# Impact of STEM Professional Development on Graduate Trainees' Scholarship

**Oyinkansola Aladeokin, Morgan State University**
**Dr. Oludare Adegbola Owolabi P.E., Morgan State University**

Dr. Oludare Owolabi, a professional engineer in Maryland, joined the Morgan State University faculty in 2010. He is the director of the sustainable infrastructure development, smart innovation and relient engineering and the director of undergraduate programs in the department of civil engineering at Morgan State University.

**Adekemisola Olufunmilayo Asahiah, Morgan State University**
**Mr. Pelumi Olaitan Abiodun, Morgan State University**

Pelumi Abiodun is a current doctoral student and research assistant at the department of Civil Engineering, Morgan State University, Baltimore, Maryland. Pelumi got his BSc and MSc degree in Physics from Obafemi Awolowo University, where he also served as a research assistant at the Environmental Pollution Research unit, in Ile-Ife, Nigeria. As part of his contribution to science and engineering, Pelumi has taught as a teaching assistant both at Morgan State University and Obafemi Awolowo University. With passion to communicate research findings and gleaned from experts in the field as he advances his career, Olaitan has attended several in-persons and virtual conferences and workshop, and at some of them, made presentation on findings on air pollution, waste water reuse, and heavy metal contamination.

**Hannah Abedoh, Morgan State University**

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## Abstract

The paper highlights how a well-organized professional development workshop has been strategically utilized to improve the scholarship of graduate trainees on a multi-STEM educational program. The paper further highlights the strategies used for planning, implementation, and assessment of the workshop. The paper equally elaborates on the writing accountability group structure as a catalyst for achieving writing goals. Results show a significant increase in self-efficacy of the participants in the development of STEM education manuscripts. There was a 67% increase in academic publications among graduate students. The dominant theme in the qualitative investigation was the "supportive and collaborative environment." Insufficient time management presents a barrier. Additionally, through the writing accountability group structure, there was a significant increase in trainees' scholarship productivity. Faculty advisers and administrators can prioritize writing groups as a cost-effective and impactful intervention to enhance academic productivity. Further research is required to identify the most effective implementation strategies; however, integrating a writing collaboration approach seems to be an excellent way to move forward.


## Introduction

For advancing research and innovation, the scholarly development of graduate trainees in Science, Technology, Engineering, and Mathematics (STEM) fields is indispensable. Graduate STEM education, as highlighted by [1], is critical in fostering the development of future researchers and innovators, thus contributing to advancements and the betterment of society. A similar sentiment is expressed by [2] regarding the significance of strong STEM education programs in cultivating a proficient labor force that can propel economic expansion and innovation in a world that is becoming more competitive. This advancement necessitates not only specialized expertise but also proficient scholarly discourse.

Graduate students, who represent the future of the scientific enterprise, frequently encounter challenges in effectively conveying their research through high-quality manuscripts that are suitable for publication, thereby compromising their critical communication abilities. As investigated by [3], "Graduate students reported that organizing written narrative presented the most difficulty." To address this challenge, specialized workshops for professional development that aim to improve the research writing abilities of graduate trainees have emerged as a beneficial intervention. Furthermore, it is worth noting that these interventions not only enhance graduate

students' scholarly publications but also significantly contribute to the progression of research and innovation in STEM disciplines [4]. The workshop provides graduate students with customized strategies and guidance to effectively communicate their research findings in scholarly publications, thereby empowering them to do so.

This paper offers comprehensive information regarding the organization, execution, and evaluation of an intensive workshop designed for graduate trainees of a multi-STEM educational program based on the community of practice concept and the social cognitive. A key component of the workshop was forming a writing accountability group, an innovative strategy whereby trainees committed to specific manuscript writing goals and provided peer support. It has been established that graduate-specific professional development seminars are efficacious interventions for bolstering scholarly competencies [5]. Comparably, [6] established that implementing writing accountability groups has surfaced as a potentially effective approach to promote accountability and efficiency among academic writers. By integrating these two elements, graduate trainees are more comprehensively supported in their scholarly endeavors.

