Inclusive Qualifying Exams Toolkit

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This is a non-peer reviewed preprint submitted to EarthArXiv

INCLUSIVE QUALIFYING EXAMS

A TOOLKIT FOR REVISITING QUALIFYING EXAM PRACTICES IN EARTH & SPACE SCIENCE DOCTORAL PROGRAMS WITH AN EQUITY LENS

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ABSTRACT

Doctoral qualifying or comprehensive exams are widely used in the earth and space sciences, yet research on assessment pervasively demonstrates that high-stakes exams are heavily biased and poor predictors of success. To address these issues and work towards broadening participation in these fields, this toolkit presents related-research and strategies for academic units looking to update their qualifying exam practices.

INTRODUCTION

WHAT IS AN "EQUITY LENS"?

A lens is a piece of glass or other transparent substance with curved sides that can concentrate or disperse light rays, that can be used singly (as in a magnifying glass) or with other lenses (as in a telescope) (Oxford Dictionary).

Similarly, an equity lens focuses attention on the impacts of existing policies & practices to eliminate unintentional barriers and broaden access and participation (https://policy.umn.edu/resources/equity-lens).

FIGURE 1. THE OBSTACLE COURSE THAT WOMEN AND BIPOC RESEARCHERS MUST ENDURE IN STEM AS ILLUSTRATED BY BERHE ET AL. (2022).

MOTIVATION

The geosciences are the least diverse of the STEM fields, with only ~6% of geoscience doctorates awarded to US citizens and permanent residents going to students from ethnically and racially minoritized groups and no discernible changes in these statistics over the last forty years (Bernard & Cooperdock, 2018). This problem is further exacerbated at successive career levels, with only 3.8% of tenure-track or tenured faculty in the top 100 earth science departments being from minoritized groups (Nelson & Cheng, 2017). Other sciences suffer similar statistics, with only 5.4% of biological sciences faculty being from ethnically and racially minoritized groups and 1.6% of chemistry faculty identifying as Black (Giddings, 2020; Menon, 2021).

One likely contributing factor is the use and design of exams required to advance to doctoral candidacy in scientific doctoral programs, often known as comprehensive, candidacy, or qualifying exams (hereafter referred to as qualifying exams). Qualifying exams are widely acknowledged as a gatekeeping tool, in addition to their use for assessing subject matter competency and scholarly independence (Riviere, 2016; Guloy et al., 2020; Posselt & Liera, 2022). The body of research on high-stakes exams as a form of educational assessment for graduate students has not kept pace with research on assessment for K-12 and undergraduate education. This research demonstrates that performance in high-stakes exams is a poor predictor of success, as well as heavily biased in terms of race, ethnicity, gender, and economic background (e.g., Miller et al., 2019). For example, a 2014 Nature Careers column on the issue states, "*In simple terms, the GRE is a better indicator of sex and skin color than of ability and ultimate success*" (Miller & Stassun, 2014). It follows that doctoral qualifying exams - which have roots as far back as 13th Century Europe and have been used in the US for over 100 years (Stanford, 1976: Posset & Liera, 2022) - are subject to the same unexamined biases and poor predication outcomes as other high-stakes exams.

Research also shows that a common cause for attrition from doctoral programs in the sciences is a mismatch between the students' goals and expectations and the norms and practices of the faculty, discipline, and department (Golde, 2005; Guloy et al., 2020). Simply stated, 43.5% of doctoral students in one study agreed with the statement that, "*exams and other hurtles seem arbitrary and unhelpful*" (Golde and Dore, 2001).

These findings illustrate the need to revisit our qualifying exams practices and policies with an equity lens if we wish to improve the retention of marginalized people or groups in our graduate programs and the scientific workforce.

