EXPERIENCING ENGINEERING EDUCATION: LESSONS FROM THE COMPREHENSIVE/QUALIFYING EXAMINATIONS

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Abstract – One of the requirements of students’ candidacy in the doctoral program is to pass the comprehensive, or qualifying, examinations. This paper shares some of the experiences of doctoral candidates who have recently completed these examinations as part of the Collaborative Specialization in Engineering Education at the University of Toronto, and the observed differences in these candidacy assessments. The pedagogical aim, or purpose, of these exams, and how candidates’ experiences compare, on both an inter- and extra-disciplinary level is explored. The goal of this paper is to share some of what is in the literature, to investigate and outline the challenges from candidates’ own experiences, and to offer suggestions for future comprehensive, or qualifying, examinations.

Keywords: Engineering Education Models, Graduate Education, Assessment, Instruction, Qualitative Examination, Comprehensive Examination

1. INTRODUCTION

Recently the University of Toronto Faculty of Applied Science and Engineering began offering a graduate degree program in Engineering Education. The nature of the Collaborative Specialization in Engineering Education (EngEd) has students ‘housed’ in one of the traditional engineering departments (e.g., Civil, Chemical, etc.) or in the Faculty of Education. Given the multidisciplinary nature of this program, there are tensions around the requirements for graduation. For example, each of these departments has different requirements for comprehensive, or qualifying, examinations (hereafter “CQs”). As in many graduate programs, such an examination can be used to assess the doctoral candidate’s disciplinary knowledge, critical thinking, and ability to conduct research. The CQ examinations’ capacity to address these topics in a systematic and coherent manner may vary across universities, faculties, and within departments: from written to oral, from take-home to in-class, some exams have reading lists and guides, some are a series of (un)related questions, while others demand that a research proposal be submitted.

This paper is born out of the experiences of doctoral candidates who have recently completed—or are seeking to complete—the CQ examinations, as part of the Collaborative Specialization in Engineering Education at the University of Toronto, and the observed differences in these candidacy assessments across home departments. The examinations these candidates recently completed, or are due to complete, were observed to be different with respect to content, format, and scope. For example, regarding content, some of the graduate students were required to answer discipline-based questions, some had to answer specific questions regarding their proposals, while still others had no specific questions asked (with their thesis proposals serving as the basis for the examination). Regarding format, some students were asked to write an exam in a single sitting, some had take-home exams that lasted multiple days, while some had an oral component, which varied from a follow-up to the questions asked, to questions regarding the direction of the candidate’s project and final thesis. In terms of scope, some students faced a narrow range of questions and others a much broader one.

In this paper, we will explore graduate student experience in this context and, specifically, the experience of ‘matriculation’ in this program in the form of the CQ exam. As engineering educators in our right, we will
investigate the pedagogical aim or purpose of this program criterion and how the experience compares on both an inter- and extra-disciplinary level. We believe that there is information to be shared, but also to be learned, from other institutions going through a similar experience. Ultimately, the goal is to try and identify the challenges both from our experiences and from the literature, but also to offer suggestions to create future departmental exams (i.e., assessments) that benefit a diverse set of learning needs and the needs of collaborating programs. The CQ exam should be a meaningful experience as part of the overall Engineering Education program; it should not merely be a ‘tick box’ but a way to move a student’s final thesis project forward.

2. BACKGROUND

As Schafer and Giblin point out, “[t]he traditional structure of comprehensive exams is designed to require that students demonstrate a broad mastery of the theory and research relevant to their discipline” [5]. The CQ examination can be used to assess students’ basic skills and ability to conduct research. It also gives an opportunity for students to “demonstrate their mastery of the knowledge, literature, and research in a discipline” [5]. Some have also argued that the comprehensive exam can be used to “weed out” weak students [5]. However, there is a dearth of research on the effectiveness of comprehensive exams regarding the desired learning objectives [5].

There are four general purposes for CQ examinations [1, 2, 4]:
1. To evaluate students’ comprehensive knowledge of the field;
2. To provide an opportunity for students to integrate their learning;
3. To enable students to solve problems; and/or
4. To provide a rite of passage.