The workshop sought to enhance participants' scholarship in STEM education by strategically integrating various pedagogical approaches (e.g., goal setting, peer feedback, accountability mechanisms, etc.) and self-assessment strategies. Post-workshop surveys were utilized to assess alterations in writing-related self-efficacy and attitudes. The result illustrates a significant rise in the efficiency of the scholars' pursuits, which can be attributed to their active participation in the writing accountability group structure. Additionally, the assessment of writing productivity included tracking the submission of manuscripts throughout three years, from 2020 to 2023. This allowed for comparing the group's dynamics, productivity, and effectiveness before and after the workshop. A significant increase in the scholarship output of trainees was discovered here. This article emphasizes the significance of focused professional development seminars in fostering graduate STEM trainees' critical scientific writing abilities.

## Literature review

Professional development workshops play a pivotal role in shaping the scholarly development of graduate trainees in Science, Technology, Engineering, and Mathematics (STEM) fields. The strategic utilization of such workshops and writing accountability groups has garnered attention as an effective means to bolster the scholarship of emerging researchers [7]. A well-organized workshop provides a structured platform for skill enhancement, fostering a conducive environment for intellectual growth and research productivity [8].

Effective planning, implementation, and assessment strategies are imperative for the success of professional development workshops. As [9] discussed, meticulous planning, including clear objectives and tailored content, enhances the relevance and impact of such interventions. Furthermore, robust implementation strategies ensure active engagement and participation,

maximizing the transfer of knowledge and skills among participants [10]. Rigorous assessment mechanisms, encompassing both formative and summative evaluations, provide valuable insights into the efficacy of workshop interventions and guide future improvements [11].

The integration of writing accountability group structure is central to the effectiveness of professional development workshops. These groups serve as catalysts for achieving writing goals and fostering a culture of peer support and accountability among graduate trainees [12]. The literature highlighted the importance of structured writing groups in enhancing writing skills, productivity, and self-efficacy among participants [13]. By providing a supportive environment for peer feedback and constructive criticism, writing accountability groups facilitate iterative improvements in manuscript development and scholarly communication [14].

The results of various empirical studies demonstrate the tangible benefits of professional development workshops and writing accountability groups in enhancing the scholarship of graduate trainees. A significant increase in self-efficacy in developing STEM education manuscripts is observed among participants who engage in these interventions [15]. Moreover, implementing writing accountability group structures leads to a notable improvement in trainees' scholarship productivity, as evidenced by increased manuscript submissions and publications [16].

The effectiveness of professional development workshops hinges on various factors, including meticulous planning, thoughtful implementation, and rigorous assessment. Scholars have emphasized the need for clear objectives, targeted content, and interactive formats to maximize the impact of these interventions [8]. Despite the wealth of literature on professional development in graduate education, there remains a gap in understanding the specific strategies employed for planning, implementing, and assessing workshops within multi-STEM educational programs.

Furthermore, the role of writing accountability groups in graduate education has garnered increasing attention in recent years. These groups provide structured support and peer feedback to graduate trainees, fostering a culture of writing productivity and accountability. [17]. While existing studies have highlighted the benefits of writing accountability groups in improving writing skills and manuscript development [17], there is a paucity of research examining their incorporation into professional development initiatives targeting graduate students across multiple STEM disciplines [18].

This paper contributes to bridging this gap by elucidating the strategic utilization of professional development workshops and writing accountability groups to enhance graduate trainees' scholarship in a multi-STEM educational program. By providing insights into the planning, implementation, and assessment strategies employed, the paper offers valuable guidance for educators and administrators seeking to optimize professional development initiatives in similar contexts.

## Planning, Implementation and Evaluation

The components essential to the project management cycle are evaluation, planning, and implementation. Of these, planning and implementation are predominantly interdependent. As the phase responsible for the highest percentage of project failures, planning is the preliminary, most crucial, and most strategic of the three ("planning") stages. The assertion was substantiated in 2008 by the [19], which declared that a considerably greater likelihood of success exists for a sufficiently planned project instead of an inadequately planned one. Effective planning does not guarantee the success of a project in isolation; implementation and evaluation are also crucial components. While a well-designed strategy can offer a framework for evaluation, insufficient preparation cannot precede successful implementation.

Engaging in writing accountability activities and seminars, among other forms of professional development training, is more effectively optimized through planning. Effective planning, which spans the duration of the project, involves the following: identifying the objectives (goal setting), iterating the roadmap (structure), assigning timeframes for task implementation and milestone recognition (timelines), engaging in brainstorming sessions regarding project progress (reflection), and providing feedback based on individual perceptions of the project. As a result, the planning phase addresses the project's human, financial, material, and strategic requirements while also focusing on fostering concentration, reducing distractions, and increasing productivity.

