

# Gender Can Influence Student Experiences in MD–PhD Training

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## Abstract

**Background:** Female physician-scientists have led major advances in medicine broadly and particularly in women's health. Women remain underrepresented in dual MD–PhD degree programs that train many physician-scientists despite gender parity among medical and biomedical research students.

**Materials and Methods:** To explore how the training environment might be experienced differently for male and female students in one MD–PhD program, the authors analyzed gender differences in annual symposium speakers with exact binomial tests, student participation as question-askers at a weekly seminar with logistic regression, and number of publications with quasi-Poisson generalized linear models. They compared male and female students' perceptions of gender-based discrimination using a survey, including qualitative analysis of free text responses. The program consisted of 71 total students in the 2017–2018 and 2018–2019 academic years. Female students comprised 42.0% (81/191) of program matriculants from 1997 to 2019.

**Results:** Male and female students were equally likely to present at the annual program symposium, but faculty ( $p=0.001$ ) and keynote ( $p=0.012$ ) presenters were more likely to be male. Compared with male counterparts, female students asked fewer seminar questions ( $p<0.005$ ) and female speakers received more questions ( $p=0.03$ ). Female students perceived less support and differed from men in reasons for asking or not asking seminar questions. Free text responses described repeated small acts of discrimination toward women with cumulative impact. Positive program changes followed presentation of findings to program leaders and students.

**Conclusions:** The authors identified several aspects of one MD–PhD program that could discourage career or training persistence of female students. Increasing awareness of these issues was temporally related to positive programmatic changes.

**Keywords:** MD–PhD, gender, equity, program evaluation, graduate

## Introduction

**B**ERNICE SANDLER, AN effective and tenacious champion for Title IX, the Education Amendment of the Civil Rights Act,<sup>1</sup> wrote extensively about the “chilly climate” in the classroom in describing the subtle ways educational environments made women feel unwelcome.<sup>2</sup> Since Title IX was passed in 1972,<sup>1</sup> gender parity has been achieved in many

areas of education, including medical school, where women have comprised almost half of medical students for 20 years.<sup>3</sup> Women also constitute over half of NIH-supported PhDs in a wide range of scientific and engineering disciplines.<sup>4</sup>

Despite these indisputable successes, women remain relatively underrepresented among MD–PhD students, where they account for 37% of matriculants<sup>5–7</sup>—and are significantly less likely than men to complete the dual-degree

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program once enrolled.<sup>8,9</sup> This is of considerable concern to women's health and the intertwined issue of women's leadership in academic medicine.<sup>10</sup> Female physician-scientists are responsible for many clinical, educational, and research innovations aimed at improving the health of women; the accomplishments of recipients of endowed chairs in women's health at academic health centers exemplify these achievements.<sup>11</sup> Physicians holding both MD and PhD degrees are proportionately more likely than those holding an MD alone to become full-time faculty physician-scientists and lead NIH-funded research programs.<sup>5,8,12</sup> Finally, establishing credentials as an NIH-funded physician-scientist is almost universally considered a prerequisite to join the ranks of top leadership in academic medicine, where in 2018 women made up 46% of assistant professors, 37% of associate professors, 25% of full professors, and 15% of department chairs.<sup>3,5-7,13-16</sup>

Evidence abounds that in both medical and biomedical research training, women continue to experience the "chilly climate" described by Sandler decades ago, creating asymmetrical advantages for male and female students.<sup>17-23</sup> Feldon et al. examined data from 53 research institutions and found that for every 100 hours spent on research in biological sciences, male graduate students were 15% more likely than female students to receive journal article authorship credit.<sup>24</sup> Similarly, Pezzoni et al.<sup>25</sup> examined six cohorts of PhD students at one large research institution and found female students published 8.5% fewer articles than their male counterparts when they had a male but not a female advisor.

Gender differences in publications during graduate training may contribute to the lower proportion of women in biomedical sciences who enter elite laboratories following their PhD<sup>26</sup> or receive fellowships<sup>27,28</sup> that favor academic success.<sup>26,27,29</sup> Among medical students, King et al. found that male and female students at one school were equally likely to complete a research thesis but men were significantly more likely to be awarded "highest honors" recognition for this,<sup>30</sup> and Wayne et al. found in the absence of an intervention, small groups of medical students defaulted to selecting a male leader.<sup>31</sup> In a systematic review, Fnais et al. found evidence of harassment and discrimination in medical training in 30/57 studies, with greater prevalence among female trainees in 16 studies.<sup>21</sup>

In the intervening years since Title IX, a large body of research has revealed the cultural tenacity of gender stereotypes in creating expectations that impact the way people behave, interact, evaluate others, and make career choices.<sup>29,32-34</sup> Gender stereotypes serve as a perceptual filter such that women are implicitly seen as less competent and women's accomplishments are rated of lower quality than identical work by men.<sup>35-38</sup> For the individual female student, gender stereotypes form the basis for a number of phenomena that perpetuate a "chilly climate" and contribute to attrition from historically high status, male gender-stereotyped fields such as science<sup>39</sup> and medicine.<sup>40</sup> These include stereotype threat,<sup>41,42</sup> imposter syndrome,<sup>43,44</sup> fear of backlash for violating gender expectations by adopting male gender-typed behaviors, including assuming leadership roles and being a scientist,<sup>45-49</sup> and a lack of belonging due to the implicit incongruity between female gender stereotypes and stereotypes about scientists.<sup>50-53</sup>

Considering the lower rate of matriculation for women in MD-PhD programs and the historically chilly climate for

women in science and medicine, we used our MD-PhD program (University of Wisconsin Medical Scientist Training Program, or UW MSTP) as a case study to explore the experiences of male and female students and to determine how gender-based differences in training might manifest in our program. We wanted to determine whether male and female students were experiencing a different climate, and if so, whether these differences could derive from the implicit assumptions that emanate from gender stereotypes.

