Development and Implementation of a Scientific Writing Course for Undergraduate STEM Students

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Abstract

Undergraduate students in the field of Science, Technology, Engineering, Mathematics (STEM) are regularly encouraged and instructed to develop and write an original research paper in their field of expertise. Some undergraduate students may lack the essential skills and strategies to write a research paper or manuscript of sufficent quality for potential publication in a peer-reviewed journal. A sixteen-week writing course was developed for STEM undergraduate students to improve their presentation and writing skills toward increasing their chances of publishing a research article in a peer-reviewed journal. This paper is a report describing a scientific undergraduate writing course (established across a variety of disciplinary STEM fields) and its evaluation based on scoring rubrics and the instructor's oral feedback advice to the students. It was designed and implemented using teaching strategies aligned with pedagogical and learning theories addressing three domains: developmental planning, pedagogical planning, and implementation planning. Pedagogical strategies utilized the Visual, Aural, Read/Write, Kinesthetic (VARK) model and multimodal skills. Implementation of the course content includes using an academic student writing center, oral presentations of the student's research project for the midterm and final course evaluations, and ongoing constructive feedback from the instructor. Undergraduate students showed an increase in their understanding of developing and presenting their proposed research in their respective fields. These strategies have demonstrated a positive outcome in reaching the course goals for STEM undergraduate students during this initial phase of the course development and can be designed and adapted across other academic disciplines. We urge others to implement a similar format for undergraduate STEM courses.

Introduction

In today's modern world knowing how to write an original research paper to be published in a peer-reviewed journal is an important skill for undergraduate students to acquire (Busse & August, 2021), especially in the field of Science, Technology, Engineering, Mathematics (STEM). STEM degree programs rarely provide undergraduate students with an option to enroll in a scientific writing course (Borg Preca, Baldacchino, Briguglio & Mangion, 2023). Scientific writing is a skill that is not adequately addressed in STEM undergraduate education (Reynolds & Thompson Jr, 2011; Clabough & Clabough, 2016), and in many cases students have only limited opportunities to improve their writing skills (Libarkin & Ording, 2012) even though they may be well educated more broadly in STEM content and become proficient in experimental procedures and data analysis. However, students have the potential to become proficient in scientific writing with adequate educational opportunities (Clabough & Clabough, 2016). Universities, colleges, museums, and other educational organizations generally mandate that their faculty engage in research and publish their results in peer reviewed journals (Rawat & Meena, 2014; Carney et al., 2009).

Many college / university faculty consider scientific writing to be an important factor for student success and career readiness (Quitadamo & Kurtz, 2007) for a variety of professional roles, especially if the students pursue a higher degree and become researchers or faculty members. Undergraduate students in general need to develop their writing skills for their professional roles after college graduation (Quitadamo & Kurtz, 2007; McRell, Wilson & Levkoff, 2021) and to advance their science through scholarly activities (research articles, poster sessions, seminars, or workshops). Evidence has shown that undergraduate students who develop their writing skills expand their writing skills after graduation (Kellogg & Raulerson, 2007; Quitadamo & Kurtz, 2007; Wischgoll, 2017), and developing one's writing skills also promotes the long-term benefit of producing well-rounded future scientists (Reynolds & Thompson Jr, 2011), who have potential for publishing in peer-reviewed journals (Grice & Dambha-Miller, 2025) as proficient writing skills in the field of STEM is one of the key components of a successful career. Moreover, in STEM professional fields, researchers are encouraged to participate in broader scientific conversations among their colleagues and throughout the scientific community (Goggal et al., 2024; Ryba et al., 2021).

Contemporary Undergraduate STEM Writing

Teaching undergraduate students to develop their writing skills has been addressed in some specific STEM fields and related disciplines, including general education biology (Quitadamo & Kurtz, 2007), biology (Reynolds & Thompson Jr, 2011), botany (Ward, Clarke & Horton, 2014), and neuroscience (Petersen et al., 2020). Based on the current literature, one of the challenges that appears to be not so clearly addressed, is offering a more general writing course for STEM undergraduate students (Reynolds & Thompson Jr, 2011; Clabough & Clabough, 2016; Moon, Gere & Shultz, 2018). Therefore, it is imperative that undergraduate students develop skills and strategies to write scientifically and orally present their research, as this is integral in the field of STEM. Writing skills include: writing consistently and with precision, clarity of expression, and writing like you are telling a story. Writing strategies include: planning and outlining, describing the importance of your research, indicating any gaps in the current research of your study, providing adequate detail in writing the research paper, and consistently revising your paper (Kallestinova, 2011).