CENTRAL GOALS

There are two central goals guiding the work presented in this toolkit:

1) **To reduce/remove opportunities for implicit bias in assessment.** Implicit bias is now a well-documented issue that inhibits broadening participation in STEM. By explicitly identifying the skills, knowledge, and behaviors required to reach doctoral candidacy and then a doctorate in a program, all students can be evaluated by the same criteria, which lessens the opportunities for implicit bias to factor into decision making. In addition, research suggests a growth mindset (the belief that skills and intelligence are not fixed and can be developed) is a strong predictor of achievement and exhibits a positive relationship with achievement across all socioeconomic backgrounds (e.g., Dwek, 2007; Claro et al., 2016). Thus, framing a doctorate as the result of building specific skills, knowledge and behaviors promotes a growth mindset and enhances the probability of success regardless of a student's race, ethnicity, and socioeconomic background etc.

2) **To promote equity**. In other words, the goal here is to build a set of practices and procedures that provide each student with the personalized support they need to achieve milestones in their doctoral program and then graduate. By identifying the specific skills, knowledge, and behaviors necessary to earn a doctorate, and specific milestones on the path to them, this provides transparency to everyone involved and easier identification of where a student may need support at a given time for the student, dissertation advisor and doctoral committee.

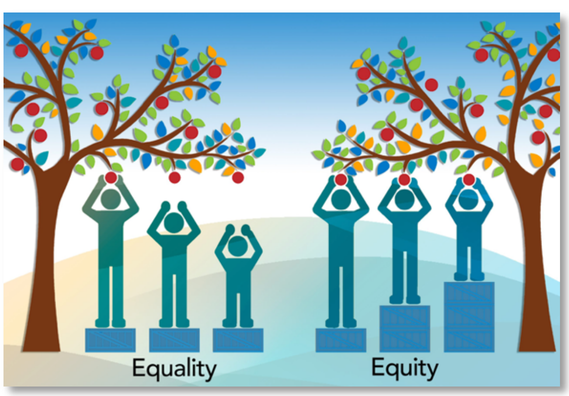

FIGURE 2. ILLUSTRATION OF WHAT IT MEANS TO PROVIDE EQUITY, WHERE EACH INDIVIDUAL HAS THE PERSONALIZED SUPPORT THEY NEED TO SUCCEED, VS. EQUALITY. IMAGE FROM DIVERSITYRESOURCES.COM.

STEPS YOU CAN TAKE

SURVIVAL STATISTICS

Gathering data is also an important first step to diagnosing the specific barriers to broadening participation that may exist in a given doctoral program or institution. Thus, collecting the necessary data and calculating the survival statistics for your program is a recommended first step.

To collect and analyze such data is not always straightforward based on what data is available and how it is collected and stored. After contacting relevant administrators to source the available data, an important second step is to de-identify the data so that it is not possible to determine specific student identities, which can also bias data analysis. One useful method is to assign each student a randomly generated number and have a source file that links student names to their number, which is kept separately from the files where the data analysis is conducted and managed by a person who is not involved with the data analysis.

A good statistic to start with is a comparison of the total number of enrolled students with a given identity to the number graduated from this same group over a given time period (which gets at the amount of attrition for different student populations). The number of enrolled vs. graduated students each year can be averaged over the usual length of a doctoral degree in your program, especially if there are any significant changes in enrollment through time. An important rule of thumb in these calculations is to pay attention to <u>the number of students</u> rather than percentages of students, as percentages can conceal part of the story.

For example, analyzing the data for the Geosciences Doctorate from the School of Earth & Exploration at Arizona State University between the 2015-2016 AY and the 2020-2021 AY suggests that one in four enrolled doctoral students did not ultimately leave with a doctoral degree. [*Here, note the use of language that is ambiguous with regards to the responsibility for the outcome; this language was chosen instead of "1 in 4 enrolled students left the program," which may imply it was the student's choice to leave*]. This same data also revealed that those who identify as women were 2.5x more likely to leave the program without a doctorate relative to men.

