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Work in Progress: A Holistic PhD Admissions Rubric–Design & Implementation

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Work-in-Progress: A Holistic PhD Admissions Rubric - Design and Implementation

Abstract

Addressing today's complex engineering challenges requires that all perspectives and lived experiences are brought to the table. The NSF and other organizations have stressed the importance of bringing a more representative proportion of the national population into the professional STEM research pipeline. By investing in building a robust and diverse community of engineers, we will have access to a workforce with the insight into societal needs needed to solve today's problems

A comprehensive graduate student recruitment program must focus on increasing the diversity of its applicant pool and matriculating cohorts. Critical to this goal is the use of evidence-based best practices during the graduate admissions process. The admissions process should ensure that every student comes into the school with the same potential for success, regardless of background and experiences. It is therefore crucial that the process rely on true indicators of graduate school success, such as research interest and potential, motivation and persistence, and potential for leadership; while de-emphasizing poorer predictors, including traditional academic preparation indicators and GRE scores.

To this end, a Holistic PhD Admissions Rubric was developed and implemented for use by all graduate programs in the engineering school of a large R1 University. This rubric is an evaluation tool built into the central admissions system that aids faculty reviewers through best practices in PhD admissions. The rubric facilitates the use of these practices while still permitting a degree of uniformity to the review process, albeit one that further ensures excellence, access, and equity. The rubric utilizes nine criteria, including metrics such as letters of evaluation scores, demonstration of research potential/vision, evidence of motivation/persistence/ability to overcome obstacles, and potential for leadership. Each criterion includes suggestions on where in the application materials to seek out that information, as well as descriptors for each criterion's numerical rating. A score is given for each criterion and then all criteria scores are totaled and used as part of the overall admissions evaluation.

Faculty dialogues, meetings, and educational emails were used to increase implementation of the rubric across the school beginning with the admissions cycle for students matriculating in the Fall of 2019. The rubric was updated for the admissions cycle for students matriculating in the Fall of 2020 based on continued feedback of faculty users, and review by premier experts in the field of holistic graduate admissions. In the admissions cycle for students matriculating in the Fall of 2020, 57% of admitted PhD students had a completed rubric in their application file, and we expect this number to continue to increase.

Our research team plans to conduct a survey of the faculty who review PhD applications and a series of focus groups with graduate program admission directors in order to better understand the role the rubric takes in the admissions process. We want to understand how faculty are using the rubric and whether they find it helpful and easy to use. Additionally, we want to know if the rubric has changed how faculty approach the PhD application evaluation process and the value they place on various application metrics. We will also assess faculty perspective on the quality of student

being admitted into their programs both before and after implementation of the rubric. This review of faculty perspective will then be compared to admissions data in the two years prior to rubric implementation and two years after, concentrating specifically on GRE scores and GPA, as well as demographic data. We will also assess the first year GPA and first year retention rate of the class matriculating in the Fall of 2019 (the first year of rubric implementation) as a work-in-progress. Future work will focus on longer-term retention rates, as well as other metrics of graduate school success, including time-to-degree and research productivity.

Introduction

The National Science Foundation, other members of the National Academies, the US Congress, and a host of other institutions, have all spoken to the critical need to cultivate an engineering workforce that represents our entire population [1-4]. Research has shown positive educational benefits when students interact with those who come from different perspectives and lived experiences, contributing to improved complex thinking, intellectual self-confidence and engagement, improved motivation to understand the perspectives of others, greater feelings of citizenship, and a stronger motivation to achieve [5-11]. Measurable performance benefits have also been observed in the workplace [12-16]. These reasons and others reflect the importance of building an engineering workforce with the breadth of knowledge, perseverance, and understanding of societal needs required to address today's global challenges.

STEM programs in higher education are falling behind in producing a diverse science and engineering workforce. As of 2019, approximately 34,000 students in the United States earned a doctorate degree in a STEM field (excluding psychology & social sciences) [17]. Of this cohort, only 38% were female, with only 24% of engineering doctorates being female [18]. Only 7% of this 2019 PhD cohort were domestic minority (using the IPEDS classification of Hispanic/Latino, American Indian/Alaska Native, or Black/African American), with only 1.7% of engineering doctorates fitting this category [19]. A multitude of reasons have been linked to this deficiency, including a lack of effective and comprehensive K-12 outreach programs and inadequate support of current college and graduate students from traditionally underrepresented groups. Recruitment and admissions procedures are likewise important. It is critical to cultivate a diverse applicant pool that encompasses applicants from all backgrounds and situations. Building a robust, strategic, and comprehensive marketing and recruitment program to reach a wide audience is key [20]. However, once a diverse applicant pool has been developed, the admissions process itself must be fair, evidence-based, and as free from bias as possible.

When focusing specifically on graduate admissions, a variety of factors have been correlated with the lack of student diversity, including the reliance on traditional quantitative admissions metrics, like GRE scores and GPA [21-23]. GRE scores have been proven again and again to be poor indicators of success in graduate school, particularly in research-based degree programs; and instead, are better predictors of gender and race/ethnicity. Likewise, research tells us that a student's GPA is a result of a wide variety of factors in addition to academic potential, including gender, race, first generation status, and socioeconomic standing [24-29].

Alternatively, several better indicators have now been correlated with graduate school success in research-based degree programs, including self-efficacy, perseverance, motivation, and a passion for research and prior research experience [30-34]. A holistic application review process that

focuses on these evidence-based metrics of success with a de-emphasis on poor and biased predictors should level the playing field for applicants from all backgrounds and experiences, resulting in a more diverse graduate student body that is much more likely to succeed and thrive in graduate studies [35-37].

