt further research. I consider writing up research to be part of doing research because it is a form of expressing the research, and can happen at any point of the research endeavor. The two are linked. (Jennifer, PhD)

Question #4: What Do You Know Now About Doing Research that You Didn't Know When You Started the Program?

This question, more than any other, prompted a number of the participants to discuss the role of theory and theoretical frameworks in research. Although these responses came from both master's students and PhD students, it is interesting to note that, with only one exception, all of them have significant time in their respective programs, have lots of research experience, and are either close to completing, or have completed, their thesis.

> I am more cognizant of the role of theory as an analytical tool to the process of doing a research than I was previously. (Stephanie, PhD)
>
> How to put together a framework that could work to analyze the data that was collected. (Marnie, PhD)
>
> How methodical one has to be in order to ensure the data is meaningful and valid. And there's enough of it. (Nicole, MSc)

Three also talked about realizing that research need not be quantitative.

> When I started I didn't know: that no result is still a result; that qualitative is so much harder (but so much more interesting) than quantitative. (Donna, PhD)
>
> I believed true research was quantitative and results needed to be quantified. I also believed that the results were a true and complete representation of the data. I now have a much better understanding of the rationale for and importance of qualitative data. I understand data analysis and results from this perspective to be a version of truth a truthful fiction. (Richard, PhD)

Question #5: What Has Helped You the Most in Doing Research?

The most common responses to this question were talking to others.

> … talking to people who had done research. (Nicole, MSc)
>
> Talking to some people about what I was doing, and listening to what they thought it was interesting about my research was supportive (kept me going) and helpful (helped me develop ideas and to reflect on what I was doing). (Marnie, PhD)
>
> The community we built—hands down. Research can be lonely, and sometimes life gets in the way of research. I needed the support to get me going (life and research), to talk and to put a fresh lens on my work, to ask questions, to fill in gaps, etc. (Mandy, PhD)

What is interesting about these responses, however, is who the others are (community of graduate students, graduate students who were further along in their research, graduate students they met at conferences, friends) and who they are not (supervisors). That is, none of the participants mentioned talking to their supervisor as something that helped them. This is not to say that the supervisor was completely absent in their responses, but they were identified as providing help through feedback, teaching, guidance, mentoring, and collaboration—but never as *talking*.

> The biggest help in doing my research came primarily from my Supervisor and then from other Professors with whom I took the courses. (Maureen, PhD)

This was not a monologue vs. dialogue divide. Many of the participants referred to the help from their supervisors as dialogical. But this is not the same as what they mean by talking. Talking seems to be reserved for the discussions that happen within a community of graduate students.

The second most common response to this question had to do with reading.

> Reading articles and books that are written in a way that is easy to "copy" or glean ideas of how to do it from. (Samantha, PhD)
>
> Further, reading the products of others has also been helpful because it makes it seem possible to attain and pursue. I particularly attend to various methodologies other researchers in related fields use because I find I yearn for a better sense of determining the best methods for a particular study. (Jennifer, PhD)

For these participants, reading is a method for identifying the structures associated with doing research.

Question #6: What Has Helped You the Most in Writing Up Your Research?

This use of reading as a means to extract structure and norms was also identified as something that has most helped the participants in writing up their research.

> The most helpful process I find when writing up research is to refer back to other written up research. I find examples to be particularly helpful because I can identify and work within the norms. Looking through and comparing many different examples of written up research allows me to identify the key structural elements that are required to constitute an acceptable publication. (Jennifer, PhD)
>
> Reading other people's research and trying to reverse engineer how it was written. (Nicole, MSc)

Feedback on written work by the supervisor, members of the supervisory committee, peers, and reviewers was also mentioned as instrumental in improving writing.

> Having feedback and suggestions for organization and another perspective on my results. (Donna, PhD)

Interestingly, and unlike the responses to the previous question, talking was not mentioned as an aid to improving writing by a single participant. Whereas the participants clearly see talking with peers as a generative tool for learning to do research, discourse around written work seems to be limited to products written in isolation.