Some other statistics to consider are:

- *The timing of student attrition (i.e., time since started program). For example, ~50% of students who leave without a doctorate leave in the semester before or after qualifying exams.*
- *% of students who ultimately did not get a doctorate but who took qualifying exams + the outcome of the exam. For example, ~50% of students who leave without a doctorate took a qualifying exam, and of those, only ~20% received a failing result on the exam.*
- *% of enrolled students who left with a master's degree rather than a doctorate. For example, ~52% left without a degree of any kind. This number can be compared to national averages available through the AGI for example: https://www.americangeosciences.org/geoscience-currents/geoscience-degree-completion-rates-1973-2007.*

Once data collection is complete, the data can be used to diagnose specific concerns and identify the specific metrics that your program or institution wishes to improve. For example, perhaps the data suggests that the majority of attrition for the unit's graduate degree programs happens shortly after qualifying exams due to negative exam outcomes (deferred decisions and/or exam failures), which points towards the need to look at the unit's goals for the exams themselves (see next section), as well as the specific processes used to decide exam outcomes. Alternatively, perhaps the data reveals that the majority of graduate student attrition occurs in a time window *immediately before and after* qualifying exams coupled with the observation that students tend to leave even if they pass exams, which may suggest a cultural problem around exams and/or this phase of the degree program. Or perhaps the data shows that the majority of students who leave a program do so with passing exam results and/or a master's degree, which suggests that changing career goals and priorities may be the root cause of attrition.

Anonymous aggregate data from exit interviews, graduate student climate surveys, and/or focus groups can also provide valuable sources of data and more detailed information about student perceptions and experiences and the reasons why students may not finish a particular degree program. These efforts should be conducted by a trained, neutral third party such as someone from the institution's human resources department, a collaborating social scientist with related expertise, a trained ombuds-person, or hired external contractor.

IDENTIFYING GOALS OF EXAMS

In addition to collecting data, identifying the specific program goals that graduate qualifying exams fulfill is second important step in inclusive qualifying exams. For example, are qualifying exams intended to be a second selection process, following graduate admissions, to determine which students will obtain doctorates from a given graduate program? If so, that program may want to re-visit their practices around graduate admissions as part of addressing the inclusiveness of their qualifying exam processes (see section on Rubrics below for additional references on equitable graduate admissions). Alternatively, are qualifying exams used primarily to assess the suitability of a dissertation prospectus? If so, the unit may want to consider other constructive venues in which to conduct prospectus assessment. Or are qualifying exams used solely as an assessment to determine the topical areas where a given student would benefit from additional study prior to graduation? If so, this is an excellent motivation to use rubrics and/or consider alterative assessment practices, such as the development of portfolios, mentoring plans/individual development plans, and/or program learning outcomes.

ALTERNATIVE ASSESSMENT PRACTICES

LEARNING OUTCOMES

Developing learning outcomes, also known as learning objectives, for doctoral degree programs, is one way to create the foundation for graduate assessment (including via rubrics). Learning outcomes can be defined as "*What students accomplish and learn when enrolled in a program"* (ASU Office of Evaluation) and have been shown to be an important tool for successful student learning if properly linked to assessment. Learning outcomes are widely accepted as part of best practices in K-12 & undergraduate education but have not been as widely recognized and adopted in graduate education.

In order to develop degree learning outcomes, the School of Earth & Space Exploration at Arizona State University convened a task force of twelve faculty and graduate students representing the School's three doctoral programs (Geoscience, Astronomy/Astrophysics & Engineering Systems Design) to meet during the summer of 2023, known as the School of Earth & Space Exploration Equity in Qualifying Exams Leadership Team (SEQEL). Ultimately this task force determined that the three PhD programs sought to build the same overarching skills (or learning outcomes). The ten categories of these learning outcomes (in red) identified by the task force fall under three broad goals of the unit's doctoral programs (in green):