Therefore, in order to develop a graduate admissions review process that is as free from bias as possible and incorporates best practices in holistic review, admissions committees and institutional faculty must understand the value of holistic review and be provided with tools that allow them to implement these practices with ease in the review process of large volumes of applications. To that end, the Holistic PhD Admissions Rubric was developed and implemented into the central application system of an engineering school at a large R1 university encompassing nine PhD programs.

Rubric Design and Implementation

First Rubric Iteration

The Holistic PhD Admissions Rubric was designed using best practices in holistic graduate admissions gathered from relevant literature [30-34]. The first iteration of this rubric contained 13 criteria, each with a 1-4 scoring system with qualifiers for each score rating (Figure 1). Criteria were listed in order of best predictor of graduate success (letters of evaluation, evidence of motivation, and prior research experience) to poorest (GPA and GRE), as reflected in best practices. Here, letters of evaluations are letters of recommendations, and each recommender also assigns a rating score for each applicant. Qualifiers for each score were kept general enough to apply across nine different degree programs. Because the traditional quantitative metrics that have proven to be poor predictors of success, like GPA and GRE, are now reduced to being just two of 13 criteria, the value on these metrics is decreased overall. Each criterion also included information about where in the application a reviewer can find information needed to determine a score; and in some cases, included tips on how to contextualize the application information. For example, for the GPA criterion, the rubric included a tip for considering the undergraduate institution environment and academic progress over time.

A limited pilot of rubric implementation was carried out in the Fall of 2017, where the rubric was provided as a stand-alone document (not integrated into the central application system) for some faculty to use upon reviewing applications. Based on these results, this initial version was partially implemented into the central application for the 2018-2019 admission cycle (applicants matriculating the Fall of 2019). Upon viewing an application, the rubric could be opened within the same window and scored within the system; however, only the main criteria (bold text in Figure 1) and numerical score options were displayed. Faculty reviewers had to open the full rubric in a separate window to view the detailed qualifiers of criteria and scores.

In order to educate faculty and admissions staff on the merits of holistic graduate admissions review and on the use of the rubric, several faculty dialogues were held prior to the 2018-2019 admissions cycle. These sessions were dedicated to discussing the positive and negative predictors of graduate school success, using data from STEM studies [25, 38-39]. Additionally, the rubric designers attended faculty meetings in each department to walk through the rubric. Finally, in order to encourage faculty to use this tool, the school dean's office required a completed rubric for each nominee to a school-level fellowship.

Figure 1: First Iteration of PhD Holistic Admissions Rubric

Category	Criterion	1	2	3	4	Score
Letters of Evaluation	Knowledge of applicant	Writer does not know applicant	Writer does not know applicant well	Writer knows applicant well	Writer knows applicant well and describes skills that align with success in graduate school	
	Overall evaluation scores	Poor	Fair	Good	Excellent, outstanding	
	Clear demonstration of research potential & vision	Not indicated	Vague details; indicated potential and vision insufficient	Indicated with detail, potential and vision are good	Indicated with detail, potential and vision are outstanding	
Personal Statement	Clear research goals & interests in solving real-world problems, alignment with program	No goals or interests indicated	Goals and interest evident but not well articulated, do not align with program	Clear goals and interest are evident but do not align with program	Clear goals and interest are evident and align with program	
	Writing ability	Poor writing skills	Fair writing skills	Good writing skills	Excellent writing skills	
	Clear evidence of applicant's motivation, persistence, character, and ability to overcome obstacles (also found on letters of eval)	Not indicated	Vague details; indicated evidence insufficient	Indicated with detail and evidence is good	Indicated with detail and evidence is outstanding	
	Clear demonstration of or potential for leadership & engagement (also found in CV and letters of eval)	Not indicated	Vague details; indicated potential insufficient	Indicated with detail and potential is good	Indicated with detail and potential is outstanding	
Research Potential (CV)	Quantity of prior research experience in academic and beyond	No experience	Little experience	Some experience	Large amount of experience	
	Quality of prior research experience in academic and beyond	No experience	Time spent in a lab with no demonstrated outcomes	Secondary author on publication(s) and/or prior presentation experience	Peer-reviewed conference presenter, first-author publication(s)	
	Evidence of passion for research (also found in personal statement and letters of eval)	No evidence	Little evidence	Some evidence	Large amount of evidence	
Academic Performance	Academic preparation for discipline (or the potential to take preparation courses). Use of transcripts needed.	No preparation or potential for preparation	Little preparation or potential for preparation	Some preparation or potential for preparation	Well-prepared or high potential for preparation	
	GPA Tip: Consider undergraduate institutional environment and academic progression over time as seen on transcripts)	2.4 or below	2.5 – 2.8	2.9 – 3.4	3.5 or above	
	GRE (sum of verbal and quantitative)	300 or below	301-309	310-319	320 or above	

Second Rubric Iteration

The following year, after discussions with faculty who used the first iteration of the Holistic PhD Admissions Rubric and with experts in the field of holistic graduate admissions, the rubric was modified for the 2019-2020 admissions cycle for applicants who would matriculate in the Fall of 2020 (Figure 2). The modifications sought to simplify the rubric-driven application review process, reducing the total number of criteria to nine, and the scoring system to 1-3. Criteria were still listed in order of highest predictor to lowest, but the GRE scores were removed altogether to further deemphasize its value in graduate admissions. Again, each criterion included information on where in the application a reviewer can find information to determine a score. This version of the application was made available to faculty and staff through full implementation directly into the central application system, including the full qualifier description for each score option. Upon viewing an application, the rubric can be opened within the same window and scored within the system.