Question #7: What More Help Do You Feel You Need Around Doing and Writing Research?

Responses to this question were a mishmash of requests from help identifying a theoretical framework to how to set up cameras and microphones. One interesting theme that emerged was a thirst for very detailed specifications.

> A short YouTube tutorial about formatting and citations would have saved some time. (Mathew, MSc)
>
> Choice of methodologies suitable for education research (pros/cons etc.). Ratio of theory/methodology/practice chapters in thesis. (Veronica, PhD)

For three of the master's students, and only master's students, this equated to specifications for a thesis.

> A general expectation of length and/or structure of a thesis would also be helpful. (Barb, MSc)

> I think that when I embarked on the thesis writing project, I did not have a clear idea of what it entailed. This lack of clarity caused me to procrastinate. It would have helped me to read a book on the exact steps of conducting/writing research earlier on. (Nicole, MSc)

The final category of responses pertains to improving writing for the purpose of improving its readability.

> In writing a research to be able to find better ways of saying things; that is, how can I make my writing more reader friendly and easier to understand? (Stephanie PhD)
>
> How to find perfect balance between accountability and readability. (Veronica, PhD)

Results and Discussion: Across the Grain

In what follows, I present the themes that emerged as a result of the analysis of the data across all of the responses, irrespective of the question that prompted the response.

The Research Question as a Phenomenon of Interest

That the research question should be centered around a phenomenon of interest is something that every doctoral student referred to. The fact that four of the master's students did not was at first surprising. But upon further investigation, it began to make sense. Many of the master's students entered into the thesis stream with the a priori conceptions that research had to be quantitative and that research questions were assigned.

> I now know that research does not necessarily need to be quantitative. I have learned that stories, anecdotes, interviews and observations can be valued in research. (Mathew, MSc)
>
> The process is a lot more open than I thought it would be, I had considered that I would be directed more into what areas of research needed to be done or what specific things I should look towards when conduction my research. A lot more sandbox-y than I had anticipated. (Charley, MSc)

The two PhD students who had not written a master's thesis were not immune to such a priori conceptions.

> Before entering the program, my understanding about doing research was based almost entirely an empirical model. I believed true research was quantitative and results needed to be quantified. I also believed that the results were a true and complete representation of the data. (Richard, PhD)
>
> I have come to realize that when I think of research I think big and yet much of the research that I have been reading is very focused on specific details. (Samantha PhD)

At the same time, however, the master's students were also the only participants who viewed their research as being focused on their classroom practice.

> Asking a question and investigating by making some alteration to typical practice. This may be simply making note of something already happening, or making a larger change altogether. (Barb, MSc)
>
> Conducting a thought out and planned series of actions amongst potential subjects of study (i.e. students) and noting the reactions or behaviors that it induces. (Charley, MSc)

Community of Researchers

One of the most pervasive themes that emerged exclusively from the doctoral students was the value of having a community of researchers to engage with. They identified this as instrumental in their development as researchers and invaluable in the crafting and doing of research. Ironically, the community they spoke of was often absent of supervisors and referred exclusively to the community of graduate students.

> The community we built. (Mandy, PhD)

The varying levels of progress and experience that exists within a graduate program naturally creates the potential for a vertically integrated community. This potential is realized only if a network is built between the disparate members of a graduate program.

> Having such a strong network of people with various capabilities makes it easy to get help in my research when I need it. (Jennifer, PhD)

This is not to say that supervisors do not play an important role in the mentorship of graduate students, for they do. Every participant mentioned, across multiple questions, the importance of collaboration, mentorship, and feedback, from supervisors and supervisory committees. But they also held this as separate from a community of peers with which to interact with and to help them navigate and negotiate what it means to do research.

Guidelines

Many of the participants mentioned, in one way or another, their desire to have clear guidelines around the doing and writing up of research in general, and a thesis in particular. Sometimes, this thirst for clear guidelines was articulated as something they wanted to be given.

