AUTHENTIC EXPERIENCES IN TWO MATHEMATICS GRADUATE STUDENT INSTRUCTOR TRAINING COURSES

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INTRODUCTION

Teaching plays a fundamental role in the professional life of an academic mathematician. It is therefore beneficial for graduate mathematics students to teach a course during their graduate degree; and given enrolments that often outpace faculty hiring, good graduate student teaching is beneficial for mathematics departments too.

A demand for good graduate student teaching implies a demand for good graduate student instructor training programs. Graduate teaching assistants (GTAs) are not, in general, capable of good teaching on the strength of their mathematical background alone; while GTAs are capable of fast and impressive gains in "knowledge of student thinking" (Kung & Speer, 2009), they are genuine neophytes when it comes to content knowledge for teaching (Gutmann *et al*., 2005) and beliefs about teaching and learning (Gutmann, 2009; Raychaudhuri & Hsu, 2012). However, there is evidence that sound professional development programs can convert their potential (Ellis, 2015; Ellis *et al*., 2016).

In her extensive study of professional development programs for mathematics GTAs (2014), and later in an overview included in *Insights and Recommendations from the MAA National Study of College Calculus* (2015), Ellis describes three models, and gives three examples, of graduate student instructor training: the Apprenticeship Model, the Coordinated Innovation Model, and the Peer Mentor Model.

The Apprenticeship Model is the most involved of the three. The major component in this model is a one-term training course in which GTAs plan and deliver lessons to each other, and then deliver a single lesson to a real class. These lessons are followed by reflections. Unless the GTA already has a record of strong teaching, the training course is a requirement to be assigned as an instructor. After being assigned, GTAs participate in weekly meetings with a coordinator, but have significant freedom to design their own lessons and assessments.

In contrast, the main component of the Coordinated Innovation Model is a five-day pre-service training seminar in which GTAs deliver lessons to each other. GTAs take the seminar in order to qualify as

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instructors in a tightly coordinated Calculus program, where lessons and assessments are predetermined by a supervising faculty member.

Finally, the Peer Mentor Model aims to prepare GTAs to be "recitation instructors" who run once- or twice-weekly recitations in which they answer students' questions or provide students with problem sets to help them reinforce what they learn in their lectures. Ellis provides two examples of the Peer Mentor Model (2014, pp. 166-186). The main component in the first example is three in-service training seminars run by a senior GTA, and the main component in the second example is a two-day pre-service training seminar also run by a senior GTA.

Of the three models, the Apprenticeship Model is by far the most thorough. It is likely not incidental that its accompanying example operates at the smallest scale:

> a small, public technical institution with approximately 8000 undergraduates, 20 PhD students, and 15 Master's students. [...] In a typical fall semester, there are approximately 270 Calculus I students in 6 classes of 30-40 students (Ellis, 2015, p. 119).

In comparison, the example of the Coordinated Innovation Model is from a university with approximately 25000 undergraduates, and 1500 Calculus 1 students in 50 classes of 30 students. The first example of the Peer Mentor Model is from a university with approximately 25000 undergraduates, and over 1000 Calculus 1 students in STEM majors alone. The second example of the Peer Mentor Model is from a university with approximately 30000 undergraduates, and 1200 Calculus 1 students.

Deep, extensive training requires resources and commitment, and it is easier to marshal these at a smaller scale. Nevertheless, we contend that it is possible to set up rigorous training courses with authentic learning experiences at a much larger scale.

THE VALUE OF AUTHENTIC EXPERIENCES IN INSTRUCTOR TRAINING COURSES

The substantial body of literature on teacher training programs includes little conclusive evidence of what constitutes an effective program (Buck & O'Brien, 2005; Grossman, 2005; Wilson *et al*., 2002). Furthermore, in the narrower field of mathematics teacher training, the focus is predominantly on the elementary school and high school settings (Boyd *et al*., 2014; Hamlett, 2009), not the university setting. There is considerable research in the area of mathematics TA training in general (Shannon *et al*., 1998; Speer *et al*., 2010), but rather less in the area of mathematics instructor training in particular.

Nevertheless, a common thread in evaluations of teacher training programs at all levels is that participants and trainers alike perceive great value in field work and other varieties of authentic experiences, especially mentored experiences (Dusto, 2014; Kaelin, 2013; Shannon *et al*., 1998; Smith & Lilach, 2006; Speer *et al*., 2010). Speer *et al*. assert its value and lament its general absence:

> A TA's first teaching experience provides rich opportunities to support and shape emerging instructional practices. Yet, traditionally, support structures and guided enculturation experiences have not been available, let alone an expected part of graduate student professional development (2010, p. 76).