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Implementation refers to the systematic conversion of a pre-existing abstract notion or proposal into a tangible entity in accordance with a predetermined protocol or blueprint. The process of carrying out decisions and overseeing subsequent performance is known as execution. Project execution is the process by which the responsibilities and activities outlined in the project's planning document are carried out.

Implementation is an essential phase in which planning serves as a compass to ensure that tasks are executed efficiently. Implementing projects successfully necessitates rigorous adherence to the planning documentation. As [20] states, successful implementation requires keeping one's word and exhibiting adaptability and flexibility to accommodate human resources and other requirements. This phase encompasses monitoring deadlines and making necessary adjustments to

objectives. Lundsford [21] asserts that periodic feedback elicitation provides valuable insights that can inform modifications aimed at more effectively addressing the requirements of members. To invigorate inert groups, it is possible to modify regulations, redefine objectives, or investigate new group activities.

The regular feedback from writing workshops provided the rationale for forming a writing accountability group to significantly enhance the writing workshop. The planning document is utilized during the evaluation phase, the concluding stage, to appraise the planning and implementation activities (Figure 1). This assessment aims to ascertain whether the project has been carried out per the documented strategy, utilizing the resources at hand, and within the designated periods. Additionally, it seeks to investigate more efficient implementation strategies unavailable before the project's inception. The objective of this endeavor is to enhance the forthcoming project planning procedure. Evaluation additionally reveals the accomplishments, constraints, and corrective measures that were executed within the endeavor to mitigate and prevent an impending misalignment.

The goal of assessment is to ascertain the level of effectiveness that writing groups exhibit. The evaluation of post-training productivity, encompassing elements such as the quantity and caliber of manuscripts, skill enhancement, and member contentment, can serve to gauge perceived progress [22]. Insights regarding the strengths and weaknesses of the development initiative can be gathered through periodic surveys [23]. Keeping track of the development of drafts, manuscript submissions, and publications yields measurable indicators of professional advancement.

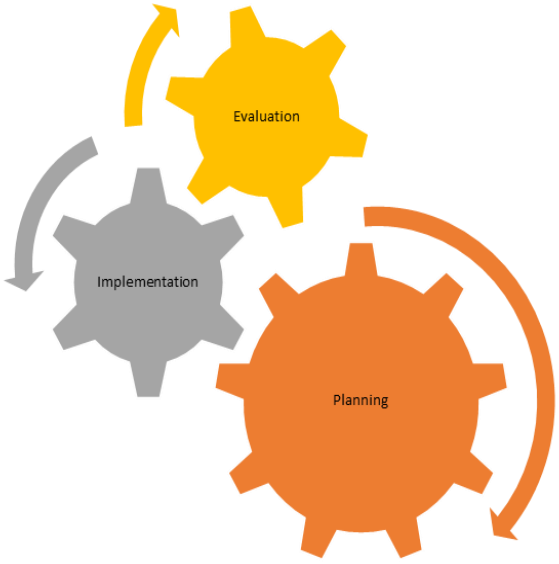


Figure 1. Planning, Implementation and Evaluation by priority

Writing is an invaluable instrument for conveying one's ideas to others [24] and is a fundamental ability that guarantees achievement, including academic endeavors. As an illustration of how "a student-centered instructional framework in a social context" [25] helps in addressing the persistent difficulty of proficient writing among students of all abilities, a workshop utilizing active pedagogy [26] provides an answer. A combination of skill development, networking, inspiration, and introspection are incorporated into the interactive writing workshop. Moreover, it cultivates professionalism by equipping students with writing proficiency, fluency, and self-assurance.

## Impact Assessment of Writing Workshop Efficacy

Assessment illuminates the condition of each undertaking, including the writing workshop. This signifies the domains that require further endeavors. The assessment of the writing workshop's efficacy unveiled participant networking, enhanced writing confidence, and improved fluency. Nevertheless, it unveiled a disparity between the seminars and the craft of writing. Although participants departed the workshop with inspiration, their improved writing was limited to quality rather than quantity. A writing accountability group was established as an additional measure to bridge the divide.