Undergraduate students who intend to become proficient in writing about research topics in their scientific discipline can increase their writing skills if they are encouraged to address topics relevant to their major / field of study, content knowledge, interests, attitudes, and careers, including opportunities to make an oral presentation of their proposed research to their colleagues in class. Moreover, this has been shown to be an efficient way to assess their content knowledge, interests, attitudes, and career goals (Reynolds & Thompson Jr, 2011; Corwin, Prunuske & Seidel, 2018).

Scientific Writing Course Overview

The scientific writing course, designed for undergraduate STEM students, was introduced in 2016 and has been continuously taught for eight years. It is offered two semesters per year, typically enrolling 20 students per section, 60-80 per year. The scientific writing course consists of a one-semester, 16-week course (including a midterm and a final examination), meeting once a week for 2.5 hours, specifically addressing principles of writing a formal publishable scientific paper and related

communication skills intended to improve the students' eventual professional goals of successfully writing and publishing in peer-reviewed scientific journals.

The course uses publication guidelines of the American Psychological Association (APA), which provides students with structured guidelines for scientific research-based writing. The APA format is one example of guidelines typically used by scientific authors (Nicoll et al., 2018); and, therefore, the APA format prepares undergraduate students to write using professional standards that they typically have not used previously, including how to read research journals, avoid plagiarism, and properly cite publications.

APA style is quite different from the Modern Language Association (MLA) format that is typically used to educate undergraduate students to write more proficiently (Hutchinson & Pederson, 2023; Lusin, 2023). APA style was chosen because this writing format is commonly used in scientific writing and thus was more consistent with the goals of the scientific writing course. Undergraduate students are encouraged to read samples of published work that exemplify APA style, while also accessing the following websites to increase their understanding and use of APA format. These resources included the American Psychological Association (https://apastyle.apa. org/) and the Purdue University's Online Writing Lab (https://owl.purdue.edu/owl/research_and_citation/apa_style/apa_formatting_ and_style_guide/index.html).

Scientific Writing Course Structure

The course includes lectures, student-centered learning, and experiential leaning. Prior to the beginning of each class module, undergraduate students read a published peer-reviewed article (Table 1) that is relevant to the main topic of the module lesson for that week. For example, in Module 1, Developing a title and developing research questions, students are assigned to read a published peer-reviewed article for the purpose of understanding how the author(s) organize the research report, and each student is required to write a reflection on how the author(s) organize the research report.

During the first session of the class, the assigned article is presented to the students digitally, using a projector, and we discuss how to critically analyze the published peer-reviewed scientific article. In subsequent modules, the assigned article (listed in Table 1 for that class) is projected digitally and discussed relative to the assigned topic for that module by encouraging student participation in the discussion; this generally lasts 30-45 minutes of a 150-minute class. Following this initial session, students participate individually or collaboratively work on their assigned tasks related to the module for that week.

During these weekly sessions / modules, the detailed discussion of the digitally projected paper includes: title, abstract, and keywords, followed by specific aspects of the main text of a manuscript, i.e., Introduction, Materials and Methods, Results, and Discussion (IMRAD structure). Further attention is given to technical aspects such as categories of research instruments, proper composition of cited references, and APA writing style.