Authentic experiences also figure in theoretical models of sound instructor training programs. In Chodakowski's reckoning, authentic experiences such as practicums form one of the three "cornerstones of teacher education" (2014). The other cornerstones are subject understanding and pedagogical understanding. (It is worth noting in passing that addressing deficiencies or anxieties in subject understanding is a fixture of the literature in mathematics teacher education. In the university setting, the degrees and strong academic backgrounds of mathematics GTAs are taken, in an unexamined assumption, to be a proxy for subject understanding.)

In Ellis' work, features of successful professional development training programs identified in research on K-12 mathematics instruction (Garet *et al*., 2001; Hawley & Valli, 1999) are converted to the more moderate following set of features of successful mathematics GTA instructor training programs (2014, pp. 264-265).

1. Successful programs have in-service as well as pre-service components.

2. Successful programs are situated in the particular context of mathematics instruction.

3. Successful programs provide opportunities for "approximations of practice" and feedback.

4. Successful programs are supported by the department and institution.

5. Successful programs support innovative instructional practices.

Ellis sets modest bars for each of these features. For example, in-service components might consist of weekly meetings with other course instructors; what is important is that GTAs not be given a short pre-service seminar and then set loose on their own. On "approximations of practice", she writes that

> even presenting and getting feedback on a seven-minute lesson can be wildly important in removing the mystery (and fear) of stepping into the classroom for the first time. More extensive experiences in practice teaching can go much further, approximating the practices of teaching rather than simply removing the fear of a new experience (2014, p. 261).

In fact, Ellis' read of the landscape of opportunities for mathematics GTA professional development is so forbearing that she adds a sixth feature: "the trait of existence is implied in this list as a novel and necessary component" (2014, p. 265).

In this paper, we present two cases of mathematics GTA instructor training courses at large, research-intensive Canadian universities. Both courses fulfill all the criteria enumerated by Ellis, and are centred on the authentic experience of giving a guest lesson to actual undergraduate students in the context of an actual undergraduate mathematics course. Both universities are also larger, and the demands on mathematics GTA instructors arguably greater, than those presented in Ellis' work.

In the following three sections we break down these two cases, hereafter referred to as Course A and Course B, by setting, structure and implementation. Our intended audience is the faculty member or departmental administrator interested in setting up a similar course.

COURSE SETTINGS

COURSE A SETTING

Course A is a graduate course at the main Vancouver campus of the University of British Columbia (UBC). UBC is the second-largest university in Canada, and a member of the U15 Group of Canadian Research Universities. The Vancouver campus has approximately 54000 students, of whom 45000 are undergraduates. The Mathematics Department has approximately 70 faculty members and 100 graduate students.

In the 2017-2018 academic year, Term 1 Calculus 1 courses at UBC had a final total enrolment of over 4400 students across eight courses and 37 sections. Each section was taught by a single instructor. The majority of sections had between 80 and 200 students, with a small number of very large sections of around 350 students taught by experienced senior faculty members. The enrolment for Term 2 Calculus 2 courses was slightly less.

GTAs who are approved to be instructors are generally assigned to sections of around 80 students in Calculus 1 or Calculus 2. These sections are part of multi-section courses coordinated by a faculty member (the "instructor-in-charge") and taught by a team of faculty members, postdoctoral fellows and graduate students. All sections of a multi-section course have a common final exam. The other assessments, which might include assignments, worksheets, quizzes and midterm tests, are usually common as well. The assessments are designed by the instructor-in-charge, in some cases with the help of the other course instructors. The schedule is set by the instructor-in-charge, but course instructors have flexibility; instructors-in-charge use weekly meetings to make sure all sections are within one or two lessons of each other. Classroom activities are not prescribed, but the instructor-in-charge and other faculty instructors normally provide guidance at the weekly meetings. Many also provide materials such as learning objectives, course notes, worksheets and clicker questions.

COURSE B SETTING

Course B is a graduate seminar at the University of Waterloo (UWaterloo). UWaterloo is the sixth-largest university in Canada, and also a member of the U15 Group of Canadian Research Universities. It has an enrolment of approximately 36500 students, of whom 31000 are undergraduates. Its Faculty of Mathematics comprises five departments (Applied Mathematics, Combinatorics and Optimization, Computer Science, Statistics and Actuarial Science, and Pure Mathematics) and other units, with a total of approximately 240 faculty members and over 900 graduate students.