## Writing Accountability Group

Engaging in academic writing proves to be a challenging undertaking. Graduate Trainees often encounter difficulties in carving out dedicated writing time, given their simultaneous management of many responsibilities. These challenges could be further compounded by issues related to confidence in navigating the intricate writing process. According to researchers [27] and [14]), even highly productive academics have admitted having issues due to a lack of an acceptable work-life balance [28]. Utilizing an appropriate and efficient format, writing accountability groups possess the capability to tackle numerous of these challenges.

A writing accountability group (WAG) is an organized strategy intended to increase productivity and support people working on writing projects. It is a collaborative platform featuring regular semi-structured sessions and a consistent core of participants [29]. Collaboration promotes active learning by engaging students in reading, talking, writing, and thinking, as well as practicing synthetic and analytic skills [30], and writing with others can nurture motivation through mutual support, shared accountability, or friendly competition [31]. While writing is often solitary, having a supportive community helps sustain motivation and effort.

Effective writing accountability groups set confidentiality, commitment, and constructive feedback guidelines. Establishing a Graduate Training Writing Accountability Group starts with gathering a cohort of students who have identical goals: to promote intellectual writing and are dedicated to participating in frequent writing sessions. These frequent writing sessions provide a platform for defining individual writing objectives, discussing progress, sharing challenges, and creating a supportive environment [32]. During the writing segment of each session, graduate

trainees engage in independent work on their respective manuscripts, benefitting from the collaborative environment cultivated within these small groups. The organized support offered by WAGs leverages social accountability and connections to encourage the development of effective writing habits, which are critical for academic and research success.

## Theoretical Framework

### Community of Practice Theory

The concept of community of practice (CoP) as a framework pertains to academic homophily, which denotes a collective of individuals who possess a common concern or enthusiasm for a specific activity, and by regular interaction over an extended period, they enhance their knowledge and skills in that activity [33]. The community, united by a common identity, forms the foundation for the collective acquisition, advancement, and preservation of the specialized knowledge that the community possesses. A writing accountability group can be defined as a community of practice (CoP) that focuses on enhancing members' writing abilities and fostering improvement in their writing talents. It offers a platform for writers to consistently engage and form connections. As members actively participate in organized writing activities, focusing on their mutual enthusiasm for writing, they provide peer review for others and receive feedback on their work in a relaxed and casual environment. This enhances learning by promoting collaborative practice and the construction of knowledge. They cultivate a collective collection of resources and establish connections that facilitate acquiring knowledge.

### Social Cognitive Theory

The social origins of conduct are emphasized in this theory, which was developed by Albert Bandura. Self-influence is a hypothesis that was proposed by [34]. This theory proposes that human conduct is heavily motivated and regulated by the ongoing practice of self-influence. A significant part of the theory is referred to as observational learning or modeling, which refers to the process of learning that takes place through the observation of the actions of other people [35]. When applied to a writing accountability group, social cognition theory argues that individuals can improve their writing skills by seeing and modeling the writing behaviors, methods, and self-regulation practices of other group members. To foster members' sense of self-efficacy in writing, the group provides an environment that encourages collaborative and vicarious learning. Writing abilities such as self-monitoring and self-evaluation can be developed using group feedback. Individually, members can enhance their writing skills by exercising human agency together. These social interactions make it easier for people to learn together.

## Methodology

The graduate student writing workshop was designed as a peer-facilitated program, convening for eight hours, five days a week, over 10 weeks during the summer and three weeks during the winter from 2020 to 2022. The workshop was led by speakers from diverse STEM backgrounds and covered various topics on writing and research. In response to the challenges posed by the COVID-19 pandemic, the workshops were adapted to accommodate different formats—virtual, in-person, and hybrid—to accommodate a wider audience. The workshop fostered active participation and engagement through interactive breakout sessions, live scenarios, audio excerpts, and other virtual tools. Each session commenced with a 25-minute segment dedicated to reporting and goal setting, followed by an intensive two-hour presentation led by a facilitator and a subsequent five-hour writing session. Finally, 35 minutes were allotted for reporting and goal setting to conclude each session.