Figure 2: Second Iteration of PhD Holistic Admissions Rubric

Criterion	Potential Sources of Information	1	2	3	Score
Overall evaluation scores	Letters of evaluation	Poor or fair	Good or excellent	Outstanding	
Clear demonstration of research potential & vision	Letters of evaluation, CV, personal statement	Not indicated or vague details; indicated potential and vision insufficient	Indicated with detail, potential and vision are good	Indicated with detail, potential and vision are outstanding	
Clear research goals & interest in solving real-world problems, alignment of goals with faculty expertise	Letters of evaluation, CV, personal statement	No goals or interests indicated	Expression of goals and interests evident, but not well-articulated or do not align with faculty expertise	Expression of goals and interests clearly articulated and align with faculty expertise	
Clear evidence of applicant's motivation, persistence, ability to overcome obstacles	Letters of evaluation, CV, personal statement, trends in GPA over time, transcripts	Not indicated or vague details; indicated potential insufficient	Indicated with detail but are not well-articulated	Indicated with detail and clearly articulated	
Evidence of enthusiasm or commitment to research, potential for future research	Letters of evaluation, CV, personal statement	Little or no expression of research enthusiasm or commitment	Research enthusiasm or commitment articulated through demonstration of interest	Research enthusiasm or commitment clearly articulated through demonstration of research experience beyond senior project or capstone (research experiences can include academic and beyond)	
Demonstrated prior research experience in academia or beyond	CV, personal statement	No experience indicated	Co-op, internship, or research experience indicated but outcomes are not clearly articulated	Co-op, internship, or research experience with clearly articulated outcomes (e.g. senior thesis, capstone or co-op report/presentation, conference presentation, publication)	

Clear potential for leadership & engagement in academic and beyond	Letters of evaluation, CV, personal statement	Not indicated or vague details; indicated potential insufficient	Indicated with detail and potential is good	Indicated with detail and potential is outstanding	
Academic preparation for discipline, or the potential to take preparatory courses	Transcripts, letters of evaluation	Little or no preparation or potential for preparation	Some preparation or potential for preparation	Well-prepared or high potential for preparation	
GPA in major and progression Tip: Consider undergraduate institutional environment and academic progression over time as seen on transcripts	Transcripts	2.9 or below without upward trend in GPA over most recent three semesters	3.0 -3.4 without upward trend in GPA over most recent three semesters; or 2.9 or below with upward trend in GPA over most recent three semesters	3.5 or above; or 3.0 – 3.4 with upward trend in GPA over most recent three semesters	

An email detailing the new rubric and instructions on its use were sent to all admissions faculty and staff. A completed rubric continued to be required for all nominees to school-level fellowships in the 2019-2020 and 2020-2021 admission cycles.

Assessment

Two areas of assessment were performed for this study: 1) an investigation of faculty impressions of the use and value of the rubric and 2) an analysis of admissions and first-year metrics before and after implementation of the rubric.

Faculty Perspectives on the Use and Value of the Rubric

A 17-question survey was sent to any faculty with access to the central application system in order to understand how useful and impactful the rubric had been in reviewing PhD applications from the perspective of the reviewers themselves. The survey was completely anonymous and participation was strictly voluntary. Questions focused on understanding the capacity with which faculty use the rubric, how frequently they used it, how easy it was to use, and whether they felt it was helpful in reviewing applicants who have differing experiences and backgrounds. Just as importantly, the survey also asks questions related to how the use of the rubric effected faculty views on holistic admissions: did using the rubric demonstrate the importance of holistic admissions when reviewing applications, did its use change what parts of the application the reviewer emphasizes when reviewing applications, and do faculty feel that the use of the rubric changed the quality of the students admitted.

It should be noted that 18 respondents completed the survey, representing about 9.3% of all faculty who had access to the central application system for graduate application review and included five of the nine PhD programs within the school. The low response rate was likely due to faculty fatigue during the COVID-19 pandemic as the survey was administered in October-November of 2020. Care should therefore be taken when interpreting the survey results, and should be placed into context with information gained in the focus groups with admissions faculty.

In order to contextualize survey responses and gain a deeper insight into faculty impressions, two focus groups were held with faculty highly involved in the graduate admissions process. These

sessions focused on assessing the rubric's role in the admissions process across different programs, how faculty actually use the rubric, whether any training is given by programs prior to the application review cycle, and whether they find it easy to use and valuable in their reviews. Finally, feedback on how the rubric could be improved and best used was also sought. Each session lasted approximately one hour and a total of five faculty and one staff member participated, representing five of the PhD programs in the school.