In the 2017-2018 academic year, Term 1 Calculus 1 courses at UWaterloo had a final total enrolment of over 4600 students across six courses and 39 sections. Each section was taught by a single instructor. The majority of sections had between 50 and 180 students, with a small number of very large sections, offered to students in specialized programs, of over 200 students.

GTAs who are approved to be instructors are assigned to a variety of courses including, but not restricted to, Calculus courses. In the 2017-2018 academic year, for example, GTAs were assigned to

teach courses in Algebra, Elementary Number Theory, Financial Mathematics, Group Theory, and Probability, as well as Calculus. Enrolment varies widely: GTAs have been assigned to teach Calculus sections with more than 180 students and Group Theory sections with fewer than 25. Many upper year courses are also single-section courses, where the instructor has close to full control over the schedule, curriculum and assessments, including the final exam. Materials from previous versions of the course are generally provided, and mentorship by a former instructor is often available, but the sole instructor is, in principle, responsible for the entire course.

COURSE STRUCTURES

COURSE A STRUCTURE

Course A is a one term, one credit graduate course. Most courses at UBC, including graduate courses, are one term and three credits; some courses such as graduate reading seminars are two credits. It is a required course for GTAs who wish to be assigned as instructors to a UBC Mathematics course. It is offered in the first term of each academic year. The course is taught by a teaching-focused tenure-track or tenured faculty member in the Mathematics Department, and teaching the course is equivalent, in terms of teaching load, to teaching any other one term course such as an undergraduate course. Typical enrolment is around 20 GTAs. Outside the practicum component described below, GTAs in Course A have three 50-minute classes per week. The course is 12 weeks long.

PRACTICUM COMPONENT

The centrepiece of Course A is a practicum component in which GTAs are assigned to teach a full *guest lesson* of 50 or 80 minutes to an actual class of Calculus 1 students. The practicum component takes three or four weeks to run, and during that time, regular Course A classes are suspended.

Preparations for the guest lesson begin weeks beforehand, when the Course A instructor requests colleagues who are teaching Calculus 1 to host a GTA. GTAs then contact their host instructors and arrange to attend the class at least twice: once as soon as possible, and once immediately before the guest lesson. The first visit is to get some sense of the class culture: *Are the students weaker or stronger than expected? How much interaction are they used to? How is the classroom laid out, and how does the instructor use it?* The second visit is to establish where the latest lesson left off. The GTAs have the date of their guest lesson at least a week in advance, and they are expected to clear their lesson plans in advance with both the host instructor and the Course A instructor. The second visit might prompt some last minute changes.

In addition to the regular students and the host instructor, guest lessons are attended by the Course A instructor and the other GTAs in the guest GTA's "lesson group" of up to five Course A GTAs. During the lesson, the lesson group fills out feedback forms which are based on the guidelines generated by the class in the first six weeks of the term (see the following subsection). After the lesson, the lesson group and the Course A instructor discuss it at length. The purpose of the discussion, which is moderated by the Course A instructor, is to assess the lesson's structure and the instructor's delivery, and to provide helpful advice for all of the students in the lesson group.

OTHER COMPONENTS

Outside the practicum component, GTAs in Course A meet three times each week. The first two classes each week include a combination of readings, discussions, small-scale practice, and other activities. The

readings are drawn from historical documents – for example, Hardy's *A Mathematician's Apology* – and research literature in mathematics and mathematics education – for example, papers on active learning in calculus teaching. Small-scale practice involves mock lessons given to other students in the class. These can be as short as minute-long introductions to topics in calculus, and as long as 10-minute classroom activities.

One class each week is reserved for a guest visit, a casual chat with coffee and donuts, moderated by the Course A instructor. Guests have included faculty who have won teaching prizes, the department head and undergraduate chair, educational specialists from various units at the university, and panels of undergraduate students. Some of the guests are chosen in part because of their strong research programs; their presence underlines the importance the department places on teaching, and gives GTAs opportunities to ask questions about balancing their own research and teaching.

The weeks preceding the practicum are designed to lead naturally to the practicum, and to draw on the strengths and interests of the Course A instructor. Under one instructor, for example, the class broke down the structure of a lesson into successively larger units of time: they considered first the split-second impressions taken by students; next, the first minute of a lesson, when a topic is introduced and linked to previous topics; next, the first ten minutes of a lesson, when substantial interaction with students is inevitable; and so on. Throughout, GTAs learn the mechanics of teaching – for instance, good questioning techniques – and begin to shape their own teaching philosophies – for instance, by considering, more generally, the role of questions in learning mathematics. They also work on converting a checklist of good practices into an evaluation form for the practicum component.