During the second session of the class, after the digital presentation of the article, students with similar research interests (e.g., genomics, general biology, environmental science, chemistry, etc.) pair-up with each other to discuss with their colleagues their progress with developing ideas and plans for writing a formal publishable scientific paper. This includes analyzing and discussing their writing, as well as practicing their oral presentation that they eventually will present to the class. Moreover, they obtain mutual feedback from their colleagues. This session typically lasts for 45 to 60 minutes. Additionally, during the second session of the class, the course assignment focuses on an oral digital presentation (Microsoft PowerPoint, Prezi, or Canva) of the research topic, not a written formal manuscript. Finally, during the remaining time, undergraduate students discuss with the instructor about their progress and receive constructive oral and written feedback relevant to their current writing progress on

Week	Title of Article	Relevancy
Module 1: Writing Your First Research Paper	*How to write Your First Research Paper.* Kallestinova, E. D. (2011).	To understand what the characteristics are of writing a research paper. What is the topic of the paper? Why is the topic important?
Module 2: Developing Your Title	*Creating Effective Titles for Your Scientific Publications.* Bowman, D., & Kinnan, S. (2018).	To understand what the characteristics of a good title for a peer-review journal are?
Module 3: Developing Your Abstract	*Writing good abstracts.* Alexandrov, A. V., and Hennerici, M. G. (2007).	To understand how to develop an abstract and what to include.
Module 4: APA Guidelines and References	Purdue OWL: APA Formatting and Style Guide (7th Edition)	To understand and provide instructions to writers for accurate IMRAD, citations and formatting.
Module 5: Developing Your Literature Review	*Ten Simple Rules for Writing a Literature Review.* Pautasso, M. (2013).	To understand and demonstrates and cites an understanding of a particular topic.
Module 6: Presentation of a Scientist	*Ten simple rules for effective presentation slides.* Naegle, K. M. (2021).	To understand and provide opportunities to highlight one's research and connecting your audience with the content knowledge.
Midterm Examination		
Module 7: Collaboration in STEM	*Collaborative learning in higher education: Evoking positive interdependence.* Scager, K., Boonstra, J., Peeters, T., Vulperhorst, J., & Wiegant, F. (2016).	To understand the benefits of interacting between two or more research groups to share resources and increasing scientific research.
Module 8: Developing Your Methods Section	*The Principles of Biomedical Scientific Writing: Materials and Methods.* Ghasemi, A., Bahadoran, Z., Zadeh-Vakili, A., Montazeri, S. A., & Hosseinpanah, F. (2019).	To clearly explain the research design and methods (including the materials used, study procedures, data collected and analysis to be used), while providing how other scientists could replicate the study.
Module 9: Developing Your Limitations Section	*Discussing study limitations in reports of biomedical studies-the need for more transparency.* Puhan, M. A., Akl, E. A., Bryant, D., Xie, F., Apolone, G., & Riet, G. T. (2012).	To understand how to provide honesty and transparency by noting any limitations of the study.
Module 10: Developing Surveys and Questionnaires	*Designing a questionnaire.* Jenn, N. C. (2006).	To understand how to measure perceptions of questionnaire respondents that otherwise may be unobservable characteristics such as attitudes, beliefs, and/or behaviors.
Module 11: Developing References, Tables, Charts, and Figures	*Utilizing tables, figures, charts and graphs to enhance the readability of a research paper.* Divecha, C. A., Tullu, M. S., & Karande, S. (2023).	To understanding and extrapolating the data from one's research to promote accurate visuals in STEM
Module 12: Oral Presentation	*How to deliver an oral presentation.* Wellstead, G., Whitehurst, K., Gundogan, B., & Agha, R. (2017).	Demonstrating your work, content knowledge, and expertise by providing an effective presentation.
Final Examination		

Table 1. Peer Review Articles for Undergraduate Students to Read and Provide a Reflection

each of the major sections of their presentation (title, abstract, keywords, introduction, etc.) because constructive "feedback is an important aspect of education that allows students and instructors to engage in a process of reflection and improvement to enhance learning" (Camarata & Slieman, 2020, p.1). After the instructor reviews the details of each student's progress, individually, the instructor encourages the students to discuss and revise their digital presentation, which will be presented orally to their colleagues, including guidance and feedback from the instructor. Subsequently, for each module per week, the same fundamental instructional format is used.

For the oral midterm presentation and oral final presentation, undergraduate students develop their presentations using a digital presentation software (Microsoft PowerPoint, Prezi, or Canva) to enhance their audience's (their colleague's) understanding of the topic that is being presented. This consists of the general organization used for a formal scientific report, including a research title, abstract, keywords, the IMRAD structure, references, and proper formatting.