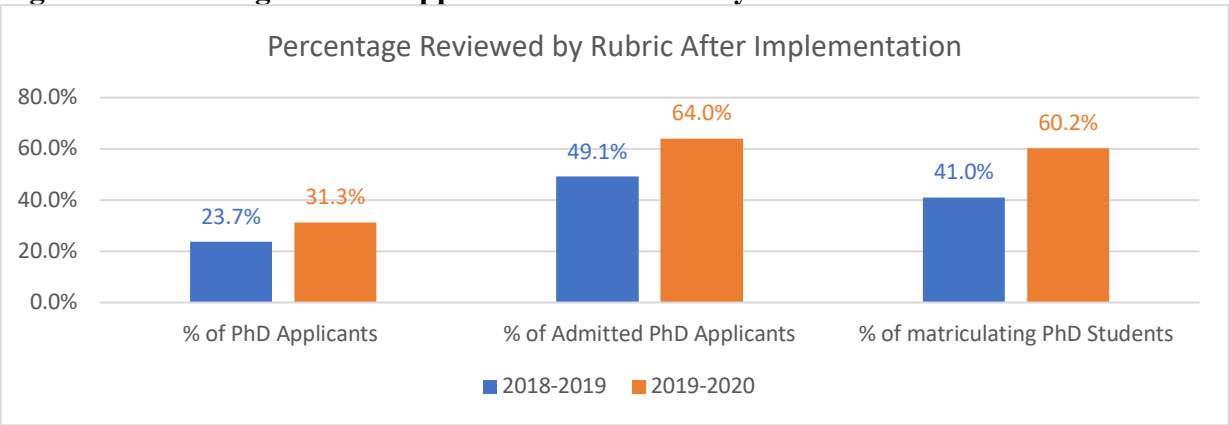
Admissions & Retention Metrics Before & After Rubric Implementation
In order to determine any effects rubric implementation had on the diversity and quality of applicants admitted to the school's PhD programs, admissions data were collected for three admissions cycles. The first set of data was collected in the admissions cycle immediately prior to the rubric roll-out: the 2017-2018 admissions cycle (for applicants matriculating in the Fall of 2018). Earlier data could not be used for direct comparison as the school changed central application systems prior to this admissions cycle. The second set of data was collected during the first year that the Holistic PhD Admissions rubric was implemented: the 2018-2019 admissions cycle (for applicants matriculating in the Fall of 2019. Data from the 2019-2020 admissions cycle (for applicants matriculating in the Fall of 2020) are also included here for review; however, there were several external and internal factors at play during this period, including the elimination of GRE requirements in two PhD programs, and of course, the widely-felt effects of the COVID-19 pandemic on potential applicants' choices to pursue a PhD. This effect is especially impactful for international students, which typically make up about 70% of overall applicant numbers, as well as for women and domestic minority applicants who experienced an outsized impact from the pandemic.

For each cycle, the numbers of PhD applicants, admitted PhD applicants, and matriculating PhD students were assessed, along with other metrics, including the presence of a completed rubric, gender, race/ethnicity, the GPA of the applicant's most recent degree, and quantitative GRE scores. For race/ethnicity, the collected data focused on domestic minorities underrepresented in STEM (as defined by the Integrated Postsecondary Education Data System (IPEDS), and includes Hispanic/Latino, American Indian/Alaska Native, Black/African American, and Native Hawaiian/Other Pacific Islander), compared to the total domestic pool.

Relationships were also assessed between rubric use and metrics of graduate school success. As this study is focused on immediate effects of rubric implementation in the short-term, metrics of success focused on first-year cumulative graduate GPA and retention rate for the 2018 and 2019 matriculants. Data from 2020 matriculants will not be discussed here as, again due to the COVID-19 pandemic, the university shifted to alternative grading options in the affected terms.

Outcomes
Rubric Use
Frequency of rubric use over time: During the 2018-2019 admissions cycle, in which the rubric made its debut, 23.7% of all PhD applications were reviewed using the rubric (Figure 3). Of those applicants who were admitted that year, about 49.1% were reviewed with the rubric; as was 41% of the matriculating PhD students. In its second year of implementation, rubric use increased: 31.3% of PhD applications, 64% of admitted PhD applicants, and 60.2% of matriculating PhD students, were reviewed with the rubric.

Figure 3: Percentage of PhD Applications Reviewed by Rubric



Who uses the rubric and how often: Of the faculty survey respondents, 34% used the rubric as a potential PhD advisor. An additional 42% used the rubric as part of their department's admissions committee, as the admissions or graduate program director, or as a faculty member helping with the admissions process. Members of fellowship nomination committees made up about 17% of the respondents, while 7 % had never used the rubric at all. When asked how frequently they used the rubric when reviewing PhD applications, a majority (62%) said always or most of the time, while 23% said sometimes, and 15% said never.

Focus-group discussions with faculty revealed that, in the departments represented, most departments do remind faculty about the rubric and the importance of holistic review in admissions at the start of each application review cycle. Most departments find it difficult to use the rubric for every single applicant due to the volume of applications, and typically only complete rubrics for those they plan to offer admission, or even just for those being nominated for fellowships. Some departments have created their own scoring systems and prefer to use those instead of the rubric. For all departments represented, much of the work of reviewing applications is the same as it was prior to implementation of the rubric, but that the presence of the rubric reminds reviewers what they should be looking for.

<u>Feedback on the two iterations of the rubric</u>

Focus group participants seem to agree that the scoring system of the second rubric was too limited and could not quantifiably separate candidates within different tiers; and for this reason, the first iteration of the rubric was actually easier to use. Some perceived redundancies in each iteration were also pointed out, as was a desire to add reviewer notes directly to the rubric within the central application system for ease of application review.

<u>Ease of rubric use</u>

In the faculty survey, 39% of respondents strongly or somewhat agreed that having the rubric incorporated into the central application system was helpful, while 23% neither agreed nor disagreed, and 38.5% somewhat or strongly disagreed. Discussions with focus group participants indicate that the central application system itself is difficult to use and might be affecting the survey responses. Most participants agreed that the rubric should be present in the system at least as a reminder on what to look for when conducting holistic review.

A majority (61%) of survey respondents felt that the rubric did not make the application review process faster, while 31% where neutral, and 8% felt it made review somewhat faster. No respondents felt the rubric made the review process much faster. Similar results were seen when asked if the rubric made the application review process easier, with 45.5% saying no, 45.5% being neutral, and 8% saying somewhat so. Again, no respondent felt the rubric made the process much easier. Most of the focus-group participants felt that holistic review just takes longer, but that this extra time is worth the effort. Additionally, some participants felt that faculty in their program were already performing holistic review; and that being asked to complete a rubric on top of that, makes the process longer.