In the few weeks after the practicum, the GTAs in Course A turn to broader issues such as course objectives and prerequisites, academic integrity, equity and diversity. Many of these are discussed through case studies.

The last task is for GTAs to write statements of teaching philosophy. The expectation is that these will be revised after GTAs teach a course, but the exercise helps them begin to establish their identities as instructors. One of the principal guidelines of the course is that GTAs should be given the opportunity not just to teach well but to be reflective about their own teaching. The development of teaching philosophies is a central theme.

FORMAL ASSESSMENT

GTAs who complete Course A are given a transcript grade of either Pass or Fail. The Course A instructor also assigns a readiness score to every GTA who passes, which is recorded internally to the Mathematics Department.

There are three possible readiness scores: 1, 2, and 3. The majority of GTAs receive a score of 2, which means that they are ready to be assigned as instructors. (At UBC, instructorships are assigned to eligible GTAs by seniority, with preference given to GTAs who have not yet taught.) GTAs who excel are given a score of 3, which means that they should also be considered for difficult instructor assignments – for example, to the UBC Calculus 1 course designed for students with a very weak mathematical background. Finally, some GTAs may be given a score of 1. This score indicates that the GTA is not ready for an instructor assignment. It is accompanied by a comment explaining why and giving a recommended course of action. For example, a GTA might be given a score of 1 because of an acute unfamiliarity with the mathematical background of North American first year students. The recommended course of action might be for the GTA to be assigned a mentored TAship in an area with

many opportunities for one-on-one interactions with first year students – for example, in UBC's drop-in Math Learning Centre.

Readiness scores of 1 are assigned primarily based on the GTA's practicum performance, while readiness scores of 3 are assigned based on the GTA's overall performance. In other words, GTAs must deliver a good practicum lesson to avoid a score of 1 but must be insightful and enthusiastic about teaching in general to get a score of 3.

In practice, it is preferred to give readiness scores of 1 instead of failing grades. A failing grade would mean that a GTA would have to retake Course A in order to be assigned as an instructor, while a readiness score of 1 is compatible with a wider range of remedial options.

COURSE B STRUCTURE

Course B is a one term, not-for-credit graduate seminar. It is open to all GTAs in the Faculty of Mathematics at UWaterloo and offered in the second term of each academic year. A total of 12 GTAs enrolled in its first iteration. The course is jointly taught by four teaching-focused faculty members – one tenured faculty member and three long-term lecturers. There is no teaching credit currently associated with this course, though it does count toward the instructors' service commitments. Outside the practicum component described below, GTAs in Course B have one 90-minute class per week. The course is 12 weeks long.

PRACTICUM COMPONENT

Like Course A, the centrepiece of Course B is a practicum component in which GTAs are assigned to teach a full guest lesson of 50 or 80 minutes. GTAs may opt out of the practicum component if they have prior teaching experience.

More than a month before the guest lessons, GTAs are assigned to visit a class – if possible, a class in the course where the GTA's guest lesson will take place. Host instructors are contacted in advance by one of the Course B instructors. GTAs observe the class with prompts provided by the Course B instructors. These prompts focus on one aspect of the class – for example, the activities of the students in the class. The class visits are analyzed in Course B the following week, and GTAs discuss adopting techniques into their own teaching.

Host instructors for the guest lessons are also initially contacted by one of the Course B instructors. The Course B instructors attempt to secure hosts in a variety of courses, especially those that are likely to be assigned in subsequent terms to GTAs (GTAs at UWaterloo are not generally assigned to teach Calculus; see section 2). GTAs then contact their host instructors to determine the content of their guest lesson.

Guest lessons are attended by at least one of the Course B instructors. Other instructors and GTAs are invited to attend. During the lesson, the attending instructors and GTAs take notes, occasionally on feedback forms. After the lesson, the attending instructors and GTAs discuss the lesson with the guest GTA.

OTHER COMPONENTS

Outside the practicum component, GTAs in Course B meet once per week. Classes in the first two weeks are preparatory: GTAs are introduced to the fundamentals of preparing lessons and giving presentations. The remaining weeks are mainly occupied by two multi-week activities.