The CQ exam serves as a medium to collect information on students’ research plans, probe student understanding, and gain insight on the breadth and depth of achieved learning outcomes [5]. Each student’s approval or rejection of Ph.D. candidacy could play a role in an institution’s financial and research resource expenditure. It is, therefore, important to devise a rationale for a CQ that is in line with the objectives of a student’s research. If misaligned, it may be difficult to determine whether the disqualification stems from the student’s poor performance or from the inappropriateness of the exam’s design. Apart from alignment, for appropriate measurement and assessment of a student's qualification for the CQ, validity and reliability of the assessment process needs careful consideration [3]. That is a) Do students know what they claim to know, gathered either through post-presentation Q&A or written/verbal exam, and b) Do the committee members have more or less the same point of view and judgment toward the student’s research?

As CQ exams are based on communication and negotiation, the feedback shared and discussed between student and committee members is critical in determining a student’s continuing candidacy. Committee members may find out that a student’s research needs revision and further development for one or several of the following reasons:
1. Research questions: weak gap identified, too broad or narrow questions, questions not related to gap or challenge;
2. Procedure and methods: trivial or existing procedure, variables identified not measuring or related to objectives;
3. Scope of experiments: too little or too large a scope
4. Metrics and variables to measure: irrelevant or insufficient variables identified; and/or
5. Data analysis methods: heavy and time-consuming, shallow or irrelevant data analysis techniques used.

The format of CQ examinations varies between institutions, and within these institutions’ faculties and within departments; there is no common nor singular structure to a CQ examination. CQ examination formats can range from an in-class undergraduate exam to take-home and customized exams. The advantage of customization is that it can, and should, be used to focus on a student’s research interests [10]. The variations in the format of exams could imply that different disciplines have different objectives and value different skills and abilities. In addition, it could also indicate different disciplines/programs have different views on what matters most [10].

While the exams do vary, the process is an opportunity for students to invite their committee members to become more knowledgeable about the areas they find themselves interested in, and the challenges and assumptions they face or predict in their research.

2.1 Departmental Exams at the University of Toronto

All students who are registered in a graduate degree program are members of the School of Graduate Studies (SGS). SGS shares the responsibility for graduate studies with graduate units and divisions, and operating through a system of collegial governance, consultation, and decanal leadership, defines and administers University-wide regulations for graduate education [8]. Its mandate includes maintaining both excellence and consistency across the various faculties of the university.

SGS does not have a standard or specific requirements for CQ examinations, but instead has written policy for a
‘Code of Good Practice.’ To allow for a breadth of exams, SGS has named these exams ‘Departmental Examinations,’ which refers to “examinations taken in common by all doctoral students” [9]. By allowing each faculty, and departments within these faculties, some flexibility in the CQ exams, these exams could, in theory, be tailored to meet the unique needs of the individuals involved with each Ph.D. project.

2.2. Departmental Exams within the Engineering Education Program at the University of Toronto

The Collaborative Specialization in Engineering Education at the University of Toronto is shared by two faculties, the Faculty of Applied Science and Engineering and The Ontario Institute for Studies in Education. The EngEd Program is an “interdisciplinary initiative designed for students who are interested in pursuing courses and research in engineering education. This opportunity allows students to join a small community of scholars interested in research and learning at the nexus of education and engineering practice” [7].

The Faculty of Applied Science and Engineering is home to eight departments; EngEd graduate students fall into one of three departments: CHE, Chemical Engineering & Applied Chemistry; CIV, Civil Engineering, or MIE, Mechanical & Industrial Engineering. The Ontario Institute for Studies in Education is home to four departments; however, only through the Centre for Curriculum, Teaching, and Learning (CTL) can one complete an EngEd graduate degree.

Both Faculties, and their departments, have different requirements for CQ examinations. As in many graduate programs, such an exam can be used to assess the doctoral candidate’s disciplinary knowledge, critical thinking, and ability to conduct research. The CQ exam’s capacity to address these topics in a systematic and coherent manner varies across the two faculties, and within their respective departments (as shown in Figure 1); as a result, the purpose of the CQ for the EngEd, as a unique specialization, is unclear.

3. CAPTURING THE EXPERIENCE

Given this understanding of CQ examinations at the University of Toronto and beyond, we include here our reflections on the experience in the EngEd program as a starting point for discussion. We summarize these deeply personal experiences below (in quotations), separated into four themes: transparency, utility, fear, and procedure.