We chose to examine gendered differences in question asking in a weekly seminar for several reasons. Being able to formulate and articulate questions is fundamental to becoming a scientist<sup>54</sup> and practicing effective question asking in scientific forums can produce professional benefits for students.<sup>55</sup> Question asking may be a behavioral indicator of climate for women, because gender stereotypes lead women to self-monitor the amount of time they take the floor in group settings due to fear of the documented social backlash they may incur.<sup>56</sup> Furthermore, several studies have reported that women in a number of scientific settings ask fewer questions than men<sup>57-60</sup>—and in a study by Carter et al., which asked about factors that prevented question asking in seminars, women's responses reflected the conflicting expectations of female gender stereotypes and expected question-asking behavior of a scientist. Specifically, women expressed worry they were too soft-spoken, unassertive, and unimportant, and feared judgment from audience members.<sup>58</sup>

Because exposure to female role models has been shown to protect women from some harmful effects of gender stereotypes,<sup>61,62</sup> we collected data on the gender of student and faculty speakers at an annual MSTP-wide symposium. Because of previous reports<sup>24,25</sup> on gender differences in graduate students' publication rates, we assessed the number of total- and first-author publications for students during their period of training from program records for years 1997–2019.

Finally, we surveyed students' perceptions of gender bias in training, reasons for asking or not asking questions in the weekly seminar, and program support (since organizational support has been shown to mitigate the impact of negative working environments).<sup>63</sup> The student leaders of this work (K.M.B. and A.S.H.) presented all results to program leaders and students. We describe ensuing programmatic changes and question-asking behavior and climate survey data in the following year.

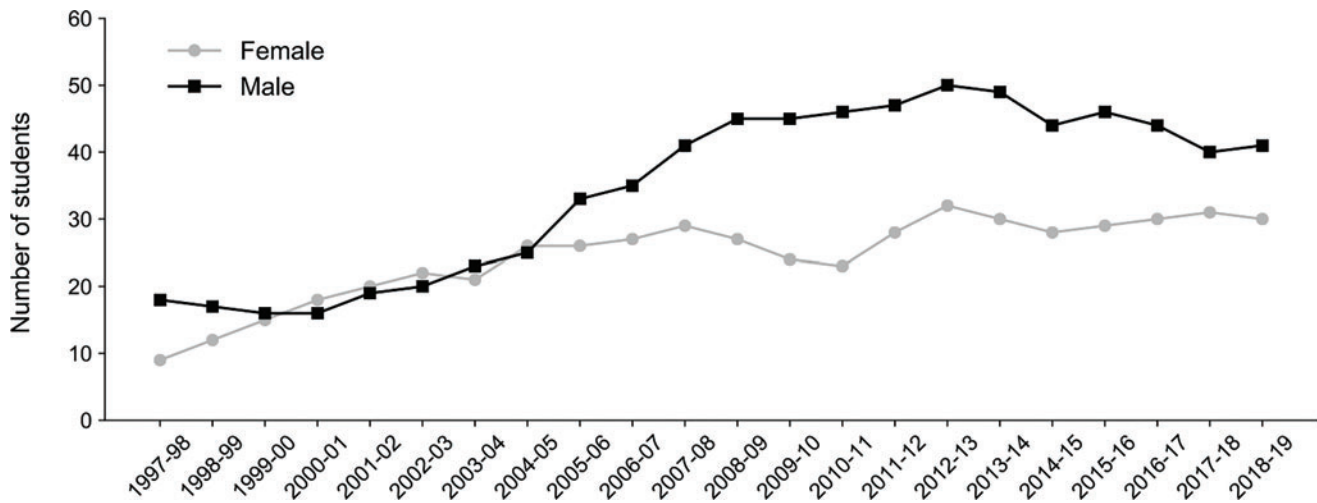
## Materials and Methods

### *Program demographics*

Program size increased steadily from 27 students (18 men and 9 women) in 1997 until 2011 with ranges from 69 to 82 students each subsequent year (Fig. 1). From 1999 to 2005, the program had near equal numbers of male and female students with percentages of women ranging from 48.4% to 52.5%. In 2005, as the program size increased, the number of men began to exceed the number of women. From 2005 to 2019, the percentage of women ranged from 33.3% to 44.1%.

### *Program publication outcomes*

Research staff at the UW SMPH Ebling Library regularly conduct literature searches to keep the MSTP updated on program members' publications. These results were



**FIG. 1.** Program gender demographics vary over time. Yearly program size by gender shows female representation has varied, but has been increasing in recent years. The total number of female students in the program each year is represented by *light-gray circles*; the total number of male students in the program each year is represented by *dark-gray squares*.

narrowed by “Wisconsin” affiliation and PhD advisor’s name to include only publications from MSTP research. First-author and total publications for program graduates from 1997 to 2019 were compared by gender using a quasi-Poisson generalized linear model with gender as a predictor.<sup>64</sup> The research impact per publication from program graduates (1997–2019) was measured using the Field-Weight Citation Impact (FWCI) and male and female FWCI scores were compared using an unpaired *t*-test (after evaluating the data for the appropriateness of this test using equality of variances and normality).<sup>64,65</sup>

#### Invited symposium participation

The UW MSTP hosts an annual symposium where students, faculty, and invited speakers present their research. We collected speaker data from 1997 through 2019. We tested for equal gender representation among student, faculty, and invited keynote speakers using an exact binomial test.<sup>64</sup>

#### Seminar participation

The UW MSTP holds a weekly seminar during the academic year, required for all students in preclinical medical study (1.5 years) and graduate study (3–5 years). Seminars feature either student research talks or faculty presentations on topics such as responsible conduct of research or career development. Audience members are encouraged to pose questions. We counted the number of students in each seminar who asked at least one question<sup>56,59,66</sup> in seminars over two academic years, and recorded the gender (as perceived by the observer) of the question-asker and the gender and rank (*i.e.*, student or faculty) of the speaker. We focused on question-askers rather than the number of questions because we were interested in the number of students participating in seminars. A program administrator (C.H.) recorded attendance.