In 2022, a different practical approach was initiated due to the cumbersome and low productivity of the previous workshops. A writing accountability group was initiated involving a cohort of graduate students who are part of a National Science Foundation-funded project called ETA-STEM (selection criteria) with a shared multi-STEM background. The WAG met for 2 hours, five days a week for 10 weeks during summer and 4 weeks during winter. The two-hour meeting serves as a writing session and a platform to enhance writing skills and conduct content analysis effectively. Each member of the WAG is scheduled to write a portion of their research questions every week. The structure of the 2-hour WAG is described briefly below:

00:00 – 00:15 – Ice breakers, Writing hints and hacks.

00:15 – 01:30 –Individual writing and content analysis

01:30 – 02:00- Feed backs

The process allows for peer-writers to understand and contribute to multi-STEM writings.

The effectiveness of this approach is reinforced by the findings of [29], which highlight the positive impact of frequent, shorter writing sessions in building lasting writing habits among graduate students. This model, exemplified by the WAG initiative, is particularly relevant for graduate students with demanding academic schedules, fostering a supportive environment for scholarly productivity.

Post WAG in the summer of 2023, a self-developed instrument was distributed as a feedback tool to understand the benefits and demerits of this approach. Also, a survey was conducted without including any personal identifiers to ensure participants' freedom of expression and gather quantitative data on their satisfaction levels, productivity, and perceived impact of the writing group over time. Microsoft Excel (2016) was used to clean and analyze this data. Statistical

methods were used to analyze data to identify the impact of the writing group on paper submission over time.

## Results

The demography of graduate students that participated in the writing accountability group over time is presented in Table 1. The result showed that 53.8% were self-identified as male and 46.2% self-identified as female. There were 53.8% doctoral students in the group over the period of engagement and 38.5% were masters' degree pursuant. The largest proportion of the participants were in Engineering and 30.8% were from other STEM, business, and educational fields.

Table 1: Demography of Participants

| Item | Frequency, N | Percentage % |
|---|---|---|
| Self-Identified Gender | | |
| Male | 7 | 53.8 |
| Female | 6 | 46.2 |
| Non-Binary | 0 | 0.0 |
| Others | 0 | 0.0 |
| Graduate Level | | |
| Master | 5 | 38.5 |
| Doctoral Student | 7 | 53.8 |
| Doctoral Candidate | 1 | 7.7 |
| Field/ Discipline | | |
| Science | 0 | 0.0 |
| Technology | 3 | 23.1 |
| Engineering | 6 | 46.2 |
| Others | 4 | 30.8 |

Participation in Writing Accountability group

The result in Figure 2 indicates that the writing accountability group has occurred four times. During the occurrence of WAG, 69.2% participated during the winter of 2024, and 61.5% participated during the summer and winter of 2023. From the results presented in Table 2, 38.46%

of participants have been on the writing accountability group thrice, and 30.77% have been on the WAG once.

