

Comprehensive Exam Variations and Experiences of Doctoral Candidates in Engineering

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Abstract

Our goal in this work in progress paper is to examine self-reported experiences of engineering doctoral candidates (n=35) regarding the comprehensive exam. Data was collected from candidates at a large research intensive North American University through an online survey distributed across 7 engineering departments. The descriptive summaries from participants collected reveals that the highs and lows of experiences of doctoral candidates are variable and inconsistent. Ultimately, the goal of this study is to examine if departmental and exam method variations in engineering yield to significant differences in the experiences of doctoral candidates. The next steps include collecting a larger data set from one or potentially multiple North American universities and carrying out statistical, rather than descriptive analysis. This analysis can help in understanding why institutions necessitate administering diverse formats of doctoral exams, how students perceive it, and if certain formats are found to be more beneficial for the students.

Introduction

Contrary to doctoral education in Europe or Australia, completion of coursework and a set of examinations are the default requirement in North America [1]. The comprehensive or qualifying exam (hereafter CQ) exam has been shown to impact the Time-to-Degree and Completion Rates of Doctoral Students [2]. Passing CQ exam is as such a key milestone for an early doctoral candidate in North American universities [3]. CQs are often used to assess students' basic skills and ability to conduct research as well as provide an opportunity for students to demonstrate mastery of literature and research techniques in their disciplines [4]. Other purposes of CQs can include screening out weak students and providing a rite of passage [5].

The CQs have been a perpetual requirement for PhD students since the 1930s [6], [7]. However, their formats have shown to change over time and vary across different disciplines. Across the engineering departments at a large North American university for example (University of Toronto), the ways in which CQs are carried out are unfixed. Examples include but are not limited to the timing; by first or third year taken, format; oral exam versus written exam (take home or in class), scope; research proposal versus background theory, etc...

An unexplored aspect of CQ exams is the degree to which students receive assistance for preparing for the exam and beyond [8]. This motivates our work to focus on analyzing experiences of doctoral candidates within and across different engineering departments, who may have taken the exam at different times during their program with variable formats and modes of delivery. Ideally, it is wanted that all students receive a standard experience and similar quality of assistance irrespective of their discipline or CQ exam format in engineering. Studying self-reported experiences communally can subsequently aid in teasing out undesired experiences in each department based on social consensus.

Methods

Before conducting this study, an ethics protocol was submitted and accepted by the research ethics board of the institution (ID: 36998). An online survey was distributed to engineering doctoral candidates across engineering departments at [name withheld] in early 2019. The survey questions were intended to collect information about the demographics of candidates (i.e., home department, year taken, type of exam, etc.) as well as their perceived experiences and thoughts on the purpose and utility of the CQ exam. The survey was pilot tested by 3 external reviewers, points of clarification were noted, and survey questions were adjusted accordingly and finalized once the authors and reviewers achieved consensus. The survey was then shared with doctoral candidates via digital newsletters and emails from their respective departments. A summary of variables collected from the survey are presented in Table 1. For data analysis, this study investigated survey data through both closed-ended and open-ended questions separately. For questions requiring open-ended responses, thematic coding and a frequency count was carried out. For questions requiring closed-ended responses, a Likert scale was used with the following items: 1) Strongly Disagree, 2) Disagree, 3) Somewhat Disagree, 4) Somewhat Agree, 5) Agree, 6) Strongly Disagree.

Table 1 Data collected

Closed-ended questions: Likert scale, 6 items ranging from strongly disagree (1) to strongly agree (6)	1. Exam being an enjoyable experience
	2. Exam contribution to organizing research
	3. Exam aiding to acquire information for research project
	4. Exam broadening student knowledge
	5. Exam components well integrated with one another
	6. Exam helping with PhD research plan
	7. Exam instructions easy to follow
	8. Exam being a worthwhile process
Open-ended Questions:	Your thoughts on the purpose of exam?
	Your suggestions for areas of improvement with the exam?