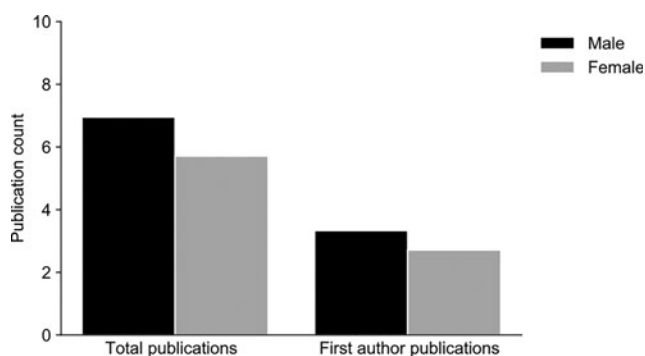
At each seminar one author (A.S.H. or K.M.B.) recorded question asking; authors were excluded from question-asking and attendance counts. We used mixed effects logistic regression to predict probability of question asking,

with attendee gender and speaker gender as covariates. To account for variability between seminars, we included seminar date as a random effect. Anonymization of data necessitated treating students as independent between seminars. The 2017–2018 and 2018–2019 academic years were analyzed separately.

#### Program survey

We developed a survey to query students’ reasons for asking (*e.g.*, “I am interested in the topic”) or not asking (*e.g.*, “I feel as though I do not know the topic well enough”) questions in seminar. Students were instructed to check all that apply from a list of options or to describe other reasons. The survey asked students their perceptions of support in MD and PhD portions of training with a 5-point Likert-type scale, where 1 was “Not at all supported” and 5 “Very well supported”; results were analyzed using an unpaired *t*-test.<sup>67</sup> The survey also asked about the role of gender in perceptions of competence in science and medicine, whether students had experienced discrimination, and whether students had suggestions for program improvement. We distributed the survey (see Complete List of Survey Questions section in Supplementary Data), stated to be optional and for the purpose of program improvement, *via* email. The anonymous survey was distributed twice: first in April 2018 and again in April 2019.

We compared overall averages of survey responses by gender. We analyzed free response text for themes using NVivo software (NVivo 10; QSR International, Inc., Burlington, MA) to facilitate coding, labeling, and organizing meaningful segments of text. Four authors (A.S.H., K.M.B., A.F., and M.C.) analyzed the text line by line to identify and descriptively label content areas. These authors met regularly to revise and refine the labels, group statements with similar content and meaning, and develop the final thematic structure.<sup>68,69</sup> Two authors (A.S.H. and K.M.B.) independently recoded the text using the final consensus themes; inter-rater agreement ranged from 90.4% to 100% with a kappa value of 0.80.



**FIG. 2.** Publication differences by gender are not statistically significant. Student publications from their PhD research differ by gender for total (5.71 for women and 6.95 for men) and first-author (2.71 for women and 3.33 for men) publications. These differences are not significant by quasi-Poisson generalized linear model with gender as a predictor ( $p=0.13$  for total and  $p=0.14$  for first-author publications), unless 4 outliers with more than 20 publications from their PhD work (2 men and 2 women) are removed ( $p=0.037$  for total and  $p=0.031$  for first-author publications).

#### Statistical analyses

All nontext data were analyzed using R (R Core Team 2018, packages lme4 and ggplot2) and Python. R scripts and packages were used to perform exact binomial tests (student, faculty, and keynote symposium speaker analyses) and the quasi-Poisson generalized linear model (publication analysis), as well as to generate Figures 4 and 5 (logistic regression analyses of question-askers in seminars). Python Matplotlib packages were used to generate Figures 1–3 and to perform unpaired  $t$ -tests (FWCI analysis and Likert scale analysis). All data and code used in this project are available in a GitHub repository: <https://github.com/katarinabraun/MSTP-training-environments>

#### Ethics

The University of Wisconsin–Madison Institutional Review Board deemed this study quality improvement, rather than research, and so declined to subject this study to full review.

## Results

### Program publication outcomes

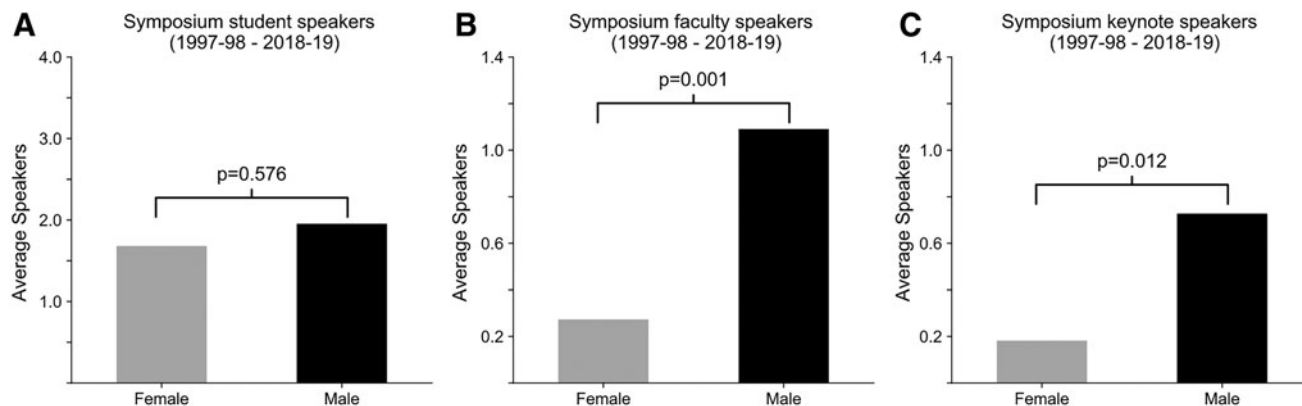
For students completing the program in 1997–2019, differences between the average number of total and first-author publications for women (5.71 total and 2.71 first-author) and men (6.95 total and 3.33 first-author) did not reach statistical significance ( $p=0.13$  for total and  $p=0.14$  for first-author publications; Fig. 2). If we remove 4 outliers with more than 20 articles from their PhD work (2 male and 2 female students), the difference by gender was more pronounced ( $p=0.037$  for total and  $p=0.031$  for first-author publications) with fewer publications for female students. The mean citation impact per publication measured by FWCI score for women (1.53) and men (1.94) was not significantly different ( $p=0.22$ ).