Every doctoral graduate from the School of Earth & Space Exploration will:

a) Be knowledgeable in their field and possess a set of skills relevant to their research area.
    1. Background Literature
    2. Content Knowledge

        3. Tools & Technology
    b) Be able to carry out independent scientific research and draw conclusions.
        4. Independence
        5. Research & Engineering Specialty
    c) Be active participants in the scientific community.
        6. Oral Communication
        7. Written Communication
        8. Peer Review
        9. Collaboration
        10. Mentoring & Teaching

The specific language for each learning outcomes utilizes Bloom's taxonomy. For example, the learning outcome for the Content Knowledge category is, "*A doctoral graduate can explain core concepts/content knowledge relevant to their field and how it relates to their particular project or problem*." Or for the Oral Communication category, "*A doctoral graduate can develop clear, effective oral presentations for a variety of audiences on their scholarly work."* The language for each of the School of Earth & Space Exploration's ten learning outcomes for their PhD programs can be found in Appendix 1.

Once a program had defined its learning outcomes, it can more easily develop specific tools to assess a student's progress towards or accomplishment of a given learning outcome. Using the example of the School of Earth & Space Exploration's Oral Communication learning outcome above, the program decided to assess the students proficiency in this skill through asking them to meet four milestones, which are 1) giving a clear & concise 1 minute elevator pitch about their scholarly work, 2) giving a clear & accurate 15 minute scientific talk on their original research, 3) sharing scholarly work at a professional scientific meeting/ workshop and also at a meeting with the general public, and 4) presenting a clear & effective 1 hour public defense talk on their scholarly work.

RUBRICS

The introduction of uniform assessment frameworks has been shown to reduce attrition and shorten the time to degree in doctoral education (Guloy et al., 2020). Similarly, extensive work on the use of rubrics in graduate admissions by J. Posselt and others (e.g., Posselt, 2014, 2016) has shown that they can improve equity when they consider numerous and divergent criteria, are systematic, include socio-emotional competencies, are reviewed by a diverse group of reviewers, and have adequate time allotted for reviewing. It follows that rubrics have the potential to be a similarly effective tool to improve equity in graduate assessment.

The rubric designed by the ASU SEQEL task force is designed around ten skills (i.e., learning outcomes) each graduate student in the School of Earth and Space Exploration will learn to earn a doctorate organized under the three broad goals of the School of Earth & Space Exploration doctoral programs. The rubric then contains four milestones, or steps, towards developing proficiency in each of the ten learning outcomes. For this particular rubric, it was determined that a student is ready to graduate with their doctorate when they have completed all 40 milestones, and a PhD student has met the requirements to advance to doctoral candidacy (i.e., pass their qualifying exam) when they have completed Milestones 1 & 2 for all ten learning outcomes (or ~20 milestones total). The full rubric developed by ASU's School of Earth & Space Exploration is available upon request from the author (cbtill@asu.edu).

The rubric designed in this way can thus act as a transparent mentoring plan for graduate study, in addition to use for qualifying exams. For example, upon entering a program, each new graduate student sits down with their advisor(s) go over the rubric together in detail, filling out any milestones that require individualization for a particular student. Then, each time the student meets with their doctoral advising committee, the committee establishes the student's location on the rubric (i.e., what milestones they have completed to date) and which milestone's they should focus on next. This provides the student with a sense of progress and accomplishment as well as a sense of what remains to be done. This also provides the student, advisor and committee a way to track progress and identify if there are areas where a student needs particular guidance and support.

