

Understanding the Challenges and Needs of International STEM Graduate Students: Implications for Writing Center Writing Groups

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Abstract: We report outcomes from a multi-year study of writing center-sponsored writing groups at a land-grant university in the American Midwest to advocate for the unique needs of international STEM graduate students. Survey participants self-reported writing confidence, academic knowledge, amenability to peer feedback and collaboration, and other characteristics. Scores were low for international students, lower for STEM students, and lowest among international STEM students. International STEM graduate students also reported the highest degrees of improvement between pre- and post-participation surveys. We argue that writing centers and academic departments need to develop support services tailored to the unique needs of this population.

Introduction

WAC/WID and Writing Center scholarship demonstrate a shared commitment to considering the needs of STEM writers (Condon & Rutz, 2012; Gere, Knutson, & McCarty, 2018; Harris, 1992; Russell, 2002; Walker, 2013). Recently, several scholars have investigated the unique needs of graduate STEM writers (Berdanier & Zerbe, 2018; Simpson et al., 2015; Smith et al., 2017), but there remains more to learn about this large and diverse population.

Roughly one third of the ~40,000 annually awarded STEM graduate degrees are earned by international students (National Science Foundation, 2020). This population, Simpson (2019) explained, may experience “issues of authority” with their advisors due to cultural and linguistic differences (p. 73), and thus may lean on writing centers “to augment the relationship between advisors and advisees” (p. 74). Furthermore, international STEM students may struggle to accommodate to—or be accommodated by—American academic culture (de Araujo, 2011), writing expectations (Simpson, 2019), and the culture of STEM education more broadly (National Research Council, 2009; Perez et al., 2014), or may lack adequate mentorship and writing support in their home departments (Rogers & Zawacki, 2016). Writing groups are one extracurricular intervention (Aitchison, 2009; Cuthbert, Spark, & Burke, 2009; Gere, 1987; Moss, Highberg, & Nicolas, 2003; Phillips, 2012) with the potential to successfully support international STEM graduate students with these and other kinds of professional challenges.

Writing groups, which in the U.S. are often provided by writing centers, are frequently promoted as a way for graduate students and advanced undergraduate students to become more productive writers (Aitchison, 2009; Gere, 1987; Phillips, 2012). While some of the foundational studies of writing groups qualitatively detail participants’ satisfaction and experience with writing groups (Cuthbert et al., 2009; Gere & Abbott,

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1985; Moss, Highberg, & Nicolas, 2003), and others detail cases in which participants navigate emotional and gendered tensions (Wolfe & Alexander, 2005), little empirical research has been conducted on understanding the reasons that motivate graduate students to register for writing groups. Many factors make it challenging to empirically study writing group participants: attrition, low engagement, and group retention issues all contribute to the low completion rate for writing groups, especially those that are non-compulsory and not-for-credit (Bourgeois & Giaimo, 2019). Furthermore, while research on international or transnational writing groups—groups of scholars and students engaged in writing abroad or across countries—is plentiful (Healey et al., 2013; Kumar & Aitchison, 2018; Marquis et al., 2014), there are few studies that focus on international students and their motivations to register for writing groups in a U.S. academic context.

The composition and structure of writing groups can vary widely based on institutional contexts such as student and tutor populations, administrative structures, and available resources. At the writing center that is the focus of this study, writing groups include people from multiple kinds of disciplinary, educational, and sociocultural backgrounds who occupy different positions in the university (i.e., undergraduate, graduate, staff, post-doctoral researchers, and faculty). Graduate students comprise the majority of the writing group population. Writing groups often bring together mixed populations of international and domestic students. The self-reported data of the graduate students who enrolled in writing groups indicate that these populations want different things out of their groups and feel differently about their writing and academic knowledge and confidence.

To contribute to the WAC/WID and Writing Center scholarship on supporting the unique needs of international graduate students in STEM, we will report outcomes from an IRB-approved, multi-year study of non-compulsory, non-credit, semester-long, multidisciplinary writing groups facilitated by graduate writing tutors at a land-grant institution in the American Midwest. Our study found that many elements that are related to successful outcomes among graduate students, such as writing confidence, academic knowledge, amenability to peer-to-peer engagement and collaboration, as well as adaptive metacognitive skills and habits related to writing and academic work, are low for international graduate students in our study, lower for STEM students, specifically, and, critical to this project, lowest among international STEM students. From our findings, we have developed several interventions that may bolster the success of STEM and international STEM students—among other groups—in engaging in positive, productive, and adaptive processes related to academic writing and research.

Method

To address several gaps in the research about why graduate students engage with and persist (or fail to persist) in voluntary writing groups, and whether different populations seek or require different forms of support, we conducted a 3-year study at a large, R1-classified land-grant university located in the U.S. Midwest to track the habits, attitudes, and confidences of people who sign up for, but who might not complete, writing groups. The study period ran from the fall of 2017 through the summer of 2019. The university's writing center provides non-compulsory, non-credit, semester-long writing groups for mixed populations of undergraduate and graduate students, post-docs, faculty, and staff. Roughly 50% of group registrants are international students (which is ~ 38% higher than the general international student population at the university). During the study period, writing group non-engagement/withdrawal rates among registrants ranged from 20%-50%. Our mixed methods analysis of survey responses (Appendix A) was guided by the following research questions:

1. What motivates graduate students to voluntarily enroll and participate in a multidisciplinary writing group?

2. What disciplinary or demographic differences, if any, are there in graduate students' writing habits, writing skill confidence, academic knowledge confidence, and amenability to engaging in collaborative writing processes?
3. To what extent does voluntary participation in a multidisciplinary writing group change graduate students' writing habits, writing skill confidence, academic knowledge confidence, and amenability to engaging in collaborative writing processes?