The first activity is for GTAs to prepare, deliver and reflect on a sequence of three 15-minute "mini-lessons". This is done in groups of three GTAs and one Course B instructor. The mini-lessons are excerpts of full lessons: the first mini-lesson is the first 15 minutes of one lesson, the second mini-lesson is 15 minutes in the middle of another lesson, and the last mini-lesson is the last 15 minutes of a third lesson. Each has a different focus – motivation, interaction and time management, respectively. During the reflections, students are encouraged to set goals for subsequent mini-lessons. The sequence of mini-lessons and reflections is inspired by the structure of Instructional Skills Workshops (Fenrich & Johnson, 2016).

The second activity is for GTAs to create an assessment over two sessions. Between sessions, GTAs study learning objectives and local approaches to creating assessments; for example, they might learn about Bloom's taxonomy between their first and second drafts. This activity is particularly suitable for the UWaterloo setting, where GTAs may be assigned as instructors in courses where they are responsible for creating all assessments.

FORMAL ASSESSMENT

Because Course B is not for credit, GTAs taking it receive no formal assessment. Moreover, their performance in the course does not explicitly affect their chances of being assigned as instructors, since assignments are made at the departmental level, while Course B is coordinated at the faculty level.

KEY DIFFERENCES IN COURSE STRUCTURES

Of the two GTA instructor training courses described above, Course A is more established, but Course B is in some sense more ambitious.

Unlike Course B, Course A is required and for credit. This has several consequences. First, Course A has almost double the contact hours with students as Course B. All of the GTAs enrolled in Course B are volunteers, and the Course B instructors need to weigh the perceived value of their course against the GTAs' willingness to commit time without gaining course credit. Second, Course A may be used formally to assess a GTA's readiness to teach, unlike Course B. All prospective GTA instructors take Course A, and the course is advertised as both a requirement and an assessment. In contrast, it is currently not possible to compare the readiness of a GTA who has taken Course B with the readiness of a GTA who has not. Finally, because of the course's formal credit, remediation suggested to GTAs in Course A carries more weight than in Course B.

The guest visits described in the "*Other components*" subsection of section 4.1 are another feature of Course A that derives from its established position. There are enough connections between the course and the local mathematical and education communities to make this a regular feature. Course B occasionally hosts guest visits, and these visits will likely increase as the course becomes more well-known and the number of contact hours increases.

Unlike Course A, Course B has a major focus on constructing assessments. This derives from the fact that a significant number of GTAs in Course B will be assigned as the sole instructor in upper year courses. Instructors of single-section courses at UWaterloo are expected to construct their own assessments, including homework assignments, tests and final exams.

Finally, Course B is team-taught, unlike Course A, which is taught by a single instructor. This is logistically efficient, since instructors in Course B receive no teaching credit. It may also turn out to be pedagogically efficient, since Course B serves a GTA population drawn from several different departments in the UWaterloo Faculty of Mathematics.

COURSE IMPLEMENTATION

COURSE A IMPLEMENTATIONS

Course A was started in 1997. It was the initiative of the department head at UBC at the time, who met with Steven Krantz, the author of *How To Teach Mathematics* (2010), and then head of the Mathematics Department at Washington University in St Louis[2], at a meeting of department heads in Washington, D.C.

From its inception, Course A was a one term, one credit pre-service graduate course. However, until 2009, the course had no practicum component. The main activity in the course was for GTAs to prepare and deliver mini-lessons to each other.

In 2009, the practicum component was introduced. In its first iteration, GTAs gave guest lessons in courses taught by their research supervisors. This turned out to be problematic in terms of assessment because of the wide variation in the courses where GTAs gave guest lessons. First, it was difficult to compare how GTAs interacted with students: teaching a class of 10 fourth year Honours students in an advanced topology course is much different than teaching 100 first year Business students in a differential calculus course. Second, in some cases, it was difficult for the other GTAs attending the guest lesson even to evaluate the correctness of the content: a Masters candidate in Mathematical Biology may not be, and should not be expected to be, an expert in topology. Third, in many cases, there was simply a mismatch between the setting of the assessment and the setting of assignment for which the GTAs were being assessed: proficiency in teaching a small topology course is hardly an indicator of competence to teach first year Calculus.

In 2010, GTAs began to give guest lessons in Calculus 1 courses, and the current course structure was essentially established.