3.1 Transparency

It was apparent that while there are guidelines and policies for the CQ examinations, as mentioned above, students did not always feel like they knew exactly what they had to do and what was expected of them. As one student pointed out, “Even the description made me feel a little anxious, mostly because it was so vague. It asked me to situate my interests, which I thought I had begun to do with the statement of intent submitted in my application, so I also thought I had it ‘in hand.’ But as time has gone by, and I have engaged in the process, it remains that elusive beast for me.” And the uncertainty was both around the process itself (“did not know what to expect;” “was uncertain what the process would be [...] was under time constraints [...] which gave me less time to prepare and understand”) and the overarching objectives (“I am not really even sure what the learning outcomes [were]. Is it even supposed to help us, or is it just to show the faculty that we can go through the process?”).

3.2 Utility

The theme of utility wove through the reflections in a questioning of the purpose of the CQ examination. Beyond being “a necessary step in a [doctoral] degree,” students who had completed the CQ exam were uncertain about its
usefulness; as one student noted, the exam only “vaguely relates to my proposal.” In contrast, a student who has yet to undertake the CQ examination remarked, “I hope that the process is a useful one that can assist in my studies and be a guiding force which enhances my understanding of my research, as well as my subject area within education and engineering education.” Another student, who is currently in the midst of completing the CQ examination, said, “I saw it as an opportunity to demonstrate to your discipline or area that you are well-versed enough in the basic literature of your discipline to move forward.” However, as she undergoes this process, she has grown less certain as to its utility, saying the exam is, “elusive” in that it sometimes feels like a moving target. For a task that seems vague, yet simple, I have yet not been able to ‘hit the target.” All these students agreed, however, that the exam should be “an opportunity to move one’s Ph.D. project forward.”

3.3 Fear

A CQ examination situates a student in performance; she is expected to deliver something, with or without strict guidelines, and is evaluated on her success, which makes for stress and fear. As reported in Psychology Today, “Uncertainty is a feeling, an emotion. We can easily become lost and overwhelmed in the current of uncertainty. By stepping back and experiencing uncertainty as an emotion, we are freed from the concrete feelings of fear and doubt that coincide with uncertainty” [6]. This theme rang true in all the reflections.

One student’s reflection captured this fear related to uncertainty. She opened her reflection with, “I was pretty nervous about my qualification/comprehensive exam...I am usually not good at answering questions on the spot...I kept thinking, what if I cannot come up with good answers to the questions,” which are fears all students might face. As the student continued to reflect, she came to the conclusion that it was the fear of uncertainty; “I think it was the fear of the unknown: [I] did not know what to expect in those two hours.”

Ultimately in an examination, one is being judged, and in these circumstances evaluated on being able to continue along the path to completing a Ph.D. In this environment, there is always a looming threat: “if I fail this thing I'm out (not right away, but still, the threat is there and felt; it is high stakes).”

3.4 Exam Content/Procedure

As stated above, “The traditional structure of comprehensive exams is designed to require that students demonstrate a broad mastery of the theory and research relevant to their discipline.” Is this true of EngEd? Should it be true of EngEd? And have the students who have gone through the CQ Examination, included in this project, had similar experiences?

The exam procedures for the EngEd Program, as shown in Figure 1, are quite different, not just between the two faculties, but amongst the departments within these faculties. The students’ reflections capture that their various exams did, in fact, follow these procedures, and some of these students questioned if it was in fact right to follow the strict protocol (“Would have I been better off submitting a proposal and presenting on that (as some of my other colleagues have)?”).

One student remarked that instead of this strict process, perhaps the CQ examination should do three things: “1) create an opportunity to articulate your research interests, 2) begin to identify the theoretical underpinnings of this area of [study] & 3) develop a research question to advance knowledge in the field; but [...] how you get there could be open to different approaches.”

4. MOVING FORWARD WITH COMPREHENSIVE/QUALIFYING EXAMS

We do not pretend to know what is best for each individual for every program; rather, our intention is to look at an age-old process to see how it might be made more effective. As members of a center for excellence, one of our founding goals is always to try to be better. In that context we offer the following for future consideration:

1. Can we make the CQ more than an academic hoop? That is, make sure the experience is a fruitful one that not only challenges the student but also is relevant to the project.
2. Can we be more transparent about the CQ and its purpose? It was apparent that while there are guidelines and policies for the CQ examinations, students did not always feel like they knew exactly what they had to do and what was expected of them.
3. Can we create a new paradigm for the CQ? CQ exams could be a constructive process for all involved to meet multiple objectives, including stretching the student’s knowledge, advancing an individual research project, and assessing a student’s disciplinary and research competency. With engineering education graduate programs expanding in Canada, it may be an opportune time to re-evaluate how the CQ examinations are delivered.

References