Participants

Study participants included all writing group populations (undergraduate students, graduate students, post-docs, and a few faculty and staff members) from across the disciplines. The majority of respondents (~75%) were graduate students. Participants were surveyed before attending and after completing a semester-long, voluntary writing group (Table 1). Of the 142 graduate students who completed the pre-survey, 56 were from STEM fields, including 21 international students and 35 domestic students. The response rate to the pre-survey was roughly 60% of all registered writing group participants while the response rate to the post-survey (considering an average attrition rate of 20%-25%) was roughly 32% among eligible participants.

Table 1: Study Participants

Pre-Survey Respondents (N = 142)			
Discipline	International students	Domestic students	Total
Humanities (HUM)	8	24	32 HUM
Social Sciences (SOC)	18	36	54 SOC
STEM	21	35	56 STEM
	<i>47 total INTL</i>	<i>95 total DOM</i>	<i>142 total grad students</i>
Post-Survey Respondents (N = 66)			
Discipline	International students	Domestic students	Total
Humanities (HUM)	1	18	19 HUM
Social Sciences (SOC)	12	16	28 SOC
STEM	8	11	19 STEM
	<i>21 total INTL</i>	<i>45 total DOM</i>	<i>66 total grad students</i>

Materials

A mixed-method survey containing 5-point Likert scale items (i.e., a score of 1 indicating “strongly disagree” and a score of 5 indicating “strongly agree”), check-all-that-apply, and open-ended response questions regarding writing habits, writing skill confidence, academic knowledge confidence, and amenability to engaging in collaborative writing processes was administered prior to the start of semester-long writing groups and following each group's conclusion.

Design and Procedure

Researchers distributed two surveys to writing group registrants: a pre-survey (Appendix A) at the beginning of the semester—prior to participating in writing groups—and a post-survey at the end of the semester. The post-survey repeated the pre-survey questions and also invited feedback on the writing group facilitators and meeting locations. All survey responses were reviewed for completion as well as consistency in scoring (i.e., ensuring that no one was marking “1” when they really meant “5”). For this article, only graduate student survey responses were included in the final analysis. The total number of pre-surveys completed by graduate students was 142, and the total number of completed post-surveys was 66. We independently coded the survey questions to group them into composite scores (i.e., academic knowledge, writing confidence, writing comfort-wellness, feedback, and collaboration). Likert scale questions were re-coded such that a score of 5 always indicated “strongly agree.” Means were then calculated for each of the normalized composite scores. Question 25 (Appendix A) was excluded from the analysis because it did not fit within the established composite score categories.

Pre-survey respondents could select up to 11 different motivators (including an “Other” category that was only used twice for productivity-related needs) for joining a writing group (Appendix A). These individual motivators were sorted into three categories of motivation: productivity, learning, and collaboration (Table 2).

During quantitative data analysis, two-factor ANOVAs (Type-III) (Appendix B) were conducted in RStudio to examine the effects of demographic (international vs. domestic) and discipline (i.e., STEM fields [STEM], humanities [HUM], social sciences [SOC]) on each of the five following composite scores: academic knowledge, writing confidence, writing comfort-wellness, feedback, and collaboration.

Tukey’s test for post-hoc analysis (Appendix B) was performed each time the variable of discipline produced a significant effect in order to identify which groups had significant differences. Residual analyses were performed to test for the assumptions of the ANOVAs. Normality was assessed using Shapiro-Wilk’s normality test, and homogeneity of variances was assessed by Levene’s test. Additional one-factor ANOVAs were run to compare international and domestic STEM students’ scores (Tables 5 and 6).

Study Limitations

The pre- and post-surveys were not linked by respondent. Therefore, post-surveys included in this analysis could only be submitted by participants who did not drop out of their writing group, but respondents may not necessarily have answered the pre-survey when it was administered. The pre-survey results include both those who completed the writing group and those who dropped out. These findings, then, are mostly useful for learning about *why* people register for writing groups in the first place, as they reveal the habits, attitudes, and preferences of a more general baseline population of writers and their demands for different kinds of writing support. Of course, pre-survey results do not fully identify what leads people to persist in writing groups. Although one might argue that pre-survey intentions matter quite a bit to persistence, they are, of course, only a piece of the puzzle that is persistence and attrition. Post-survey findings can show us general trends about those students who persist in writing groups and we can use this cohort as a comparison point against the larger pre-survey respondent group. While individual-level effects cannot be measured, some general changes in group levels can be measured from the pre-to-post surveys. This study is therefore limited in the scope of its post-survey findings and mostly focuses on the pre-survey results, though some positive (though non-significant) change did seem to occur for the international STEM population that persisted in writing groups.

Results

In the pre-survey data, graduate students' reported motivations for joining writing groups differed widely according to their demographic and discipline, with international students ranking learning as a stronger motivator than either productivity or collaboration, while domestic students ranked productivity far higher than learning or collaboration. Most writers across the disciplines do not report joining writing groups to collaborate.

Our descriptive and analytic statistics show that STEM writers reported much lower initial writing confidence and knowledge scores than their humanities and social sciences peers. STEM students also realized the largest increases in these same measures upon completing their engagement with a semester-long writing group.