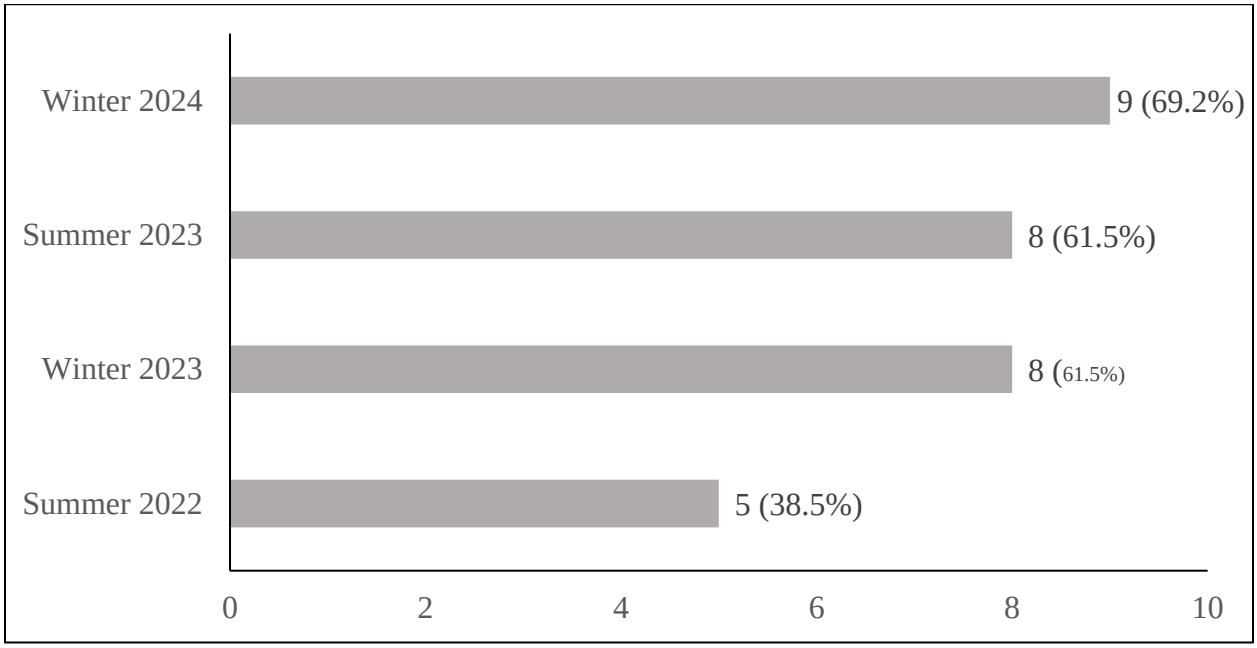


Figure 2: Participation in Writing Accounting Group Session

Table 2: Graduate student participation in writing accountability group

| Occurrence | Frequency (N) | Percentage, % |
|---|---|---|
| 4 | 2 | 15.38 |
| 3 | 5 | 38.46 |
| 2 | 2 | 15.38 |
| 1 | 4 | 30.77 |

Figure 3 revealed the writing frequency of graduate students before and after participation in the WAG. The result showed that the most typical frequency before the writing accountability group (53.85%) was “sometimes” and 30.77% wrote occasionally. Post WAG, the most common writing frequency was “often” (61.54%) and 23.08% started to write “always.”

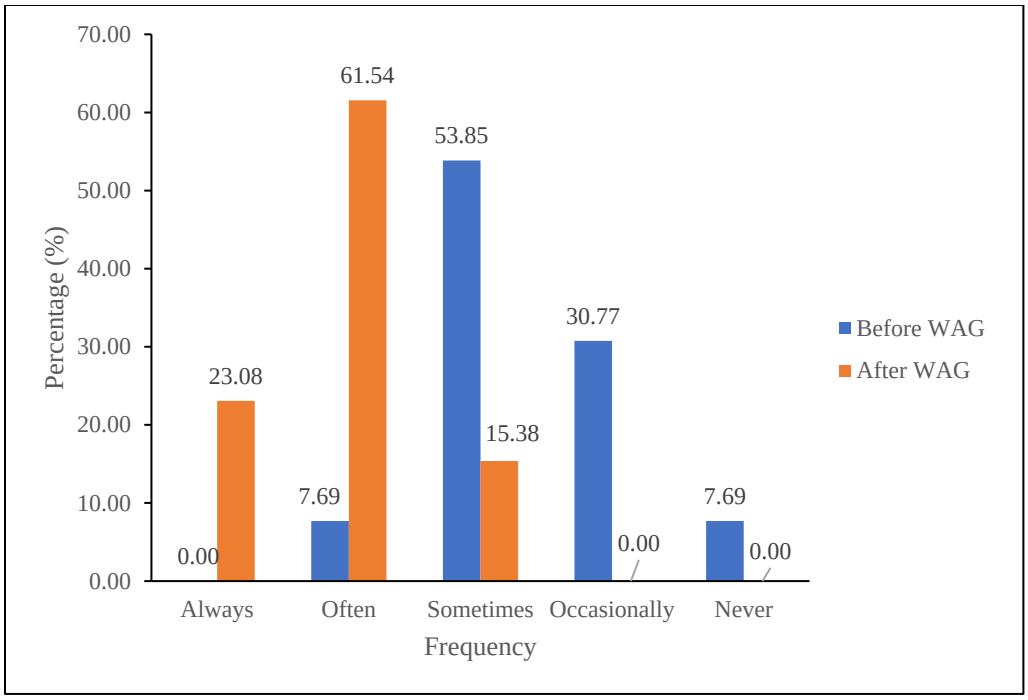


Figure 3: Comparison of writing frequency before and after WAG

Outcome of writing accountability group

The result presented in Fig 4 is composed of publications submitted by graduate students from 2020 through 2023. It is important to note that 67% of publications were published in 2023.