PORTFOLIOS

Portfolios are increasingly used in a variety of educational environments as an effective means for tracking student progress and conducting assessment, including being widely used in post-graduate medical programs (Wolf & Dietz, 1998; McMullan et al., 2003; Tochel et al., 2009). Portfolios also have the added benefit of providing students examples of their work to share with future employers and can act as tangible products of a student's progress within a program prior to obtaining a degree or having finished a dissertation for example. Also, when employed under certain conditions, portfolios have the added advantage of stimulating additional self-reflection and assessment for students (Driessen et al., 2005). Scientific doctoral programs are well suited to portfolio-type assessment, as students generate a variety of products during their doctoral program such as literature reviews, data sets, interpretative figures, dissertation prospectuses, and conference abstracts, posters and presentations, as well as final research products such as peer-reviewed journal articles. Developing clear requirements and assessment guidelines for student portfolios is thus an alternative to qualifying exams and a means to provide equitable assessment in scientific doctoral program.

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SESE Doctoral Program Learning Outcomes

Appendix 1: This document shares the ten skills (i.e., learning outcomes) each graduate student in the School of Earth and Space Exploration will learn to earn a doctorate (as of Spring 2024). The categories of the ten learning outcomes (shown in maroon) are organized under the three broad goals of the School of Earth & Space Exploration doctoral programs (shown in gold).

Every SESE doctoral graduate will:

A) Be knowledgeable in their field and possess a set of skills relevant to the research area.

1. **Background Literature**
2. **Content Knowledge**
3. **Tools & Technology**

B) Be able to carry out independent scientific research and draw conclusions.

4. **Independence**
5. **Research & Engineering Specialty**

C) Be active participants in the scientific community.

6. **Oral Communication**
7. **Written Communication**
8. **Peer Review**
9. **Collaboration**
10. **Mentoring & Teaching**

Every student graduating from SESE with a Ph.D. will:

A) Be knowledgeable in their field and possess a set of skills relevant to their research area.

Category	Learning Outcome
1. Background Literature for AST, ESD & GEO	**A doctoral graduate can evaluate primary & secondary sources of existing knowledge.**
2. Content Knowledge for AST, ESD & GEO	**A doctoral graduate can explain core concepts/content knowledge relevant to their field and how it relates to their particular project or problem.**
3. Tools & Technology for GEO PhD	**A doctoral graduate can apply relevant technical skills to their scholarly work.**
Tools & Technology for AST PhD	**A doctoral graduate can write code and effectively use or develop important software & technologies related to their scholarly work.**
Tools & Technology for ESD PhD	**A doctoral graduate has mastered the practical tools and techniques needed to advance in their scholarly work.**

B) Be able to carry out independent scientific research and draw conclusions.

Category	Learning Outcome
4. Independence for AST, ESD & GEO	**A doctoral graduate can formulate and address research questions and/or motivations for new technology.**
5. Research or Engineering Specialty for AST, ESD & GEO	**A doctoral graduate has developed expertise in one or more of the following to test scientific hypotheses; acquiring and/or analyzing data, theoretical modeling, and/or designing and/or using research instruments or exploration systems.**

C) Be active participants in the scientific community.

Category	Learning Outcome
6. Oral Communication for AST, ESD & GEO	**A doctoral graduate can develop clear, effective oral presentations for a variety of audiences on their scholarly work.**
7. Written Communication for AST & GEO* ***Written Communication for ESD**** *Same milestones for AST, ESD & GEO	**A doctoral graduate can author clear, effective, and publishable journal articles, proposals, conference abstracts and/or other relevant products regarding their scholarly work.** **A doctoral graduate can identify the dominant publication modalities & contribute to them at a professional level.**
8. Peer Review for GEO, AST & ESD	**A doctoral graduate can evaluate scholarly work* following best practices for giving & receiving constructive feedback and conducting peer review.** **"scholarly work" here has the broadest possible interpretation*

D) Be active participants in the scientific community (cont.)

Category	Learning Outcome
9. Collaboration for AST, ESD & GEO	**A doctoral graduate can constructively collaborate with others, both inside and outside their field including but not limited to co-development of papers, proposals, presentations, technology etc.**
10. Mentoring & Teaching for AST, ESD & GEO	**A doctoral graduate can establish mentoring relationships with advisors and experts in the field and can mentor others.**