Finally, most respondents responded negatively to questions about their writing comfort-wellness, with most groups indicating neutral to ambivalent attitudes toward consistent and adaptive engagement with writing processes and the acts associated with academic writing (e.g., feedback integration, revision, drafting, time management, managing stress, etc.). In the sections that follow, we present specific data in alignment with our research foci on graduate students' motivations for joining writing groups and the extent to which discipline and demographic factors affected students' self-reported scores in writing habits, writing skill confidence, academic knowledge confidence, and willingness to collaborate.

I. What Motivates Graduate Students to Join Writing Groups?

International students who registered for writing groups tended to select learning-related motivators at a higher rate than their domestic counterparts (Table 2). Domestic students, on the other hand, most often selected productivity-related motivators. Most groups, with the exception of international social science students, selected very few collaboration-related motivators. Across all respondents, productivity was the most often selected motivational category. Roughly half the number of participants selected learning motivators, and the least-selected motivational category was collaboration. The least popular individual motivator was learning about a specific type or genre of writing, which only 10 participants selected.

Table 2: Frequency of the 10 Individual Motivator Options Selected by Study Participants

Productivity	INT STEM	DOM STEM	INT SOC	DOM SOC	INT HUM	DOM HUM	All
To help set regular writing goals	11	29	11	31	6	20	108
To set aside dedicated time/space in which to write	9	29	12	32	5	22	109
To provide me with accountability	8	30	12	31	4	21	106
Learning	INT STEM	DOM STEM	INT SOC	DOM SOC	INT HUM	DOM HUM	All
To improve my writing process	13	24	13	13	6	11	80
To learn strategies for revision	9	12	10	10	3	5	49
To learn more about a specific type or genre of writing	2	3	3	2	0	0	10

To improve my English language fluency	13	0	12	1	3	0	29
Collaboration	INT STEM	DOM STEM	INT SOC	DOM SOC	INT HUM	DOM HUM	All
To receive feedback from someone outside of my department	3	8	9	6	2	5	33
To get feedback from my peers	4	7	6	5	1	2	25
To join a community of writers/peers	7	8	10	10	3	17	55

II. Disciplinary Effects Within Study Sample

When comparing the results of different disciplinary groupings, (STEM, HUM, SOC), we found several significant differences (Table 3). Respondents from humanities disciplines reported strong confidence in their academic knowledge and writing skills, amenability to giving and receiving feedback and collaborating with others, and they reported higher (though still largely neutral) comfort with the writing process as compared to students from the other disciplines. Humanities graduate students, for the most part, reported significantly more positive responses to survey questions overall (Table 3). STEM graduate students' responses to questions about their academic knowledge, writing confidence, amenability to feedback and collaboration, and writing comfort-wellness were all consistently lower than the scores of any other group. Interestingly, all graduate students' responses to questions regarding group collaboration were largely neutral and non-significant.

Table 3: Means, Standard Deviations, and One-Way Analyses of Variance in Five Pre-Survey Measures by Discipline

Items	STEM		SOC		HUM		<i>F</i> (2,139)	η^2	<i>p</i>
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>			
Academic Knowledge	3.65	0.71	3.85	0.65	4.24	0.56	8.33***	0.11	< 0.001
Writing Confidence	3.44	0.60	3.53	0.71	3.85	0.47	4.64*	0.06	0.011
Feedback	3.29	1.09	3.85	0.96	3.85	1.02	5.10**	0.07	0.007
Writing Comfort-Wellness	2.64	0.65	2.77	0.53	3.01	0.72	3.58*	0.05	0.031
Group Collaboration	3.39	0.60	3.47	0.58	3.54	0.47	0.67	0.01	0.511

*** $p < .001$, ** $p < .01$, * $p < .05$

III. Demographic Effects Within Study Sample

Yet another set of significant results came from analyzing differences in attitudes, confidence levels, and amenability to feedback and collaboration between international and domestic students. International

students' scores were significantly lower than domestic students' in several categories of response (Table 4). Here, we find that international students report lower academic knowledge, writing confidence, writing comfort-wellness, and amenability to feedback than domestic students. Both domestic and international students reported low overall comfort with writing practices. International students were somewhat more positively inclined toward collaboration than their domestic peers, though not significantly so.

Table 4: Means, Standard Deviations, and One-Way Analyses of Variance in Five Pre-Survey Measures by Demographic

Items	DOM		INT		<i>F</i> (1,139)	η^2	<i>p</i>
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>			
Academic Knowledge	4.10	0.56	3.47	0.47	42.90***	0.24	1.04E-09
Feedback	3.90	0.92	3.15	1.01	19.67***	0.12	1.86E-05
Writing Confidence	3.69	0.66	3.32	0.52	11.25**	0.07	0.001
Writing Comfort-Wellness	2.81	0.65	2.69	0.61	1.10	0.01	0.297
Group Collaboration	3.49	0.59	3.89	0.49	1.09	0.008	0.299
*** <i>p</i> < .001, ** <i>p</i> < .01, * <i>p</i> < .05							

IV. Effects of Demographic on STEM Graduate Students' Academic Knowledge Scores

Taken together (Tables 3 and 4), these broad-view approaches to the dataset indicate that there are statistically significant differences between the self-reported competencies, confidence levels, and attitudes across academic disciplines and across the domestic-international divide. For example, humanities students tend to be more confident in just about every measure, such as academic knowledge, writing confidence, feedback, and writing comfort-wellness. There is a significant difference between these groups, with STEM students reporting the lowest scores in these categories. Social science students tended to fluctuate somewhat between the two other groups. Sometimes, they aligned more with STEM, sometimes they aligned more with humanities; on several occasions they were right in between these two groups.