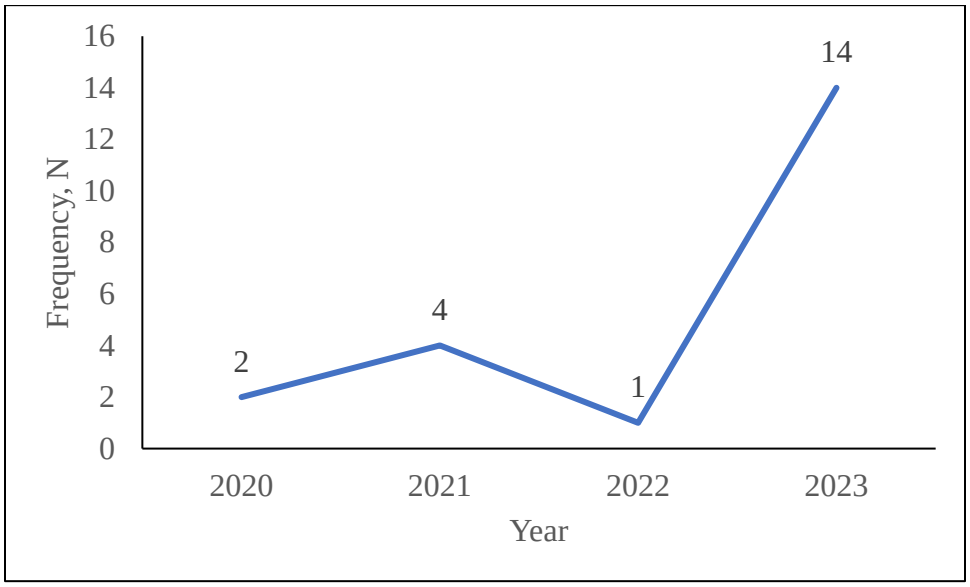


Fig 4: Graduate student publications submission

The result presented in Table 3 below shows the authorship/co-authorship of academic publications post participation of WAG. The result indicated that 92.31% had published at least one academic writing post-participation and only 7.69% had not published any academic writing. The result also showed that all the participants that have engaged in WAG more than once have become authors/co-authors.

Table 3: Cross tabulation of frequency of participation and authorship/co-authorship

| Occurrence | Yes | No |
|---|---|---|
| | N(%) | N(%) |
| 4 | 2(16.67) | 0(0.00) |
| 3 | 5(41.67) | 0(0.00) |
| 2 | 2(16.67) | 0(0.00) |
| 1 | 3(25.00) | 1(100.00) |
| Total | 12(92.31) | 1(7.69) |

Impact of Writing group accountability on Graduate Students

Thematic analysis results of the open-ended questions that assess the impact of WAG on the graduate students revealed 3 major themes which are, “improved writing skills”, “increase productivity” and “supportive and collaborative environment”.

Improved writing skills:

Many students mentioned that the group helped them improve their writing styles, data analysis skills, and overall quality of writing. One student stated that they went from not seeing themselves writing papers to publishing two conference papers, articles, and a thesis. Another student mentioned that the group helped them be more intentional about the terms they used, set clear objectives, and do thorough literature reviews.

Increased productivity:

Several students mentioned that the group helped them increase their productivity and stay on track with their writing goals. One student said that the constant interfacing from the group made it less cumbersome to take up a research project. Another student mentioned that the group helped them improve their consistency and resilience in writing.

Supportive and collaborative environment: Students appreciated the support and feedback from other group members. One student mentioned that the group provided a safe space to experiment

with different writing styles. Another student said the group helped them improve their collaboration and teamwork skills.

Overall positive experience:

Most students had a positive experience with the writing accountability group and would recommend it to others. One student said the group was "an impactful experience" that challenged their understanding of writing and helped them improve. Another student simply said that the group was "good."

Barriers to participating in writing accountability for graduate students.

Weak motivation/commitment - Numerous responses highlight the absence of motivation, commitment, or incentive as obstacles. Difficulty in prioritization hinders one's ability to remain actively involved.

Time management - The task of balancing numerous responsibilities and simultaneously handling classes and writing papers creates difficulty in finding sufficient time. Inadequate time management poses an obstacle.

Writer's block is a condition that many writers experience, hindering their ability to progress in their work. Commencing and surmounting obstacles can be arduous.