In order to dive a little deeper into whether the rubric serves as an effective tool for reviewing applicants who have differing backgrounds and experiences, we asked faculty whether the rubric made is easier to discuss these applicants in lieu of traditional academic metrics. From the survey respondents, 38.5% felt that it did make it easier, while 23% were neutral, and 38.5% felt it did not make it easier. Focus-group participants from programs who receive very large numbers of applications broadly felt that faculty just do not have the time to look beyond traditional metrics for every applicant. Suggestions of automated population of the rubric, or a person/team dedicated to looking at every single application would be required to capture everyone; and practices like this are already ongoing in some of the departments.

Finally, a free-response question in the survey asked what was unhelpful about the rubric. Many respondents took issue with the scoring system, and how difficult it was to quantitatively capture differences among candidates within a particular scoring tier. Another common response focused on the rubric scoring system not being compatible across the different programs/disciplines. Other comments stressed how the rubric did not align well with the application itself, and raised questions such as should the application be redesigned or should the rubric be made available to applicants. Finally, most respondents felt that the rubric serves its greatest use as a reminder in the system, and not necessarily as a component needing completion.

<u>Rubric Impact on Faculty Perspectives</u>

Though the rubric was designed in part to help faculty review applications faster and easier using holistic review, the most important aim of the rubric is to serve as an educational tool. By having a holistic review rubric easily accessible in the application system, constant and timely reminders of what predictors to look for are present. When asked how the rubric was helpful in the review of applications (a free-response question), a majority of responses indicate that the greatest value lies in this educational purpose. Below are representational examples of the responses:

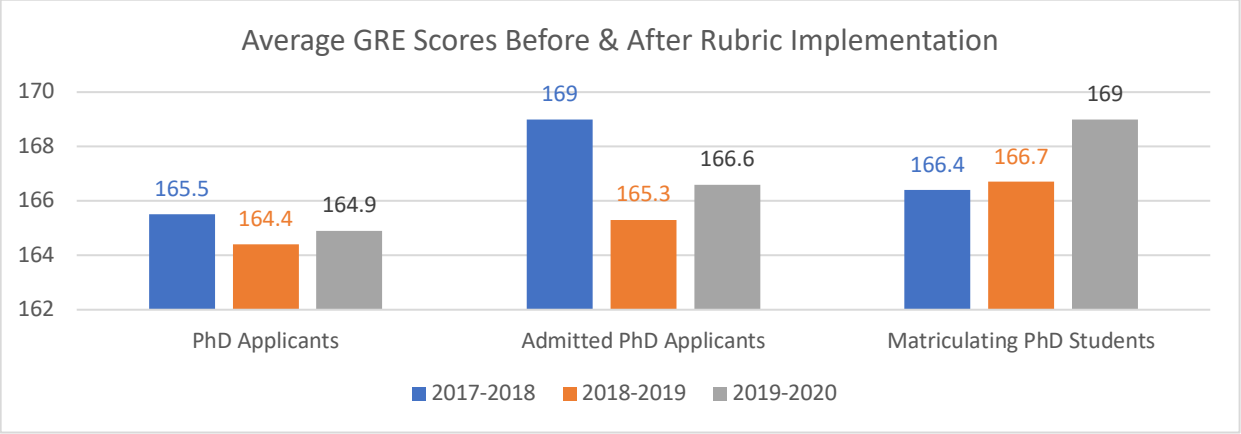
> "I think that the main value of the rubric is that it reminds the reader to consider a variety of factors when reviewing each application. This is particularly helpful when evaluating students who come from non-traditional backgrounds."
>
> "It gave me a framework to consider a wider variety of factors in considering potential graduate students that went far beyond the simple GPA, GRE metrics."
>
> "The questions in the rubric prompted me to specifically look for that information in an applicant's file which I may have otherwise missed."

Faculty were also asked to rank the value they placed on various application components prior to and after the implementation of the rubric. Those components included a) letters of evaluation, b) CV/resume, c) personal statement, d) research potential or prior research experience, e) clear evidence of motivation and persistence, f) evidence of enthusiasm for and commitment to research, g) transcripts/prior coursework, h) perceived strength of prior institution, i) leadership experience or potential, j) GPA, k) GRE scores, and l) other. Though letters of evaluation and research potential/prior research experience were at the top of both before and after rankings, the value placed on "clear evidence of motivation and persistence" more than doubled after rubric use. GRE scores were not ranked on either list, and the value on GPA after use of the rubric slightly decreased.