### Invited symposium representation

We analyzed the number of students, faculty, and invited keynote speakers by gender at the annual symposium from 1997 to 2019 (Fig. 3). The number of student speakers per symposium ranged from 0 to 7, with 34 female and 42 male speakers in total. We found no significant difference in the representation of student speakers by gender ( $p=0.576$ , Fig. 3A). The number of faculty speakers per symposium ranged from 0 to 7 per year with significantly more male ( $N=24$ ) than female ( $N=6$ ) speakers ( $p=0.001$ , Fig. 3B). Keynote speakers were also significantly more likely to be male ( $N=16$ ) than female ( $N=4$ ) ( $p=0.012$ , Fig. 3C).

### Seminar participation, 2017–2018 academic year

We recorded the number of question-askers at 15 out of 17 seminar talks. The mean number of attendees at each seminar was 12 (SD = 3.10) female and 18 (SD = 2.98) male students of whom 2 (SD = 1.82) and 6 (SD = 3.12), respectively, asked at least one question per seminar (Supplementary Table S1 and Fig. 4A). Female students were significantly less likely than male students to ask questions ( $p=0.001$ ). In the two seminars where more female students asked questions the speaker was also female.



**FIG. 3.** Invited guest and faculty speakers at the annual symposium are more likely to be male. Equal representation of male and female student, faculty, and keynote speakers at the annual symposium is determined using an exact binomial test. (A) Female and male students are equally likely to be invited to speak at the symposium ( $p=0.576$ ). (B) Faculty speakers are significantly more likely to be male ( $p=0.001$ ). (C) Invited Keynote speakers are also significantly more likely to be male ( $p=0.012$ ).

For both student and faculty seminar speakers, women were significantly more likely to receive questions than men ( $p=0.03$ ). When the speaker was male, 12.5% (SD=10.5%) of female students and 25.1% (SD=5.7%) of male students asked questions, whereas 24.1% (SD=16.9%) of female students and 39.9% (SD=20.5%) of male students asked questions when the speaker was female ( $p=0.03$ , Fig. 4B). See Supplementary Table S1 and S2 for additional information.

#### Program survey, 2017–2018 academic year

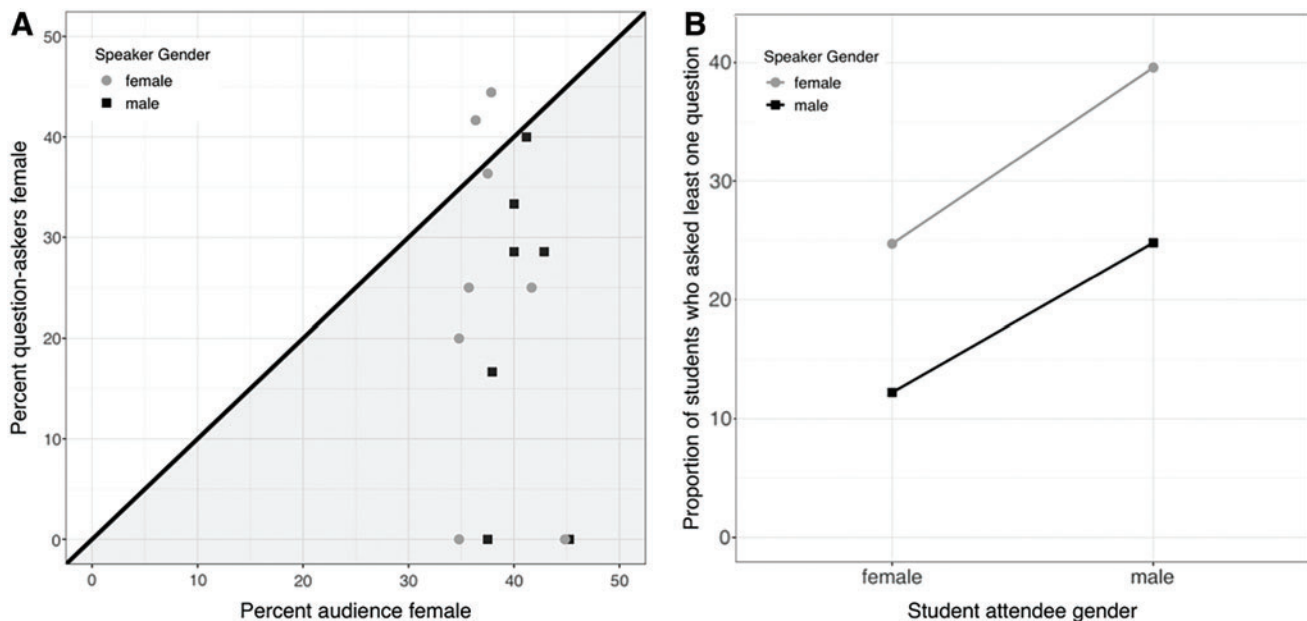
Thirty-five percent (24/69) of students completed the survey: 12 men, 11 women, and 1 gender not given. Eighty-six percent of respondents were White and 14% identified as Black, Asian, Latinx, or other, similar to program makeup overall. Out of 8 possible reasons for not asking questions, more than half of the female respondents ( $\geq 6/11$ ) checked each of the options “I feel as though I do not know the topic well enough” (91.0%), “I feel my questions are stupid questions” (72.7%), “I zone out a bit ... or I am working on other things” (72.7%), “I do not want to be embarrassed” (54.5%), and “I do not have questions I want to ask” (54.5%). The only answer checked by more than half of the male respondents was “I feel as though I do not know the topic well enough” (83.3%).

Out of 7 possible reasons for asking questions, at least half of both men ( $\geq 6/12$ ) and women ( $\geq 6/11$ ) checked “I am interested in the topic” (100% and 81.8%, respectively). No other option was checked by more than 30% of women (Supplementary Table S2). At least a third (4/12) of men also checked “Asking questions keeps me engaged” (41.7%), “I am trying to help the speaker develop his/her research”

(33.3%), and “I want to get practice participating in scientific discussions” (33.3%).