Because of our findings that show that STEM students and international students reported lower overall scores in every measured category compared with their peers, we determined that we needed to consider not only disciplinary differences when examining STEM student participation in writing groups, but also broad demographic (international vs. domestic) differences. In other words, the differences among student populations are not only driven by discipline but can also be compounded with or exacerbated by demographic factors. Our analysis of domestic and international STEM students (Table 5) found that there is a strong difference in the levels of reported academic knowledge between these two groups. Domestic STEM students are significantly more confident in this category than international STEM students. Both groups reported similarly low writing comfort-wellness scores, suggesting that STEM students in general do not feel comfortable with their writing practices. Both domestic and international STEM students also reported similar ambivalence toward feedback, collaboration, and writing confidence generally. However,

international students reported somewhat lower writing confidence scores but slightly higher amenability to both feedback and collaboration.

Table 5: Pre-Survey Scores for International and Domestic STEM students, with F and η^2 values

Items	DOM		INT		F (1,139)	η^2	p
	M	SD	M	SD			
Writing Confidence	3.52	0.65	3.31	0.50	1.60	0.029	0.211
Writing Comfort-Wellness	2.63	0.63	2.66	0.71	0.02	< 0.001	0.881
Academic Knowledge	3.91	0.47	3.40	0.43	16.14***	0.233	< 0.001
Feedback	2.95	0.68	3.03	0.46	0.23	0.004	0.634
Collaboration	3.37	0.63	3.44	0.56	0.19	0.004	0.662

*** p < .001, ** p < .01, * p < .05

V. Graduate Students' Development Through Persistent Engagement With Writing Groups

Because response rates to the post-survey were far lower than the pre-survey, and because surveys were not linked by participants, it is not possible to offer a true comparison between these two groups of respondents. However, it is striking to us that, of the three disciplines, STEM students dropped out of writing groups and the research study in considerably higher proportions (~66%) than their humanities (41%) and social science (48%) counterparts. Despite this precipitous drop in STEM students' completion of the post-survey, what we can say is that of those STEM students who remained, international STEM students who responded to the post-survey reported scores in academic knowledge, writing confidence, and collaboration, that generally aligned with those reported by their domestic STEM student counterparts (Table 6, Figure 1). While the changes in pre- to post-survey scores were not significant, we believe it may indicate some alignment between cohorts in reported outcomes related to academic knowledge, writing confidence, and collaboration among international STEM populations who persist in their writing groups. Of course, more research that traces these two cohorts over time is warranted to shore up this preliminary conclusion that writing groups can help international STEM students to develop their academic and writing competencies enough to be in line with their non-international STEM peers.

Table 6: Post-Survey Scores for International and Domestic STEM students, with F and η^2 values.

Items	DOM STEM		INT STEM		F (1,139)	η^2	p
	M	SD	M	SD			
Writing Confidence	4.02	0.33	3.85	0.46	0.80	0.045	0.384

Writing Comfort-Wellness	3.58	0.35	3.77	0.24	1.76	0.094	0.202
Academic Knowledge	2.55	0.81	2.48	0.67	0.03	0.002	0.859
Feedback	3.85	0.94	3.17	0.76	2.87	0.145	0.108
Collaboration	3.63	1.01	3.86	0.42	0.30	0.020	0.592
*** p < .001, ** p < .01, * p < .05							

Table 6 shows that, of the 19 STEM graduate students who completed the post-survey, the domestic students ($N = 11$) continued to report higher scores than their international peers in academic knowledge, writing comfort-wellness, and in amenability to feedback. The international STEM respondents to the post-survey reported higher collaboration and writing confidence scores.