Rubric Impact on Traditional Admission Metrics

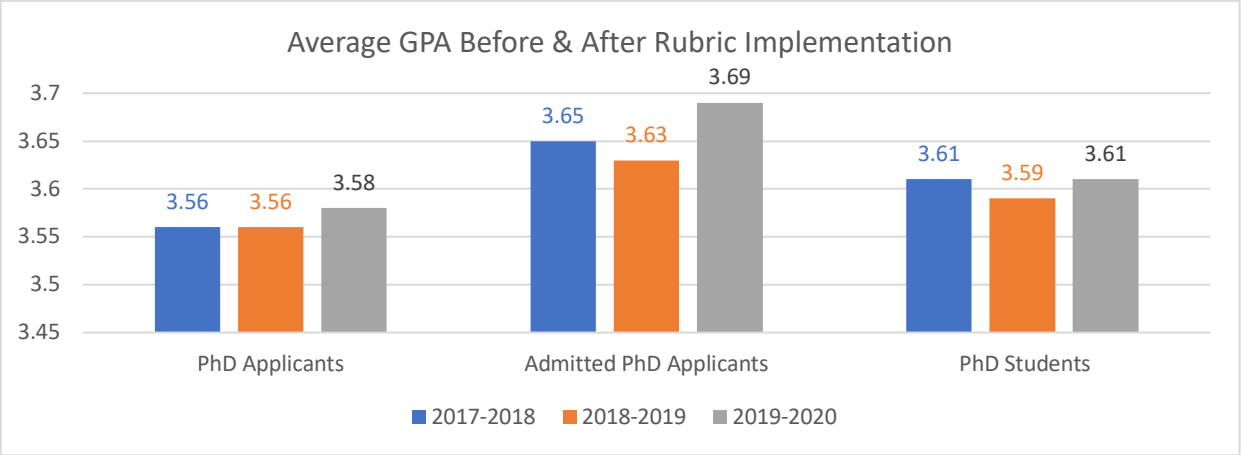
In order to assess the impact of rubric implementation on the quality of admitted applicants and matriculating students, traditional quantitative admissions metrics were analyzed before and after rollout of the rubric, including quantitative GRE (QGRE) scores and the cumulative GPA of the applicant's most recent degree. The average QGRE of applicants and admitted applicants declined slightly from the 2017-2018 admissions cycle (prior to rubric implementation) to the two admissions cycles since implementation of the rubric (Figure 4). For matriculating PhD students, the average QGRE scores for 2017-2018, 2018-2019, and 2019-2020 were 166.4, 166.7, and 169, respectively. It should be noted that two PhD programs had dropped their requirement for GRE scores for the 2019-2020 admissions cycle.

Figure 4: Average GRE Scores Before & After Rubric Implementation



The average GPA of admitted PhD applicants was nearly unchanged between the year prior to rubric use and the first year of use, at 3.65 and 3.63, respectively (Figure 5). The average GPA rose to 3.69 in the second year of rubric use. For matriculating PhD students, the average GPA was 3.61, 3.59, and 3.61 for the 2017-2018, 2018-2019, and 2019-2020 admissions cycles, respectively. When looking at these QGRE and GPA average scores as traditional quantitative admissions metrics, it would seem that the use of holistic measures in graduate admissions does not compromise the quality of admitted applicants and matriculants.

Figure 5: Average GPA Before & After Rubric Implementation



When faculty were asked whether they felt the quality of admitted applicants had changed since implementation of the rubric, 79% responded that it had not, while 14% felt the quality had increased. Seven percent felt the quality had somewhat decreased. A follow-up free-response question asked what metrics of graduate student performance respondents had used to determine quality, as any student who had matriculated after implementation of the rubric was only in their first or second year of graduate studies. About half (51%) of the respondents listed research productivity or progress, or the integration into the lab, as their indicator. Some other indicators listed include academic performance (21%), qualifying exam results (7%), the ability to match with an advisor (7%), excitement (7%), and critical thinking (7%).

Rubric Impact on the Diversity of Admitted Applicants

The final survey question asked faculty if they feel the rubric broadened access to their program to qualified PhD applicants that may not have been given consideration prior to its implementation. About 36% said yes, while another 36% were neutral and 29% strongly disagreed. Responses on the survey and in focus groups depended heavily on program. Programs who have made gains in the diversity of their applicant pool saw subsequent diversity in their admitted applicants; while programs still struggling to recruit a diverse pool of applicants realize this must happen first before holistic admissions has any meaningful effect.

When approaching this question from a data perspective, the percentages of domestic admitted applicants and matriculating students who are either minorities in STEM or female were assessed. To calculate the percentage of minorities in STEM, domestic admissions information was used; while the entire admissions pool (domestic and international) was used to calculate the percentage of females. Information on actual number of PhD applicants, admitted applicants, and

matriculating students each admission cycle, as well as the percentages that are domestic, are included in Table 1.

Table 1: Actual Numbers of PhD Admission Cycles

Admissions Cycle	Total # PhD Applicants	% of Applicants who are domestic	Total # Admitted PhD Applicants	% of admitted applicants who are domestic	Total # Matriculating PhD Students	% of Matriculating Students who are domestic
2017-2018	1265	29%	329	55%	169	47%
2018-2019	1154	30%	350	50%	188	46%
2019-2020	1177	24%	286	51%	128	49%

An increase in the percentage of domestic admitted applicants who are minorities in STEM was observed from the 2017-2018 cycle (prior to rubric implementation) to the first year of rubric use: the 2018-2019 cycle (Figure 6). In the 2019-2020 cycle, this percentage declined. For matriculating PhD students, these percentages increased for both admissions cycles after rubric implementation. An increase was observed in the percentage of admitted applicants who were female from the year prior to rubric implementation to the first year of use (36.5% in 2017-2018 cycle and 38.6% in the 2018-2019 cycle) (Figure 7). And similar to what was observed for minority admitted applicants, this percentage decreased for the 2019-2020 cycle, to 33.6%. This same trend holds when assessing the percentage of matriculating students who were female: 34.3%, 35.6%, and 30.5% for the three cycles, respectively.