> A short YouTube tutorial about formatting and citations would have saved some time. (Mathew, MSc)
>
> Choice of methodologies suitable for education research (pros/cons etc.). Ratio of theory/methodology/practice chapters in thesis. (Veronica, PhD)
> A general expectation of length and/or structure of a thesis would also be helpful. (Barb, MSc)
>
> It would have helped me to read a book on the exact steps of conducting/writing research earlier on. (Nicole, MSc)

Other times, however, it was something they wanted to figure out from themselves.

> I find examples to be particularly helpful because I can identify and work within the norms. Looking through and comparing many different examples of written up research allows me to identify the key structural elements that are required to constitute an acceptable publication. I recall in one of the courses in the program, we looked at many examples, and looked for variance and invariance. This was very helpful. (Jennifer, PhD)
>
> Reading other research at the same time to get fresh ideas for structure and terminology. (Donna, PhD)

This notion of guidelines also extended towards the help they wanted with technical aspects of doing and writing research.

> In doing a research I believe I need more help in using analytical software such as Nvivo (Stephanie, PhD)

> In particular, it would be helpful to have more time dedicated to working on working on and sharing about methods of analysis such as using NVivo, coding, and emerging themes. (Jennifer, PhD)

Divide Between Doing and Writing Research

Although question #3 explicitly asked the participants to articulate differences between doing and writing research the divide between these two aspects of research appeared all through the data. In part, this has to do with the emotional dichotomy between doing research and writing up research. The data was shot through with emotion—positive for doing research and negative for writing up research.

> Doing the research is exciting, like a game by my own rules. Writing the research: as fun as a visit to the dentist, followed by bad news and a car accident on the way home. (Nicole, MSc)

Part of this can be explained by the perceived contrast between the excitement of discovery and the mundaneness of writing up what you now already know.

> In doing research, the findings are usually unknown (although they could be anticipated), whereas in writing up research, the findings may not be clear, but they are usually known. (Donna, PhD)

> Doing the research: although not every day is a good day, every day is a different day. Writing the research: for the most part, tedium. (Nicole, MSc)

This may also be explained, in part, by the social vs. solitary divide. That is, whereas the doing of research was discussed as something that would benefit from the social interactions afforded by the aforementioned community of graduate students, the writing of research was largely seen as a solitary experience.

> It could be very lonely there are days I sit and write and write and write and lose track of time. Maybe I'm engaged in the writing, but at the end of the day I feel I need adult conversation. (Mandy, PhD)

Although only a few mentioned this explicitly, this social-solitary divide lived implicitly within the comments about feedback on writing as something that only happens once the solitary act of writing is complete.

A further divide has to do with how some participants positioned literature, analysis, and theory.

> Writing up your research is when you can make concrete conclusions based on the data. Now you can use your own research and other research done on the same topic to solidify your claim. In the writing process you now interpret your data. (Nancy, MSc)

> Writing up your research is a linear, orderly, and slightly boring activity, with alternating bouts of inspiration and writer's blocks. Trying to connect theory to practice and explain your findings through a lens of a particular theoretical framework is as hard as it gets, especially if such framework needs to be concocted from a number of various fields. (Veronica, PhD)

Although it can be argued that this is a false dichotomy to begin with, the absence of literature, theory, and analysis from the doing of research begs the question of how these graduate students perceive what is entailed in initiating the doing of research.

Conclusions

The research presented here has managed to address the aforementioned research questions, the answer to which also carry with them certain implications. In what follows, I first present the answers to the research question and then address some of the resultant implications for graduate programs enrolling mathematics education students.

Findings

Although there was not a clear divide between the master's students and the PhD students, there were attributable differences between the students who had completed a master's thesis and those who had not. The master's students tended to come in to research with the *a priori* conceptions that research was quantitative and that research questions were either assigned or needed to answer global questions. Some of these conceptions were also present within one of the PhD students who had done a course-based masters.

At the same time, however, having done a master's thesis was not sufficient experience for properly situating the role of analysis, literature, and theory. Clarity of these aspects of research was still lacking for many of the PhD students well into their doctoral work. Despite the prevalence of literature and theory within the PhD coursework and their participation in research projects, it was not until the PhD students began to write up their own research that these ideas around the role of literature and theory seemed to be reified.