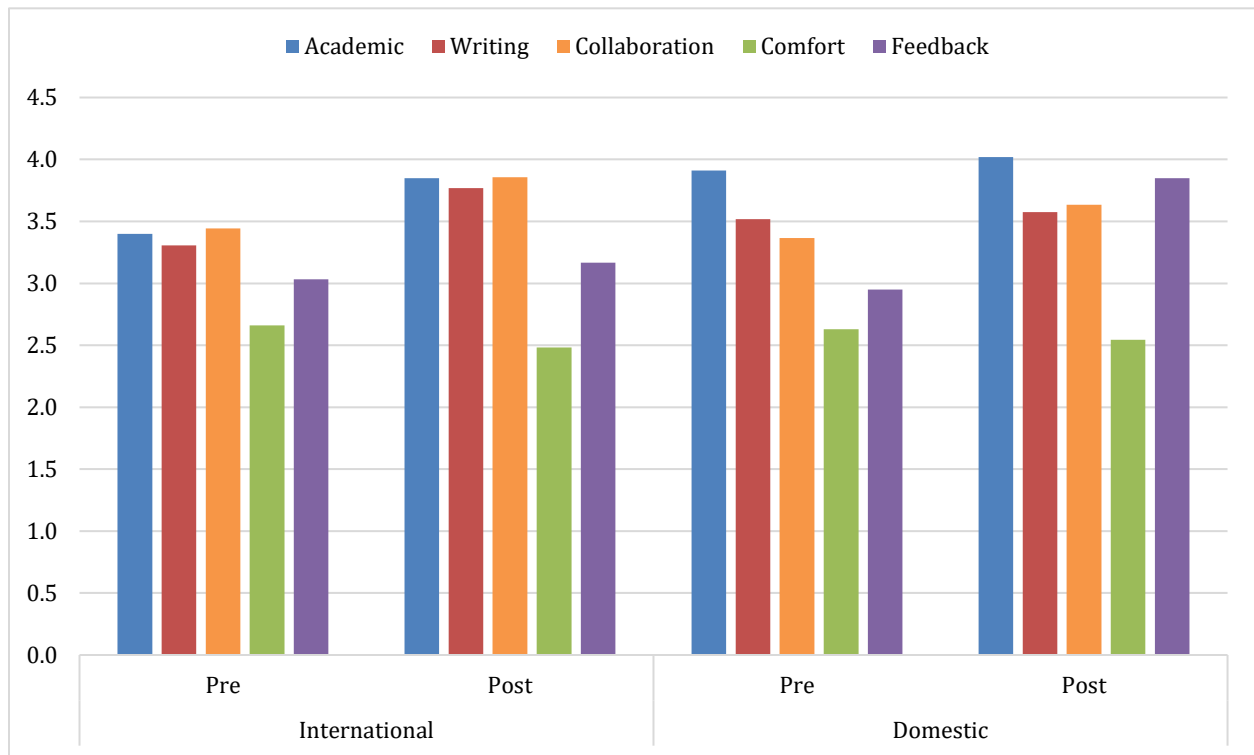


Figure 1: Pre- and post-survey mean scores of international and domestic STEM graduate students

Discussion

Our findings suggest that there are stark differences between what different graduate students want out of writing groups. While some, like humanities students or domestic students, seem fairly confident in their writing and academic abilities and sign up for writing groups to increase their productivity, other groups, like STEM students broadly and international STEM students specifically, report low writing confidence and academic knowledge scores and enroll in order to learn more about writing strategies and norms. However, there seems to be a disconnect between students’ desires to learn about and produce writing in the context of writing groups and their general low regard or ambivalence toward sharing feedback and other collaboration. We suggest that further research into what kinds of collaboration graduate students

want, with whom, and for what purposes may address this gap and inform the kinds of writing groups or other supports provided for these students. Further research into what kinds of supports effectively increase international STEM writers' confidence in these areas is also warranted.

Our data accord with and perhaps provide more nuance to Rogers & Zawacki's (2016) study comparing the assumptions and expectations of graduate students and advisors regarding dissertation writing. Their study found that faculty advisors tend to focus on the "so what" or the "why" of dissertation writing, whereas graduate students desired more explicit instruction and support for the "how" of writing. They conclude that graduate students "do not arrive in the doctoral program with all the dispositions, writing knowledge (sociocultural, sociolinguistic), skills, and experience required" (p. 74) and that "issues around explicitness, mentoring, and appropriate tutorial and peer support [are] even more critical" for international and second-language writers (p. 75). At first glance, our data confirm Rogers & Zawacki's conclusion that graduate students indeed do not arrive already possessing mastery of academic writing conventions and habits. However, our results also highlight the important influence of discipline on students' self-reported writing and academic skills and confidence, which suggests that successful interventions will need to consider both demographic and discipline as factors. Our study found that graduate students in STEM fields reported the lowest overall scores, especially with regard to general academic knowledge and writing confidence. This apparent uneasiness was magnified for international graduate students in STEM fields.

Looking again at motivational factors, it could be that international STEM students' low scores and selection of "learning" motivators are due to an awareness of their needs and a desire for the kind of explicit instruction Rogers & Zawacki (2016) describe. However, only 10 students in our study (5 STEM and 5 social sciences students) indicated a desire to learn more about genre features, which suggests that students either receive adequate genre instruction, may not understand what genre is, or are so focused on broader concerns with the writing process that they don't find genre knowledge sufficiently compelling or relevant. Further research that focuses on specific aspects of the writing process or genre, such as Rogers & Zawacki's attention to whether students feel comfortable "using the right tone" or "adapting my writing to the expectations of my audiences" (p. 57) may help to identify to what degree students recognize, care about, or feel confident in their use of genre or other rhetorical features. Another possibility is that certain populations of graduate students possess different degrees of familiarity with American academic expectations around productivity and the "publish or perish" imperative. These data suggest that writers of different disciplinary backgrounds may need different kinds of writing support, both from writing centers and beyond.

One area where students may benefit from more explicit support and instruction is in the formation of consistent and sustainable writing practices. In our study, all students—regardless of discipline or demographic background—reportedly struggle with maintaining a regular writing practice and managing writing-related distress. However, with the exception of international STEM students, they expressed little overall interest in learning about the metacognitive elements of writing and academic knowledge production. These data, then, suggest that there are some fairly large gaps in the academic preparation and development of graduate students across most disciplines, especially in STEM disciplines and particularly among international STEM students. These data suggest to us that we shouldn't lump domestic and international STEM students (or any students of these groups) together with an assumption that they will behave the same or need the same things, as our findings indicate that they seek different kinds of writing support, want different kinds of engagement and interaction, and ultimately, likely need different kinds of writing and academic support to be successful.

Nevertheless, writing appears to be a highly stressful and painful practice for many different kinds of graduate student populations, even the ones (like humanities students) who report fairly high writing skill competencies and confidence. This suggests that while graduate students are more advanced than their undergraduate counterparts, more work still may need to be done to teach and encourage positive writing practices among this population.

It is possible that the low writing comfort-wellness scores surrounding writing practices might also contribute to fairly large attrition rates in our writing groups. While attrition ranged from 20%-50%, STEM students dropped out of writing groups and the research study at considerably higher proportions (~66%) than their humanities (41%) and social science (48%) counterparts. It is possible that this attrition occurred because of the far lower scores that STEM students reported in their writing and academic knowledge scores in the pre-survey. Or perhaps it can be attributed, in part, to their reported pre-survey scores in writing comfort-wellness and group collaboration, which may have made them less likely to stick with a regular writing practice that is also collaborative and group oriented in nature. Or the high attrition levels could be explained by the disciplinary differences between how peers and faculty members value writing skills development and help-seeking behaviors, such as joining writing groups.