Inadequate skills/knowledge - Certain individuals have identified deficiencies in writing abilities or comprehension of research methodologies as hindrances. Insufficient knowledge hinders the process of writing, making it more challenging.

Restricted access to resources - A few individuals identified the limited availability of data, references, and scholarly articles as a hindrance. It imposes limitations on writing and research.

External distractions, such as noise and interruptions from people, hinder the ability to maintain concentration.

Conflicting demands - Coursework and other obligations divert attention from writing. Managing competing priorities can be challenging.

Imposter syndrome refers to a lack of confidence in one's writing abilities or a persistent feeling of being an imposter, which can impede progress for specific individuals.

Lack of accountability and inadequate communication were obstacles to maintaining regular participation.

To summarize, the primary obstacles encompass difficulties with motivation, effective time allocation, writing proficiency, availability of resources, diversions, and juggling multiple commitments. Enhancing competencies, expertise, responsibility, and effective interaction among group members can aid in surmounting these challenges.

## Discussion of Findings

The study's findings offer valuable insights into the advantages of a writing accountability group for graduate students in various disciplines. Engaging in the writing group yielded various advantageous results, such as enhanced writing skills, heightened efficiency, and a nurturing atmosphere for collaboration.

The thematic analysis demonstrated that students improved their academic writing abilities by engaging in group activities. Consistent with prior studies, research has demonstrated that writing groups and peer support can improve students' writing skills and self-efficacy [36], [37]. Through critiquing and receiving input on their work, students can enhance their comprehension of academic writing norms and bolster their abilities. Our study provides evidence that these advantages apply to various fields, ranging from scientific disciplines to engineering and others.

Another significant discovery was that the writing group enhanced productivity and fostered a sense of responsibility in writing tasks. The cross-tabulation revealed a positive correlation between the frequency of student participation and the likelihood of them being authors of publications. This implies that motivation and accountability factors in a group setting helps students overcome common obstacles such as procrastination and writer's block. Establishing writing objectives, monitoring advancement, and regularly engaging with colleagues can offer external incentives to persevere through difficulties. The literature has documented similar beneficial impacts of writing groups on productivity, as reported by [38].

In addition, the graduate students highlighted the importance of a supportive and collaborative environment. The group's synergy fostered a secure environment for individuals to engage in daring endeavors and explore new possibilities while benefiting from seasoned colleagues' mentorship. Collaborating as a team allowed students to enhance their skills in areas beyond writing, such as research, data analysis, and project management. Establishing this academic community and network had a significant effect, particularly for new graduate school individuals. Promoting collaborative learning is consistent with prior suggestions regarding writing instruction in graduate education [39], [40].

Although this study offers various evidence regarding the advantages of writing accountability groups, it is essential to acknowledge certain limitations. The sample size was comparatively limited and exhibited a dearth of gender identity and disciplinary diversity. Additional research with larger sample sizes would enable a more detailed analysis of the effects on various student demographics and academic disciplines. Additionally, it would be beneficial to carry out pre-post assessments and long-term monitoring of student outcomes to gather valuable information.

## Conclusion

The data presented in this paper emphasizes the many advantages of writing accountability groups for improving graduate scholarship. The quantitative and qualitative evidence synthesis shows that

trainees who participate in structured peer writing collaboratives experience significant productivity increases, as well as writing competence and self-efficacy.

The increase in publication rate and manuscript quality found among students participating in these groups are especially noteworthy. Writing groups help participants overcome common challenges to academic writing by encouraging goal setting, offering ongoing feedback, and cultivating an accountability culture. Peer social and emotional support fosters healthy writing habits and helps to maintain motivation.

Lastly, these data suggest that writing groups should be seriously evaluated as a valuable approach to introduce into graduate programs to help students strengthen their academic writing. They provide a structure and community that cannot be matched by individual writing efforts. Establishing writing accountability through peer communities can empower graduate students as authors by fostering confidence and skill sets that will fuel future research.

Writing groups need more attention from faculty advisers and administrators looking for low-cost, high-impact interventions to improve academic production. While more research is needed to determine the best implementation tactics, incorporating writing collaboratives appears to be a promising road forward. Supporting graduate scholars' writing growth helps to spread discipline knowledge and benefits the larger scientific and academic activity.

## Acknowledgment

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