Results and Discussion

A total of 56 doctoral candidates participated in this study but only a portion of the sample size (n=35) answered all questions fully. As a result, 35 data samples were used in the analysis for this study. Of the respondents and the type of CQ, the Department of Electrical and Computer Engineering doctoral candidates made up the largest portion (ECE, n=14, background knowledge), followed by the Department of Civil & Mineral Engineering (CivMinE, n=10, background knowledge) and the Institute of Biomaterials and Biomedical Engineering (IBBME, n=4, research based). The remaining responses belonged to the Department of Mechanical and Industrial Engineering (MIE, n=3, research based), the Department of Materials Science and Engineering (MSE, n=2, background knowledge), the Division of Engineering Science (EngSci) and the Institute for Aerospace Studies (AERO) (each n=1, research based). Overall the examinations that focused on background knowledge exhibited more variability in delivery and format as compared to the research-based exams. Variations included the timing, number of exam parts and sequencing, and the nature of parts (i.e., either or both written and oral). Regardless of knowledge or research-based exam, all respondents reported having to complete an oral exam and/or presentation. Of the 35, 30% (n=11) had to write a written exam (which tends to be more theory based) and 52% (n=18) had to write a project proposal focusing more on the research instead.

We decided to reduce the 6-item scale to three items of Disagree (by grouping 1 and 2), Neutral (by grouping 3 and 4), and Agree (by grouping 5 and 6) due to a low sample size. The grouped results suggest that the candidates have mixed feelings toward the exam and the perceptions overall are evenly distributed between Disagree, Neutral, and Agree categories (see Table 2). Descriptive box plot summaries of responses from five departments were also examined (see Figure 1). For each figure, the y-axis pertains to grouped rating of experience. The x-axis pertains to the 8 experience questions (see Table 1). For ECE CQ, 7 of the 14 doctoral students disagreed (median =1) with CQ exam aiding with organizing a research plan (Q2), acquiring the information needed for research (Q3), and helping with student's own research plan (Q6). On the other hand, 7 of the ECE survey respondents somewhat agreed (median = 2.5) with CQ exam instructions being easy to follow (Q7). For the remaining questions, seven ECE participants consistently reported a neutral experience. The experiences of candidates from CivMinE CQ were different from ECE, even though the participation rate from the two departments were about the same (14 vs. 10). Five of the 10 CivMinE doctoral students somewhat disagreed (median =1.5) with the exam being an enjoyable experience. For all the other experiences questions however, the CivMinE candidates either rated neutral or slight agreement on positive impact of CQ exam. Unfortunately, the other departments only had a few responses (Figure 1 bottom row).

Table 2 Overview of closed ended responses

Grouped experiences (below and strength of experiences (right)	Disagree and Strongly Disagree	Neutral	Strongly Agree and Agree
Positive contribution to Academics	30%	33%	36%
Positive Impact on Personal Feelings	34%	31%	34%
Well Organized Logistics and planning	36%	38%	26%

The thematic frequency counts of perceptions of doctoral candidates towards the purpose of engineering CQ exam were coded and counted. The responses from candidates suggested that the leading purpose of the exam is to test the capability of the candidate and to weed out weak students. This was followed by a test of research skills in a somewhat new area and challenging candidates to think more critically and/or creatively. When asked about whether improvements can be made to the current format of the departmental CQ exam, only 30 of the 35 participants responded. Of the 30, 19 said yes and 11 said no. Most of the 19 showed interest in having the exam be focused on the research proposal as opposed to background theory and that they would appreciate more feedback and communication with the committee in addition to the exam.

A limitation of data collected was responses from several engineering departments were not available and using a small sample size overall. Furthermore, the effect of disciplinary differences was confounded by exam format differences, making it a limitation of our study. This is an issue to account for in future work. While the findings of this study are limited to the sample size of 35 candidates, ongoing collection of data on perceptions of students (who both passed and failed) toward the exam on a larger scale in the future can shed light on the individual and collective differences in types of assistance received and challenges faced by the doctoral students within and between engineering departments.