Of course, by virtue of these students registering for writing groups, we may likely be seeing a response bias towards less confident, less productive, and less balanced writers and para-academics. That being said, even the most confident writers among the respondents (domestic HUM) also reported low writing comfort-wellness scores. Our attrition rates in our writing groups also confirm this finding: with attrition rates of 20%-50%, we would expect that a large proportion of group registrants—many of whom also report poor writing habits and practices—would struggle or be unable to complete the writing group. Therefore, students may find themselves in a negative feedback loop in which those who struggle the most to maintain a healthy and regular writing practice also struggle to commit to writing groups. Shorter events that are oriented towards productivity, such as a writing “boot camp” (Smith et al., 2017) might help to ameliorate such issues among graduate student writers, as would additional curricula and departmental support to foster positive long-term writing habits.

Conclusion

Our findings indicate that “WAC/WID [and writing centers need] to be more responsive to the needs of a fuller range of STEM learners” (Beaver, Hendrickson, & Nicholes, 2020). And while our findings indicate that we can change how we support STEM graduate students explicitly, we also acknowledge that there may be a lot of work to do outside of a writing center context to support, mentor, and ultimately educate graduate students across the disciplines on healthy, common, and sustainable writing practices in academia, such as planning, sharing feedback, and revision tasks. STEM students—particularly international STEM students—appear to need (and in the case of international STEM students, *want*) more instructional support in writing and academic knowledge development, while humanities and social science students appear not to want to learn much about writing. Humanities and social sciences disciplines likely include more curricula-specific writing instruction and emphasis on writing support, which may explain why graduate students in these disciplines report a low need or interest in receiving writing instruction and support from a writing center sponsored writing group context. This is an area where further research may be illuminating.

No group seems motivated to join writing groups for opportunities to collaborate. This is a concerning finding for several reasons related to the importance of different types of collaboration—such as publishing collaboration in the STEM and quantitative social sciences—across the disciplines. Collaboration within and across disciplines and institutions is necessary to solve the world’s most complex problems; however, several studies have shown that interdisciplinary collaboration in the academy is not widespread and not evenly rewarded. For example, Bromham, Dinnage, and Hua (2016) found that inter- and multidisciplinary proposals submitted to the Australian Research Council Discovery Program were much less likely to be funded than those that were not interdisciplinary (p. 685). Goring et al. (2014) also found that collaborative and interdisciplinary work tend to be underappreciated and underrecognized because the standard measures of “success” rely on such metrics as single-authorship (np). External rewards, such as project funding, tenure, and merit pay or promotions are just one facet of motivation that can drive junior scholars to pursue opportunities to collaborate. In their study of what other factors promote collaboration,

Maglaughlin and Sonnenwald (2005) noted “learning and teaching, new discoveries, [and] fun” as additional motivators beyond external rewards (p. 7). Our data show that graduate students tend to privilege productivity over learning opportunities, which may in part explain some of their apparent disinterest in collaboration: if graduate students don’t think they have much to learn about writing or genre, it follows that they wouldn’t see collaboration or collaborators as sources to enhance their knowledge development. It is possible that amenability to collaboration is something that develops over time and with explicit mentorship; writing groups, then, might need to include more decoding of the hidden expectations and structures underpinning academic work. Or, it may be possible that graduate students feel they already have adequate opportunities for collaboration within their departments, labs, and graduate organizations. Either way, we believe assessment of graduate students’ collaboration attitudes and practices—perhaps by way of network analysis on publications (see Mirc, Rouzies, & Teerikangas, 2017), outreach projects, and grants—could yield exciting findings that are applicable to several kinds of formal and informal curricular interventions for graduate student professional development.

Finally, the writing comfort-wellness scores were neutral to low across all disciplines and did not change much from pre-to-post survey. There are several factors that may have led to non-significant changes between the pre-and-post surveys that we feel are important to discuss because they may affect future research on this topic. The study design of pre-and-post survey assessment might not entirely suit the circumstances and pedagogical approaches provided by an informal learning site. For example, the high rate of writing group attrition is one factor that may have contributed to less measured effects in these populations. Additionally, many of the qualities and behaviors measured in the population were emotional and behavioral factors that are far less elastic than semantic categories like academic knowledge. It likely takes more time than an academic semester, and more concerted effort, to work with graduate writers to develop and amend their long-held writing behaviors, writing process, and, ultimately, their emotionality around writing acts. Writing centers, then, might not be an ideal space to provide this kind of intensive, long-term support, given that writing groups are ultimately semester-long endeavors and facilitators have little preparation for this kind of intensive metacognitive and emotional support.

We believe part of the issue may come from the ways writing is implicitly taught to graduate students across the disciplines through advisor-advisee and principal investigator (PI)/lab writing practices. Given that co-authorship is common within STEM fields, we were surprised to see that both international and domestic STEM students reported such low confidence and comfort with writing habits, norms, and processes. Kamler’s (2008) interview-based study of graduate students in education and natural science fields found that “Co-authorship helped students move through the struggles and anxieties of publishing. It taught them how to be robust in the face of rejection and ongoing revision” (p. 292). If helpful collaborations with supervisors and other co-authors are indeed common in STEM fields, we would expect to see that the STEM students in our study would report higher amenability to feedback and collaboration than their peers from disciplines that tend to favor single-authorship. It is possible that the students in our study were not yet participating in co-authorship opportunities, or that their experiences were sources of stress rather than support. Yet Kamler’s (2008) call “to rethink co-authorship more explicitly as a pedagogic practice rather than as an output-driven manoeuvre to increase productivity” (p. 292) might encourage STEM disciplines to reconsider tenure and promotion practices with student mentorship being rewarded or counted as much as or more than raw publication output. Whereas in STEM disciplines writing is often thought of as the low-priority activity that is required for grant funding and/or writing-up one’s study findings, in the humanities writing is often still viewed as a largely solitary and individualistic endeavor. Neither of these figurations of writing are particularly useful or productive to the development of emergent scholars.