When asked to rate their perceived level of support during training using a 5-point Likert scale, male students felt well supported during the medical (3.92, SD=0.90) and graduate school (4.20, SD=0.79) phases of training ( $p=0.46$ ). In contrast, although female students felt well supported during medical training (3.45, SD=1.04), they felt less well supported during graduate training (2.40, SD=1.34), although this difference did not reach statistical significance ( $p=0.11$ ). This could highlight the transition from medical school to graduate school as a potential target area for increased support. Men and women perceived similar levels of support during medical school ( $p=0.27$ ), but during graduate school women perceived less support compared with men ( $p=0.006$ ). Importantly, among the respondents, 8/11 women and 0/12 men reported experiencing gender-based discrimination during either medical or research training.

Free text responses revealed disparities in men’s and women’s experiences. Qualitative analysis of the free-response text generated 14 subthemes coalescing into 4 major themes: “male-dominated culture” (descriptions of an environment in which men and male stereotypes are dominant and expected), “ton of feathers” (the cumulative impact of many small, regular inequities), “fit the mold” (the expectation that female students should change themselves to fit into the current system), and “taking action” (descriptions of change-oriented intents and behaviors). Table 1 provides illustrative quotes within each theme that emerged from the 2017 to 2018 survey (as well as one additional theme, “awareness and progress,” that emerged from the 2018 to 2019 survey).



**FIG. 4.** Gender predicts question-asking behavior in a weekly MSTP seminar during the 2017–2018 academic year. Data are analyzed using mixed effects logistic regression to predict probability of question asking, with attendee gender and speaker gender as covariates adjusted for seminar date. **(A)** Women are significantly underrepresented as question-askers ( $p<0.005$ ). **(B)** Female speakers are more likely than male speakers to receive questions from both male and female audience members ( $p=0.03$ ). Questions posed to a female speaker are represented as *light-gray circles*; questions posed to a male speaker are represented as *dark-gray squares*. MSTP, Medical Scientist Training Program.

TABLE 1. THEMES, SUBTHEMES, AND ILLUSTRATIVE EXCERPTS DERIVED FROM FREE RESPONSES TO PROGRAM FEEDBACK SURVEY QUESTIONS FOCUSING ON DIFFERENCES IN TRAINING BY GENDER, COMPLETED BY 24 (2017–2018) AND 40 (2018–2019) MEMBERS OF THE UNIVERSITY

<i>Themes and subthemes</i>		<i>Illustrative excerpts representing subthemes</i>
<p>Theme 1: Male-dominated culture (2017–2018, 2018–2019)</p> <p>Failure to recognize women or minorities as equal, capable physician/scientists</p> <p>Explicit disrespect, condescension, or discrimination</p> <p>Suboptimal logistical environment</p> <p>Dearth of female mentors and exemplars</p> <p>Awareness of status in medical school hierarchies</p>	<p>I believe [...] women graduate students might be deemed more incompetent than their male counterparts solely based on their gender by older (particularly older male) advisors. (2017–2018 ♀)</p> <p>[...] I feel that women are not given the credit and clout they deserve, both in science and medicine. (2017–2018 ♂)</p> <p>I frequently observe female residents and students being called nurses (2018–2019 ♂)</p> <p>I've also been disappointed with the lack of balance between male and female speakers during symposium and seminar (2017–2018 ♀)</p> <p>I've always felt like when I enter a room/group as a woman there is the expectation that I have to prove my competency or expertise, whereas my male colleagues are immediately accepted as part of the group and their expertise/competency is assumed [...] (2018–2019 ♀)</p>	
<p>Theme 2: Ton of feathers (2017–2018, 2018–2019)</p> <p>Unsupportive interpersonal environment</p> <p>Varying levels of awareness about bias in science and medicine</p> <p>Sense of futility with regard to <i>status quo</i></p>	<p>Stuff like that in isolation seems small and petty, but it does impact our career trajectories and it certainly impacts that amount of energy we have to put in day in and day out vs. our male peers. (2017–2018 ♀)</p> <p>I haven't witnessed an impact [of gender on perceptions of competence], but I am aware that it exists when listening to other people's experiences. Perhaps I do not pay enough attention. (2018–2019 ♂)</p> <p>Women are absolutely not treated as being as competent as men. There is significant bias, both overt and subconscious against women presenters, and they are more likely to be overlooked for career opportunities and talked over by men. This has improved over the period I have been in the MSTP but it is far from fixed. (2018–2019 ♂)</p>	
<p>Theme 3: Fit the mold (2017–2018, 2018–2019)</p> <p>Implicit bias</p> <p>Gender stereotypes and expectations</p> <p>Deficit model—an expectation to conform to <i>status quo</i></p> <p>Backlash effects and/or fear of reprisal</p>	<p>Women are at a large disadvantage, as they are more likely [than men] to be seen as incompetent. (2017–2018 ♂)</p> <p>Unlike my male colleagues, I have been confused for a nursing student multiple times despite introducing myself as a medical student. (2018–2019 ♀)</p> <p>I don't think the same degree of enthusiasm would be seen as a weakness from a male, but rather as a strength/positive influence on the lab. (2017–2018 ♀)</p> <p>I have observed that if two people have contrasting ideas, the one who shouts loudest is the one that wins. More often than not that is a male voice. (2018–2019 ♂)</p>	
<p>Theme 4: Taking action (2017–2018, 2018–2019)</p> <p>Recommendations for change</p> <p>Acknowledgment of the unfairness of the system</p>	<p>More explicitly demonstrate or talk about our commitment to diversity at recruitment weekends. (2017–2018 ♂)</p> <p>Making sure everyone (not just women) feels supported during the transition to grad school will likely also help, because someone already inclined to leave may be more likely to do so during a difficult transition. (2017–2018 ♀)</p> <p>Continue and/or increase frequency of women's panels. (2018–2019 ♀)</p>	
<p>Theme 5: Awareness and progress (2018–2019)</p> <p>Supportive environment within the MSTP</p> <p>Support noticed in grad school</p> <p>Improvements noticed</p> <p>Individual efforts toward change</p> <p>Imposter syndrome</p>	<p>PhD mentors [compared with med school mentors] have been supportive and more focused on research skills and success than parts of my identity like gender, race or ethnicity, and or sexual orientation. (2018–2019 ♀)</p> <p>The MSTP was and always has been unbelievably supportive and nurturing, willing to do anything they can to help students achieve their goals. (2018–2019 ♂)</p> <p>I think overall people need to be more thoughtful about their question asking and respect other people's time, so I try to only ask questions that I think will be useful for the whole group to hear, not just anything that pops into my head (2018–2019 ♀)</p> <p>I think a lot of what's going on is on the right track. The fact that we have begun to talk about this stuff so openly and make it a focus is huge. It sends the message that even if we don't have solutions, we are at least open to talking about it and validating the feelings of people who feel underrepresented. (2018–2019 ♀)</p> <p>[...] I carry constant feelings of incompetence and imposter syndrome with me. I think I was unaware of this for a long time until it occurred to me that the men around me aren't having the same feelings [...] (2018–2019 ♀)</p>	