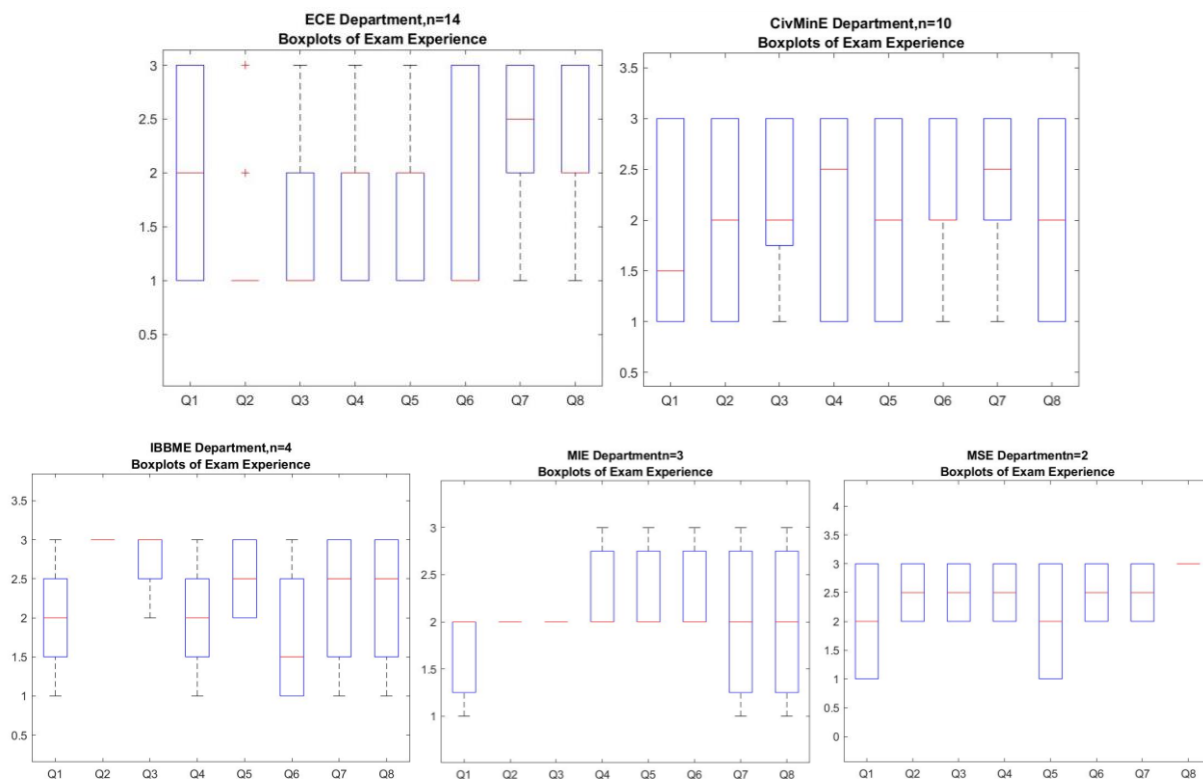


Figure 1 Box plot summaries of all ECE (top left), CivMinE (top right), IBBME (bottom left), MIE (bottom middle), and MSE (bottom right). See n for sample size of associated boxplot.

Conclusion

This study intended to survey engineering doctoral candidates and obtain their perceptions toward their departmental comprehensive exam. The analysis of responses (both open and closed) from candidates (n=35) reveals that they generally find utility and value in the exam, especially when it is focused on their research as opposed to background theory. However, when it comes to exam administration, there is room for improvement. Examples include but are not limited to: simplifying procedures and logistics of the exam, reducing the stressfulness of the exam, and improving the feedback obtained before and during the exam from the committee. Overall, the data point to the impression that the exam could present more value to doctoral candidates. With many students indicating that they perceive the CQ exam as a tool for ‘weeding out’, coupled with the fact that many respondents indicated that the exam may not have been worthwhile, the exam may be largely viewed as a gatekeeping practice or milestone, rather than a pedagogical tool. Further research will seek to identify how CQ exams might be administered to provide additional clarity of purpose and to be reflective of the research of the department and institutions of which they are a part.

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