Figure 6: Percent of Admits & Matriculating Students Who are Domestic Minorities

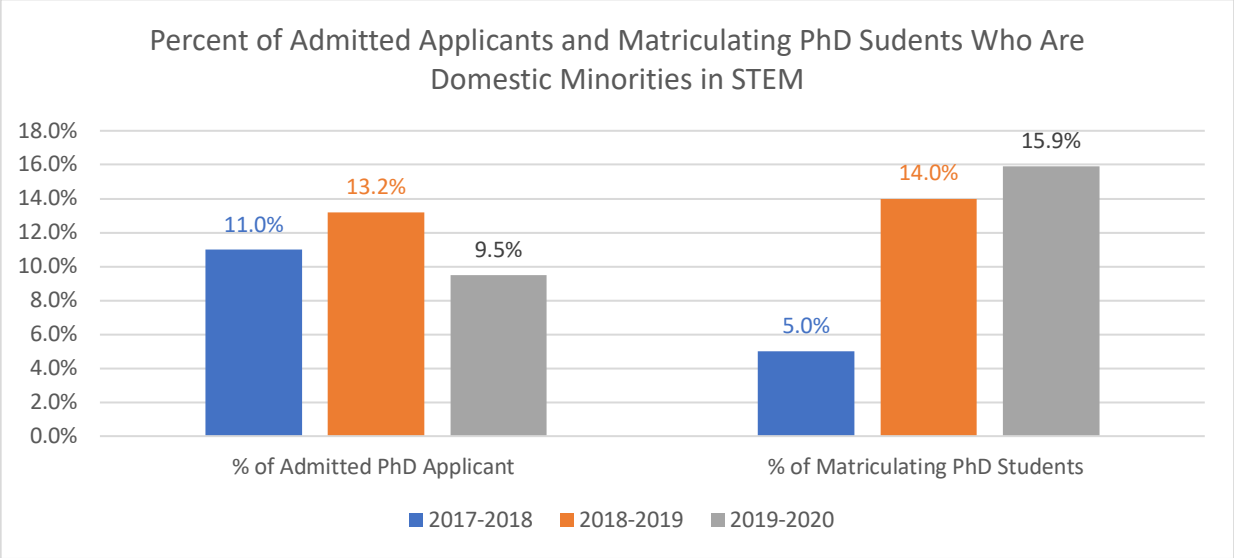
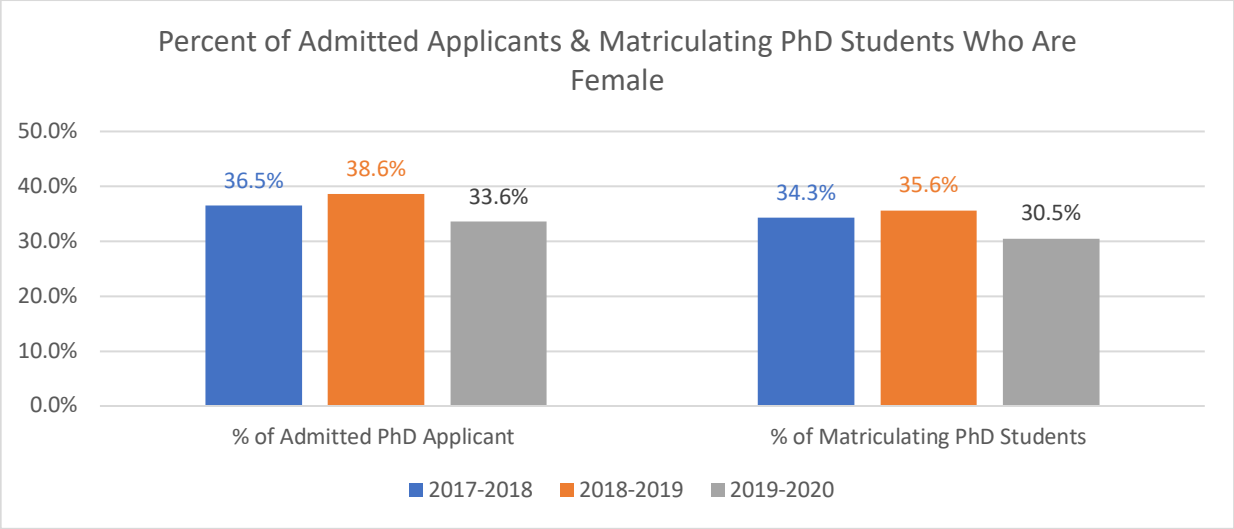


Figure 7: Percent of Admits & Matriculating PhD Students Who Are Female



These data show a clear increase in the diversity of admitted applicants and matriculating students from the cycle prior to rubric implementation and the year after. These gains are not seen however in the second year of rubric use (2019-2020 cycle), but again, a variety of reasons, such as the COVID-19 pandemic, may exist that complicate the overall effects of the rubric, as discussed earlier. That being said, the national average of domestic engineering doctoral students in 2018 who are minority or female was 10.6% and 26.5%, respectively, below the percentage of the incoming cohort from the 2020-2021 cycle [40].

Rubric Impact on Immediate Graduate School Success

As this study was designed to measure the immediate effects of rubric implementation as an initial report of a longitudinal analysis, assessment of graduate school success for this study focused on first year cumulative graduate GPA and the rate of first-year retention. PhD students who matriculated from the admissions cycle preceding rubric implementation (2017-2018), earned an average cumulative graduate GPA of 3.63 in the first year of their PhD program (academic year 2018-2019). In the cycle after implementation, average cumulative first year GPA increased to 3.73 (academic year 2019-2020).

When assessing the first-year retention rate of each cohort of students, the outcomes are again complicated by the effects of the COVID-19 pandemic. 95.9% of PhD students who matriculated from the 2017-2018 admissions cycle completed their first year of graduate studies, with eight of those students on academic probation after their first year. A student is placed on probation when their cumulative GPA falls below 3.0. This figure increased to 99.5% for the

cohort from the 2018-2019 admissions cycle who completed their first year of graduate studies, with five students on academic probation after their first year.