♂ indicates men's responses; ♀ indicates women's responses.  
MSTP, Medical Scientist Training Program.

Women's attitudes in 2017–2018 toward gender-based discrimination and the gender *status quo* were often pessimistic, noting their pervasiveness and intractability. Women's suggestions for improvements focused on changing cultural mindsets; taking women's concerns about bias, microaggressions, and discrimination seriously; and offering more support to students who report these experiences. Women's responses revealed personal experiences of discrimination or microaggressions and strongly emphasized the need for change. Men's responses indicated varying levels of awareness. Some indicated belief that gender-based discrimination existed in the past but no longer exists, although others were aware of bias against women and considered it serious. Men's suggestions included having more discussions about social inequities, implementing blinded applications, and creating programs to help women and under-represented minorities in science and medicine.

*Program changes and follow-up, 2018–2019 academic year*

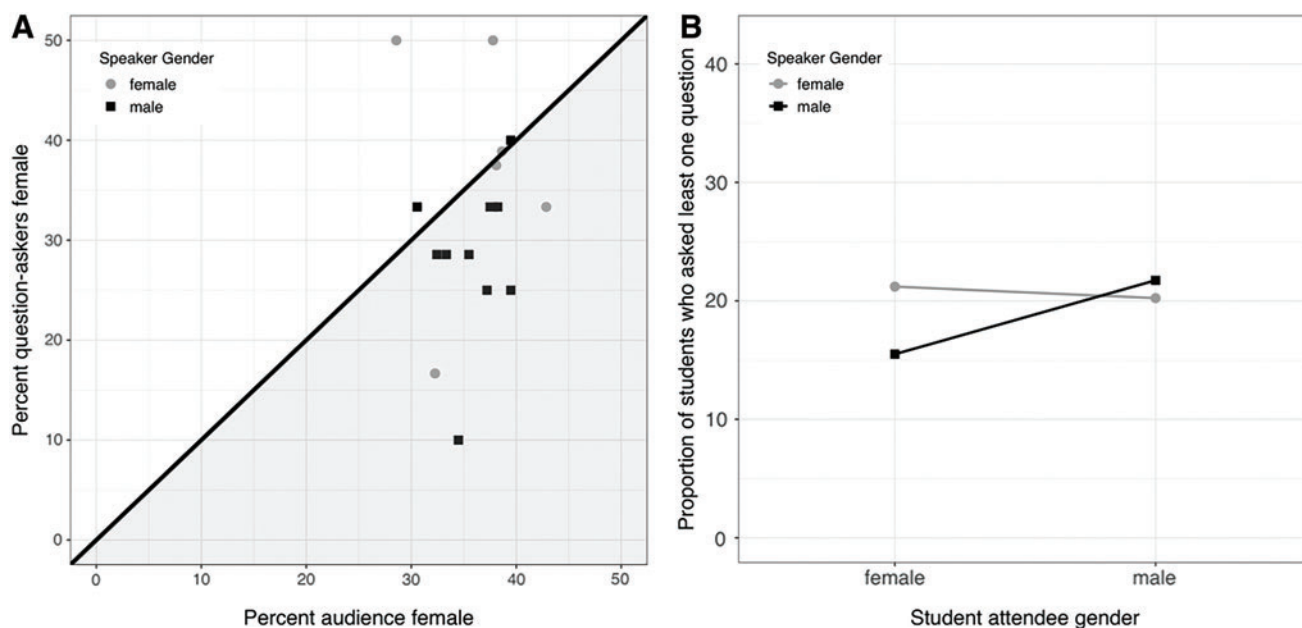
The MD–PhD students leading this study (K.M.B. and A.S.H.) presented the data on program history and gender

differences in question asking, speakers, and perceptions of training climate in several forums to program leaders and students. We did not conduct these presentations as an experimental manipulation with specified outcomes. However, they were temporally related to subsequent efforts to improve the training climate at multiple levels including changes individuals made in their own behaviors, changes in norms or regular program practices, structural changes to better ensure diversity and equity were incorporated as priority issues, and the expansion of this project's influence beyond the UW MSTP (Table 2).

In the year following these various changes (2018–2019 academic year), we continued assessing question asking in seminar (recording the numbers of question-askers in 17 out of 17 seminar talks) and repeated the climate survey. Overall average attendance at seminars increased in 2018–2019 year from 30 to 37 students, with a greater proportional increase in men. The average number of students asking questions each seminar during 2018–2019 (mean = 7.35, SD = 3.53) was comparable to that during 2017–2018 (mean = 8.13, SD = 4.45). The length of seminars did not change between years. We note that as seminars are allotted only a finite

TABLE 2. CHANGES GENERATED BY THE IMPLEMENTATION OF THIS STUDY AND THE PRESENTATION OF RESULTS FROM THIS STUDY TO STUDENTS AND LEADERSHIP OF THE UNIVERSITY OF WISCONSIN MEDICAL SCIENTIST TRAINING PROGRAM AND OTHERS 2018–2019