Many of the participants, irrespective of what program they were in or how far along they were in that program, identified a community of peers to be one of the things that was most helpful in their development. The ability to talk to fellow graduate students about their trials and tribulations was invaluable to them. Of course, they also identified the feedback, collaboration, and mentorship they received from supervisors as instrumental.

With respect to what help was still needed, a majority of participants from both the master's and PhD program felt that clear and detailed guidelines and examples as to what is expected of them in research in general and their thesis in particular would be helpful. This was more often articulated as a need for guidelines and expectations around writing research than for doing research.

In many ways, these results both support and contradict the ideas of Lovitts (2005), Gardner (2008), and Schoenfeld (1999). In agreement with Lovitts (2005), there is a clear divide between the dependent and independent phases of graduate work. And, in agreement with Gardner (2008), this divide is mitigated through immersion in a community of researchers. Unlike Gardner (2008), however, the students discussed this community as being exclusively made up of fellow graduate students. Surprisingly, participation in research projects seemed to only strengthen the participants' effectiveness as dependent researchers and had little effect on helping them to make the transition to independent researchers. It seemed like only being cast as an independent researcher responsible for writing up their own research helped to reify the skills necessary to be an independent researcher.

One final result is that despite the fact that all of the participants were enrolled in either a master's or PhD program focused specifically on mathematics education, none of the results are specific to mathematics education. In fact, of the 15 participants, only three even mentioned mathematics or mathematics education in their responses. Nicole mentioned mathematics education as the research literature that she has been exposed to. Veronica mentioned a particular methodology as coming from a particular mathematics education researcher. And Jennifer talked about mathematics education as a field and mathematics education researchers as the community that she belongs to and the community that sets the expectations for what research in that field is. The lack of specificity of the responses by the other 12 participants may be due to the general nature of the questions, but it may be that the divide between being a dependent and independent researcher that the participants seem to be identifying is a generic divide. In a way, this makes sense, as the issues of transition to independence are not unique to mathematics education and are a fundamental part of belonging within any community.

Implications

Although the results of this research are based on the comments of only 15 graduate students in two specific graduate programs, the results do speak to possible implications. It seems that, first and foremost, graduate programs need to find a way to network their students so as to help the formation of a community of peers. In smaller programs, this will necessitate either interdisciplinary communities or an expansive networking of students across institutions. Early researcher events hosted by organizations such as PME (The International Group for the Psychology of Mathematics Education) and ERME (European Researches of Mathematics Education) can help facilitate such inter-institutional graduate student communities. Likewise, national programs such as the STaR program (Reys & Reys, 2015) can help with this sort of networking.

As the writing up of research seems central to the reification of aspects such as the role of literature, theory, and analysis, it is imperative that graduate students (especially PhD students) need to independently write up research early on in their programs. The research need not be relevant to their thesis research question. What seems important is the process of integrating collected data with literature, theory, and analysis. Such an activity would help graduate students to more correctly situate and integrate the various aspects of doing and writing research and better prepare them for embarking on their thesis work. It may also allay some of the emotional discrepancy between doing and writing research.

Finally, something needs to be done to quench the seemingly great thirst for guidelines and examples. Although guidelines may overly simplify the complexity of doing and writing research for journals, conferences, and theses, the notion of a database of examples from which to draw exemplary research in general, and different aspects of research in particular, would preserve the complexity of doing research while still providing help with structure.

Limitations

The research presented here, like all research, has its limitation. First, and foremost, is its sample size. Although the goal of this article was not to produce generalizations, I tried to provide enough details about the graduate programs that these participants are enrolled in that readers may be able to make connections between the results presented here and their own context. A second limitation comes from the nature of the questions which, although open-ended, do tend to bias the students' answer towards their thesis research and away from research in general. As such, their answers emerge through the lens of the particular literature, theories, and methodologies relevant to their thesis research. Finally, a potential, and unintended, limitation occurs from the relationships between the participants and myself when acting in the multiple roles of researcher and instructor.

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