It was during the second cohort's first year that the COVID-19 pandemic started (academic year 2019-2020), which included the introduction of a modified credit/no credit grading option in the Spring 2020 semester. In this semester, all courses that students originally enrolled in to receive a letter grade were changed to the modified grading option; and students could individually select which, if any, courses to change back to receiving a letter grade. The courses for which students remained enrolled in the modified credit/no credit grading option are not included in the student's GPA. Only future analysis of this cohort over time, and the inclusion of additional cohorts after rubric implementation will give a fuller picture on the rubric's impact on student retention and success in graduate school.

Discussion

The U.S. is becoming an increasingly diverse nation, and our higher education institutions should reflect this diversity. Through culturally complex interactions, students are exposed to a variety of backgrounds and lived experiences, and show gains in cognitive skills such as critical thinking and problem-solving [5-11]. However, student demographics in STEM programs do not reflect that of their communities. This is especially true for our nation's engineering PhD programs, where only 24% of the 34,000 doctorate degrees in STEM earned in 2019 were awarded to female engineering students, and only 1.7% earned by domestic minority engineering students [17-19].

While there are a multitude of reasons for this deficiency, one important component is the admissions process. In order to develop a graduate admissions approach that is fair, evidence-based, and as free from bias as possible, programs must turn away from relying heavily on traditional quantitative admissions metrics like the GRE and GPA, and embrace a holistic application review paradigm [21-23]. A holistic-review process that focuses on true indicators of graduate school success and de-emphasizes poor or biased predictors will help level the playing field for applicants of all backgrounds [35-37].

In order to stress best-practice approaches in holistic application review, a Holistic PhD Admissions Rubric was developed as a tool embedded in the central application system to help faculty reviewers seek out and use true indicators of graduate school success when evaluating PhD applications, and to reduce reliance on poor predictors. It should be noted that this rubric was one component of a multi-faceted effort to increase diversity and inclusion in the engineering school and was implemented along with a strategic marketing and communication program educating prospective students on the school's commitment to diversity and inclusion, targeted recruitment activities, application fee waivers, and a series of fellowships for incoming students [20].

Below are some lessons learned along the way in the development and implementation of the Holistic PhD Admissions Rubric:

- Holistic review takes time: Though one of the original goals of rubric design was to make the application evaluation process easier and faster for faculty reviewers, it was soon realized how difficult this is. As holistic review relies on combing through an application

and looking for experience, motivation, passion, and leadership, and not quickly skimming for GPA and GRE scores, this kind of review in practicality takes time and effort. Most programs felt that the extra time was worth it, but acknowledged that they could not review every single applicant this way, depending on the size of their applicant pool. Some strategies proposed to help facilitate holistic review more efficiently was auto-population of the rubric and rethinking the entire application itself. Redesigning the application so that it directly addressed criteria in the rubric in a way that the central application system could facilitate auto-population, would speed application review; and it would more clearly tell applicants exactly how they are being evaluated.

- The scoring system should be robust: With the second iteration of the rubric, the scoring was streamlined. However, it was generally agreed that the second iteration scoring system was too limited, and therefore resulted in large numbers of applicants falling into narrower numerical ranges, making it difficult to differentiate applicants. One concertn about expanding the scoring system, however, is that it may increase the review and scoring time per application.

- One rubric may not work for all PhD programs: Many programs felt that the rubric did not reflect their discipline specifically enough, which discouraged some faculty from using it. The rubric could however serve as a template for each program to personalize to their needs, while still maintaining best practices in holistic review.

- The rubric works at its best as a just-in-time reminder of best practices: A vast majority of survey respondents and focus group participants felt that the rubric should be a part of the application review process, whether simply as a reminder or as a scoring tool, and that it serves its greatest role as reminder of how to conduct their review of an application holistically. This may be especially true of applicants from non-traditional backgrounds. The rubric also indicates where within an application package to find information on different criteria, which aids in the review process.

- Traditional quantitative admissions metrics were unchanged: Some faculty were concerned that holistic review would reduce the quality of admitted applicants. Oftentimes, this quality is based on the poor predictors of graduate school success, particularly the GPA and GRE. These metrics were essentially unchanged from the year prior to rubric implementation to the years after. And according to the survey, a vast majority (93%) believe that the quality of admitted students has not changed or has improved.

- Small gains in demographic diversity were achieved: Some gains in gender and racial/ethnic diversity were observed after the first year of rubric implementation. As stated earlier, there were a number of recruitment and marketing initiatives taking place at the same time as rubric implementation, making it difficult to tease out specific effects of any one component. Additionally, these gains were focused in one or two departments, and not representative of what was going on across all PhD programs. Faculty in departments with gains in diversity felt the rubric was useful for this purpose, but those in other departments felt differently.

Limitations of assessment: As this is a work-in-progress report written to share results quickly, only two years of data is available after rubric implementation, and one of those years overlaps with the COVID-19 pandemic. This makes meaningful comparisons difficult and interpretation of results should be done carefully. Additionally, as the first cohort admitted after implementation of the rubric has only completed one academic year of graduate studies, only the one-year cumulative graduate GPA and first-year retention data are available. No data is available yet for the second cohort.

Much work needs to be done to determine the usefulness of the rubric in identifying applicants most likely to succeed in graduate school. A longer, longitudinal study on student cohorts before and after rubric implementation will be conducted, focusing on factors like retention rates, cumulative GPA, research impact, and time-to-degree. Additionally, continuing to analyze changes in a variety of demographic measures is important. This will be combined with continued educational opportunities and reminders of the importance of holistic review, and the sharing of data demonstrating its effectiveness.

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