<i>Level of change</i>	<i>Description of change</i>
Individual	<p>Student authors presented findings at seminar and the program-wide retreat generating productive discussions among students and leadership, airing of reactions and opinions, and brainstorming ideas for multilevel change.</p> <p>One MSTP director hosted a dinner for students and leadership at his home to continue discussion of study findings in a safe and welcoming environment.</p> <p>Previously quiet, peers began sharing with the authors their experiences, perceptions, and ideas for improvement in person and over email.</p> <p>Greater awareness led more junior students to report intentionally asking more questions and observing the gender of question-askers in other forums.</p>
Norms of practice	<p>A written report of the study's findings was distributed to UW MSTP directors, including the individual survey responses (anonymized except for gender).</p> <p>Verbal reminders are now given by student seminar leaders before seminars that "seminar is a supportive, respectful, and collaborative environment providing an excellent opportunity to practice question-asking and leadership skills."</p> <p>Greater intentionality is practiced in incorporating diverse speakers and perspectives into MSTP events, including inviting local experts to present a seminar on implicit bias to the entire program.</p> <p>Students and leadership have met to strategize ways to broaden the diversity and inclusivity of the UW MSTP.</p>
Structural policy	<p>An MSTP Diversity and Outreach Chair position, with the charge of ensuring that issues of diversity and inclusion (gender, race/ethnicity, gender identity, <i>etc.</i>) are integrated into the program, was created on the MSTP Student Executive Board.</p> <p>Student leaders of this study reached out to leaders in diversity and inclusion in the School of Medicine and Public Health to solidify relationships between the MSTP and these leaders and to gain their perspective on the MSTPs changes and progress.</p> <p>Identification of greater difficulty for female students transitioning from medical to research training helped lead to implementation of additional director check-in meetings during the first year of graduate school.</p> <p>Demographics of invited student, faculty, and keynote speakers at the annual symposium are now tracked to ensure better equity.</p>
Beyond our institution	<p>Following a discussion of this project with international researchers, one researcher counted questions and reported those statistics at a meeting he chaired.</p> <p>The student leads on the study presented their findings at the 2019 American Physician Scientist Meeting (and have an abstract accepted for the 2020 meeting) to encourage similar self-studies in other MSTPs.</p>



**FIG. 5.** Gender does not predict question-asking behavior in a weekly MSTP seminar during the 2018–2019 academic year. Data are analyzed using mixed effects logistic regression to predict probability of question asking, with attendee gender and speaker gender as covariates adjusted for seminar date. **(A)** Women and men are equally represented as question-askers ( $p=0.30$ ). **(B)** The likelihood of female and male speakers receiving questions from both female and male audience members does not differ significantly ( $p=0.87$ ). Questions posed to a female speaker are represented as *light-gray circles*; questions posed to a male speaker are represented as *dark-gray squares*.

amount of time, if women’s proportional representation among question-askers increases, it follows that men’s proportional representation as question-askers must decrease. There was no longer a statistically significant difference in the proportions of female and male question-askers ( $p=0.30$ , Fig. 5).

The quantitative data collected in the climate survey remained similar overall (Supplementary Table S3), with some notable interesting changes from 2018 to 2019. In the 2019 survey, both men and women were more likely to report asking questions to practice participating in scientific discussions and less likely to report thinking their questions were stupid. In 2019, only one woman commented about the need for greater self-awareness in question asking (compared with six women in the 2018 survey), whereas two men commented they were trying to be more conscientious about question asking. One woman stated she felt “really supported” in seminar. Five new subthemes emerged in the free-response text, which coalesced into the new major theme “awareness and progress” (Table 1).

## Discussion

The present study found that gender can influence student experiences in MD–PhD training. Compared with men, female students were less likely to ask questions at a program-wide seminar and female speakers were more likely to receive questions. Female students reported less support, described a male-dominated culture during training, and expressed a desire to improve the *status quo*. Male students were variably aware of the negative experiences of their female colleagues. Students and program leaders noted that presentation of these results promoted an open dialog around

the role gender plays in the education and career development of physician-scientists and a number of positive changes with the goal of fostering an inclusive environment for all students. These changes were temporally related to observed changes in question-asking behavior and in the perceived program climate 1 year later.

Even in the absence of explicit prejudice, research confirms that prevailing stereotypes create advantages for men in roles or fields assumed to require stereotypically male traits and behaviors.<sup>33</sup> Scientist is such a role,<sup>39,70</sup> and science is such a field.<sup>71</sup> Stereotypes about scientists overlap with stereotypes about men to a far greater degree than they overlap with stereotypes about women,<sup>39</sup> and both men and women are quicker to pair male-gendered terms (*e.g.*, “he”) with science words (*e.g.*, “physics”) and female-gendered terms (*e.g.*, “she”) with liberal arts words (*e.g.*, “literature”).<sup>71</sup> Gender stereotypes are easily primed with seemingly trivial environmental cues that could include the predominance of men among faculty presenters and keynote speakers in our MSTPs symposium.<sup>53,72,73</sup> The significantly greater number of male than female symposium speakers likely reflects the greater proportion of men in the pool of potential conference speakers, but given the importance of exposing students to female role models,<sup>61,74</sup> current efforts are striving for gender balance among speakers, particularly since our data from weekly seminars indicated that female students may ask more questions of a female speaker.