There are several implications that writing centers can derive from these findings, including that:

- Writing groups might need to be more deliberately targeted towards specific needs that are unique to graduate students in specific disciplines.

- Writing centers would benefit from doing a more robust writing group placement approach. Writing center administrators can use our survey and methodology to develop a placement model to more effectively place graduate students across the disciplines into specific writing groups.
- Writing centers might benefit from providing writing groups solely for international STEM students (or international students writ large). These groups would need to have a lot of structured learning around the U.S. educational system and scholarly processes in addition to field-specific writing instruction and support. These groups would best be targeted towards more junior graduate students who have time to engage in metacognitive-level skill building.
- Writing centers might want to provide specific kinds of support that are geared towards either learning (grant writing workshops), productivity (writing boot camps; see Smith et al. 2017), or collaboration (writing groups), rather than lumping all of these into singular services or programs.

Moving outside of the context of writing center support, our findings also align with other scholars' conclusions that disciplines in STEM would benefit from explicit curricular interventions in graduate students' writing education (Aitchison & Pare, 2012; Gardner et al., 2018; Simpson, 2012; Walker, 2013) regarding processes of academic writing, specific rhetorical training about genres of academic writing, and decoding expectations of American universities and academia. Although there are some curricular interventions for supporting STEM writers, such as multidisciplinary writing groups (Condon & Rutz, 2012), discipline-specific writing interventions (Gardner et al., 2018), groups and training tailored to international students' needs (Simpson et al., 2015), and course-embedded writing center support (Walker, 2013), these are not widespread or standard in their execution. Furthermore, international STEM students may need support above and beyond writing-focused courses to help them navigate their disciplines (i.e., educating international STEM students on the hidden curriculum of graduate school). If curricular interventions are unavailable—such as courses on writing and publishing in the discipline—then perhaps writing center-sponsored writing groups are being used by some students to fill this void, despite perhaps not being the right solution for the problems they face.

Anecdotally, however, during our study we heard from several STEM writing group participants who acknowledged that they had to hide their participation in writing groups because of stigma, or because they worried their PI would tell them their time would be better spent in the lab. Additionally, several STEM students reported dropping-out of their writing groups because attending interfered with their lab or TA work. These kinds of experiences contribute to the psychosocial factors around the practice of writing—and impact graduate students' writing practices and help-seeking behaviors—in ways that are unsubtle and potentially harmful (Stachl & Baranger, 2020). Therefore, we suggest that supporting international STEM students ought to “begin at home,” so to speak, through program-specific support including STEM departments running regular (perhaps annual) and lengthy (full-day) mentorship workshops for PIs that specifically attend to the specialized needs of STEM students by their demographics (international student, non-native speaker, student of color etc.). Intentional departmental-level curricula around the practice of writing and academic research may also help STEM students to develop healthier writing habits, practices, and attitudes.

Surveying writing group participants, as we did for this study, about their motivations for joining groups and their self-reported knowledge, confidence, and mindsets may also help writing centers to make more informed decisions about group placement and ultimately provide better support. But writing centers are not an island. In order to better meet the needs of graduate students, there need to be several support interventions available given the complex and not necessarily intersecting nexus of needs that different graduate students have throughout their careers. Just as we cannot lump together students by demographic or discipline, we cannot expect one intervention to provide a complete remedy for the issues these students face.

Appendix A: Survey Instrument and Scoring Key

Table 8. Scoring Key for Survey Analysis

Score Code	Survey Questions Included in Score						
Academic Knowledge	2	5	7	14	16	23	
Writing Confidence	1	4	10	13	17	18	21
Feedback	8	12	19				
Collaboration	24	26	27				
Writing Comfort-Wellness Score	3	6	9	11	15	20	22

Note: Question 25 was omitted from the coded scores because it did not fit any category.

Writing Group Pre-Survey

Open Response Demographic Questions

- In which writing group are you participating?
- What is your major or department?
- What is your rank or position?
- Is English your native language?
- Are you an international student?
- Have you participated in one of the Writing Center's writing groups before?
- Have you participated in a writing group outside of the Writing Center before?

Which of the following Writing Center services have you used before? (Select all that apply)

- One-on-one consultation
- Walk-in consultation
- Live Chat Consultation via WOnline
- Drop-off Consultation via WOnline
- Workshop
- Writing Retreat
- None

How did you hear about the Writing Center's writing groups? (Select all that apply)

- Writing Center website
- Email to department or organization listserv
- From a friend or colleague
- From an adviser or supervisor

- Previous participation in a writing group
- From a writing center consultant
- Other (Please Describe)

What were your motivations for joining a writing group? (Select all that apply)

- To help set regular writing goals
- To set aside dedicated time/space in which to write
- To provide me with accountability
- To improve my writing process
- To learn strategies for revision
- To learn more about a specific type or genre of writing
- To improve my English language writing fluency
- To receive feedback from someone outside of my department.
- To receive feedback from peers
- To join a community of writers/peers
- Other [text box]

Please rate using Likert Scale (1 - 5, Strongly Disagree - Strongly Agree) the extent to which you agree or disagree with the following statements:

1. I can articulate my strengths and challenges as a writer.
2. I can find and incorporate appropriate evidence to support my claims.
3. When I write, I feel physical discomfort (e.g. headaches, stomach-aches, back-aches, insomnia, muscle tension, nausea, and/or crying).
4. I can set achievable writing goals.
5. I can critically read and analyze writing in my field.
6. I do not maintain a regular writing practice.
7. I can maintain a sense of who my audience is as I am writing.
8. When I read drafts of others' work, I have trouble providing valuable feedback on their writing.
9. When I have a pressing deadline for a writing project, I do not manage my time efficiently.
10. I feel confident in my knowledge of writing conventions in my field.
11. I can regularly meet my writing goals.
12. I have difficulty giving valuable writing feedback to others in my field.
13. When I read a rough draft, I can identify gaps when they are present in my writing.
14. I can follow the conventions of the genre or field in which I write.
15. When I'm given extensive feedback on my writing, I am not motivated to revise.

16. I can read and analyze writing from outside of my field.
17. I can attribute my success on writing projects to my writing abilities more than to luck or external forces.
18. Once I have completed a draft, I can eliminate both small and large sections that are no longer necessary.
19. I can give writing feedback to someone outside of my field.
20. When I write, I almost always experience feelings of fear or distress.
21. I can map out the structure and main sections of a writing project before writing the first draft.
22. When there are distractions around me, I cannot concentrate on my writing.
23. I can find and correct my grammatical errors.
24. I do my best writing in group settings.
25. I always write in the same location.
26. I like working with writers from other disciplines.
27. When I work with a writing group, I can learn new strategies to promote my development and success as a writer.

Appendix B: Two-Way ANOVA (Type III) and Tukey Test Results

2-Way ANOVA (Type 3): Writing_Confidence

	Sum Sq	Df	F value	Pr(>F)
(Intercept)	342.69	1	894.6517	<2e-16 ***
Demographic	0.66	1	1.7317	0.1904
Discipline	0.92	2	1.1995	0.3045
Demographic:Discipline	0.35	2	0.4608	0.6318
Residuals	52.09	136		

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

TukeyHSD: Writing_Confidence ~ Demographic * Discipline

\$Discipline

	diff	lwr	upr	p adj
SOC-HUM	-0.18361836	-0.5107998	0.1435631	0.3811245
STEM-HUM	-0.07402378	-0.3990240	0.2509765	0.8518757
STEM-SOC	0.10959459	-0.1701211	0.3893103	0.6232905

2-Way ANOVA (Type 3): Academic_Knowledge

	Sum Sq	Df	F value	Pr(>F)
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```

(Intercept)          409.94    1 1000.5350 < 2e-16 ***
Demographic           2.39     1    5.8430 0.01696 *
Discipline            0.26     2    0.3225 0.72491
Demographic:Discipline 0.03     2    0.0343 0.96629
Residuals            55.72  136
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

```

TukeyHSD: Academic_Knowledge ~ Demographic * Discipline

```

$Discipline
      diff      lwr      upr      p adj
SOC-HUM -0.0652296 -0.4036122 0.2731530 0.8914617
STEM-HUM -0.1139952 -0.4501219 0.2221315 0.7014074
STEM-SOC -0.0487656 -0.3380574 0.2405262 0.9158678

```

2-Way ANOVA (Type 3): Comfort_Wellness

```

              Sum Sq  Df  F value Pr(>F)
(Intercept)    234.625   1 738.5691 <2e-16 ***
Demographic      0.016   1  0.0488 0.8255
Discipline      0.262   2  0.4125 0.6628
Demographic:Discipline 0.092   2  0.1452 0.8649
Residuals      43.204  136
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

```

TukeyHSD: Comfort_wellness ~ Demographic * Discipline

```

$Discipline
      diff      lwr      upr      p adj
SOC-HUM 0.01449956 -0.2834574 0.3124565 0.9926961
STEM-HUM 0.09068287 -0.2052877 0.3866534 0.7485013
STEM-SOC 0.07618331 -0.1785476 0.3309142 0.7587733

```

2-Way ANOVA (Type 3): Feedback

```

              Sum Sq  Df  F value  Pr(>F)
(Intercept)    190.745   1 414.0575 < 2e-16 ***
Demographic      0.077   1  0.1661 0.68427
Discipline      1.411   2  1.5314 0.21993
Demographic:Discipline 2.547   2  2.7641 0.06658 .
Residuals      62.651  136

```

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

TukeyHSD: Feedback ~ Demographic * Discipline

\$Discipline

	diff	lwr	upr	p adj
SOC-HUM	0.03163933	-0.3271652	0.3904439	0.9762214
STEM-HUM	-0.03558416	-0.3919966	0.3208283	0.9696223
STEM-SOC	-0.06722349	-0.3739745	0.2395275	0.8620591

2-Way ANOVA (Type 3): Collaboration

	Sum Sq	Df	F value	Pr(>F)
(Intercept)	224.115	1	189.5398	<2e-16 ***
Demographic	0.611	1	0.5169	0.4734
Discipline	0.831	2	0.3516	0.7042
Demographic:Discipline	0.924	2	0.3905	0.6775
Residuals	160.809	136		

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

TukeyHSD: Collaboration ~ Demographic * Discipline

\$Discipline

	diff	lwr	upr	p adj
SOC-HUM	0.11982005	-0.4550200	0.6946601	0.8743240
STEM-HUM	0.02934812	-0.5416596	0.6003558	0.9918559
STEM-SOC	-0.09047192	-0.5819171	0.4009733	0.9005079

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