In subsequent years, a comprehensive training arc for all GTAs was formed with Course A as its keystone. Mathematics GTAs at UBC now have a two-day pre-service training workshop, then a series of in-service professional development seminars as they work through successively more sophisticated TAships, then Course A, then teaching opportunities, and finally additional opportunities for GTAs with a particular interest in teaching – a one term TA Accreditation Program and a three day Instructional Skills Workshop (Fenrich & Johnson, 2016) developed within and for the department. This arc is described in detail in work currently in progress.

[2] The Mathematics Department at Washington University in St Louis also has a required one credit graduate course in mathematics teaching. It differs from Course A and Course B mainly in not having a practicum component, and in its small-scale setting; Washington University is a private university with an undergraduate enrolment of under 8000 students, and graduate students in the Mathematics Department are not assigned to be instructors.

Course A is also embedded in the formal structures and informal culture of the department. Faculty members are aware of it, if only because they are often asked to host guest lessons. Graduate students are encouraged to discuss if and when to take Course A with their research supervisors. Finally, the process of assigning a GTA to be a course instructor involves many faculty members, not just the Course A instructor. The GTA's research supervisor, department head, graduate chair, and department teaching coordinator, all faculty members, all need to approve the assignment.

COURSE B IMPLEMENTATIONS

Course B was started in 2018 by a faculty member at the University of Waterloo who is also a recent graduate of Course A. It was started because of an absence of mathematics-specific GTA instructor training at UWaterloo.

Course B is intended to be the final component in a three-part GTA training arc that comprises the first three parts of the UBC training arc: a two-hour pre-service training workshop, in-service seminars, and an instructor training course. The first part is already well established at the departmental level, and the second part is currently being implemented.

It is also intended that Course B be formally endowed with a credit weighting equivalent to half of a regular graduate course, and that it be made into a requirement for GTAs in the Faculty of Mathematics who wish to be assigned as instructors. The second intention is complicated by the fact that the course is designed for GTAs from all five departments in the UWaterloo Faculty of Mathematics, and that these departments all ask their GTAs to teach in slightly different ways. However, the course designers anticipate that the first change will be made within two years.

CONCLUSION

Despite differences in setting, structure and implementation, both Course A and Course B contain the authentic experience of a practicum and satisfy almost all of the criteria of successful mathematics instructor GTA training programs laid out by Ellis (2014) and cited in section 2. The criteria are summarized below.

Criterion	***Course A***	***Course B***
in-service[3] and pre-service components	***Yes.*** This is required pre-service training open to all GTAs. The course is 12 weeks.	***Yes.*** This is voluntary pre-service training open to all GTAs. The course is 12 weeks.
situated in math instruction	***Yes.*** The instructor and students are in the Mathematics Department, and the course is designed specifically for Mathematics instructor training.	***Yes.*** The instructors and students are in the Faculty of Mathematics, and the course is designed specifically for Mathematics instructor training.

[3] Both courses constitute pre-service, not in-service, training. However, Course A is set in a training arc that contains separate in-service components.

approximations of practice and feedback (e.g. a practicum)	***Yes.*** Every student teaches an actual Calculus 1 class followed by feedback. Some students may also teach 1- to 10-minute mini-lessons to classmates.	***Yes.*** Every student teaches an actual class followed by feedback. Every student also teaches three 15-minute mini-lessons to classmates, and creates an assessment.
institutional support	***Yes.*** This course is required and credit-bearing.	***Pending.*** This course is not yet credit-bearing, but is planned to be.
supports innovative instruction	***Yes.*** In particular, the development of teaching philosophies and guest conversations with innovative instructors are major components.	***Yes.*** In particular, reflections on mini-lessons are meant to encourage innovation.

TABLE 1: SUMMARY OF CRITERIA FOR COURSE A AND COURSE B

It would be interesting to gauge how much the GTAs in mathematics instructor training programs perceive the value of authentic experiences, and to determine the effect of these experiences on students later taught by the GTAs. Both of these questions are beyond the scope of this paper, but the first question is the topic of research currently being conducted by the second author.

It would also be worthwhile to explore how mathematics GTA instructor training programs might respond to current shifts in mathematics education – for example, to the increasing number of online university mathematics courses – while retaining authentic experiences for the GTAs being trained.

The point of this paper is simply to highlight the feasibility of authentic experiences in ostensibly challenging settings. It should be evident to the reader that the backdrop to this work is the invaluable depiction of mathematics GTA training programs provided by Ellis (2014, 2015) in the summary program of Bressoud *et al*. (2015), and the implicit challenge therein: *Can large institutions provide mathematics GTAs the same rich training opportunities as small institutions?* Course A and Course B demonstrate that they can.

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