Once primed, the lack of fit between science and female-gender stereotypes can reduce women’s sense of belonging in science.<sup>53,75</sup> Female students in our study expressed this lack of belonging in the theme of “male-dominated culture” and their sense that they did not “fit the mold.” Because belongingness



is a predictor of career selection and persistence, perceived lack of belongingness could increase women's risk of attrition.<sup>17,53,75</sup> The sense of exhaustion expressed by female students facing daily microaggressions expressed in the "ton of feathers" theme has long been recognized as a deterrent to women's success in science and academic medicine.<sup>29,76</sup>

Our finding that women are less likely than men to ask questions in large and small academic gatherings has been previously documented<sup>57-60,77</sup> at conferences in multiple disciplines. In a recent study from over 200 seminars from 42 departments of 35 institutions in 10 countries, Carter et al. found male attendees were over 2.5 times more likely to ask questions than female attendees.<sup>58</sup> As in our study, previous works have documented fewer women speakers at seminars and conferences.<sup>78-80</sup> Given the retrospective nature of this part of the analysis we were not able to analyze the likelihood by gender of accepting speaking invitations, but other analyses have shown no difference.<sup>80</sup> To our knowledge, we are the first to demonstrate these phenomena in a physician-scientist training setting concurrent with qualitative data on how students perceive gender imbalance in training.<sup>81</sup>

Although the numbers are small, the fact that gender differences in question asking were not observed in the year following programmatic changes is encouraging, as are the qualitative changes noted by students in the 2018–2019 program climate survey. Student comments in the 2018–2019 survey suggested that open discussions helped students reflect on how gender-based and other inequities impact their own and their classmates' training and careers. It is worth noting some changes between the means of the 2018 and 2019 survey responses, such as how both men and women were more likely to report asking questions to practice participating in scientific discussions and less likely to report thinking their questions were stupid. Several men commented that they tried to ask questions conscientiously, and fewer women commented about the need for greater self-awareness in interactions in seminar. Although we can only speculate as to the reasons for these changes, it may be that discussing gender disparities in question asking led students to develop greater introspection into their own participation in question asking in scientific settings.

Students praised the openness of and support from program leadership to address issues raised, called for continued thoughtful progress, and discussed student- and program-initiated changes in the new theme of "awareness and progress." One change, instituted by a female student aiming to foster greater community within the program, may have had an outsized effect on student comfort with question asking. In the 2018–2019 academic year, this student implemented "Roses and Thorns" sessions, in which students met in 5- to 10-person groups before the weekly seminar. These settings offered students' opportunities to share and reflect on recent stressors and challenges ("thorns") and successes ("roses") in a welcoming and nonjudgmental environment before formal seminar programming. Small discussion groups with female peers have been shown to increase women's verbal participation and career aspirations in the male-predominant field of engineering,<sup>82</sup> and although we did not manipulate the gender composition of these groups, the groups may have had impacts similar to those previously observed in the literature.

Gender-based differences in publication rates have been well documented in previous studies.<sup>24,25,93-90</sup> It was en-

couraging to note that differences in first author and total publications for all men and women in our program (including outliers) were not significant and importantly that there was no difference in publication impact as measured by FWCI. Given that even small differences in publication rates may have real implications in terms of career prospects, however, we will continue to track these metrics in future years.

Lack of fit between science and female-gender stereotypes underlies an implicit assumption of lower competence.<sup>91</sup> This assumption was acknowledged in quotes from both female and male students and appeared to contribute to women's reasons for not asking questions (*e.g.*, fear of embarrassment or of asking a "stupid" question). Carter et al.<sup>58</sup> also found women more likely to endorse "internal" factors for not asking questions in scientific seminars (*e.g.*, not feeling clever enough) than men, who endorsed external factors (*e.g.*, not yet advanced enough in training). The implicit assumption of lower competence of women in science, the science setting itself, and the greater visibility of senior male faculty can erode women's confidence and impair actual performance through the well-described phenomenon of stereotype threat.<sup>41,92</sup>

The findings and presentation of this study stimulated the implementation of positive changes in the UW MSTP by program leaders and students (Table 2). We will continue tracking question-asking behaviors, responses to an annual program-wide survey, and symposium speaker gender ratios. The current work focused on gender and responses came from predominantly White students, but the discussions and subsequent interventions have been an important part of broadening dialogs on diversity and inclusion within this MSTP program, including race/ethnicity, disabilities, religion, sexual orientation, gender identity, and the intersectionality of these.

This study has several limitations. It involves a single MSTP, limiting generalizability. The 2017–2018 survey response rate was low at 35% (24/69), although the 2018–2019 response rate increased to 58% (40/69). While this may limit generalizability to all students in the program, the responses are still relevant given the goal of having a program in which all students feel welcomed and supported. Our study is observational, and we cannot rule out that the temporal correlation between presentation of the findings from our study to program leaders and students and some multilevel positive changes occurred serendipitously, although students and leaders reported intentional changes based upon this project's findings. In this study, we did not track the type of questions asked and received by gender (*e.g.*, questions challenging a speaker or questions showing interest in the topic). Future studies delving into these areas may provide greater insight. Additionally, our program may not be representative of all MD–PhD programs nationally. With 43.7% female students (31/71, 2017–2018), our program is more gender balanced than the national MD–PhD program average (39% female).<sup>6,9</sup> Fifty percent (2/4) of our MSTP directors are women, compared with 42% of MSTP directors nationally, with 11 out of 50 programs having no female leadership.<sup>13</sup>

If the U.S. is to reap the benefits of a diverse scientific workforce and invest in advancing the best and most innovative science,<sup>93,94</sup> there is urgent need for system-wide assessment of MD–PhD training programs. Increasing the

number of women physician-scientists contributing to academic medicine will help ensure the continued advancement of women's health and the vigor of biomedical research. Decreasing women's attrition from MD-PhD training programs is a critical step in reducing an early leak in the physician-scientist career pipeline. Achieving this goal will require innovative strategies to foster medical and scientific training environments more welcoming and inclusive to all.

### Conclusions

Examination of student experiences in our MSTP revealed gendered differences in training, with students exposed to fewer female role models as prestigious invited speakers, female students participating less in question asking at program-wide seminars, and students describing the persistence of a male-dominated "chilly climate" for women in medicine and science. Presentation of these findings to program leadership and students fostered discussions of disparities in academic medicine and multilevel programmatic changes and was temporally related to reductions in differences between men and women's question-asking behaviors and student-described positive changes on a program-wide climate survey. Innovative systemic initiatives will be required to resolve persistent gender inequities at all career stages in academic medicine.

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### Ethics Approval

The University of Wisconsin–Madison Institutional Review Board declined to review this study as it was a quality improvement, rather than research, study.

### Author Disclosure Statement

No competing financial interests exist.

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### Supplementary Material

Supplementary Data S1  
Supplementary Table S1  
Supplementary Table S2  
Supplementary Table S3

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