Asessment

Generally, assessments are conducted through written examinations, such as multiple-choice questions, multiple short answer items, and essay questions to assess each students' knowledge of the course content (Schuwirth & van der Vleuten, 2003). Additionally, assessments include reviewing the grammar and appropriate organization in their weekly written reflections of the assigned published peer-reviewed article (e.g., proper use of APA formatting, and structural aspects such as clarity, pacing, and organization of their thoughts) and the quality of the content in their oral midterm and oral final presentations.

The instruments used to evaluate the students' oral midterm and oral final presentation were the Peeters, Sahloff, and Stone (2010) rubric, as described more fully in the subsequent section titled Assessments for the Oral Midterm Presentation and Oral Final Presentation, and a rubric designed by the author (Table 2 and Table 3). Rubrics have been used for assessing and improving undergraduate students' public speaking skills, and they are used to guide and improve the students' nonverbal skills and verbal skills (Allen & Tanner, 2006; Peeters, Sahloff, & Stone, 2010). Moreover, an assessment is made of each student's midterm presentation (i.e., summary containing the title of their proposed research, abstract, keywords, introduction, research question(s), literature review, APA formatting, and references).

The final examination is an oral digital presentation that is more complete, containing all the elements in the midterm, plus methods, limitations, and visuals such as tables / figures / charts or graphs. This also provides an opportunity for self-reflection and self-improvement to enhance the students' learning of what they should and should not do for future presentations. After the oral midterm and oral final presentation, each student was invited to participate in a voluntary interview, and were asked the following assessment questions adapted from Corwin, Prunuske, and Seidel (2018):

What did you take away from the presentation?

Did you gather good ideas during the one-on-one session when we spoke with each other?

Were the questions and comments you received useful for advancing your work? If you were to present this work again, what changes might you make?

DEVELOPMENT: Developing the Scientific Writing Course

All of our undergraduate students who are majoring in a STEM field enroll in this course to increase their level of academic writing skills. Moreover, for the instructors who teach in the discipline of STEM, "instructors rarely have time to teach writing skills or provide students with substantial feedback on papers to help improve their writing" (McRell, Wilson & Levkoff, 2021, p. 2). To provide a seamless, yet challenging course for novice undergraduate STEM students, the writing course was established to encourage and increase our undergraduate STEM students' abilities to understand and apply principles of scholarly writing. For our undergraduate STEM students, the significance of scholarly writing was highlighted as it relates to academic success, future employment, and job security (Bartlett, Arslan, Bankston & Sarabipour, 2021; Naidoo-Chetty & du Plessis, 2021); and those undergraduate students who currently had a professor or a mentor, besides the instructor for this course, were asked to further collaborate with that mentor in the development of their current research project. The mentor acted largely independently with the undergraduate student to provide support for the student with their writing and presentation skills to augment the advice of the course instructor who also encouraged development of strategies to improve writing quality, sustain enthusiasm, and provide constructive feedback.

In the future, the mentors, in addition to the course instructor, could be encouraged to participate in the evaluation of the oral midterm and final presentations to provide additional guidance and serve as scorers for the quality of the presentations, thus possibly increasing the level of student feedback and increase the reliability of the assessments.

Using APA Format for Scientific Writing in Comparison to Other Formatting Styles

Generally, one of the following writing styles is used in preparing scientific published papers: APA as cited above, American Medical Association (AMA), NLM (National Library of Medicine, also known as the Vancouver style), Modern Language Association (MLA), and Harvard. However, other styles used in specific STEM fields include: Institute of Electrical and Electronics Engineers (IEEE) style (widely used in technology and engineering) and American Mathematical Society style (a variation of Chicago style used in Mathematics). As explained more fully above, this course specifically emphasizes the use of APA format.

For novice writers, the task of developing, writing, and submitting a scientific research manuscript suitable for submission to a peer-reviewed journal is arduous (Busse & August, 2021); and we specifically use the APA format to make these initial learning experiences more tractable for undergraduate STEM students.

PEDAGOGY: How the Scientific Writing Course is Taught

Educators have used a myriad of learning styles, which are also commonly referred to as learning modalities, that have been used by educators to address the needs of their students who may have different learning and cognitive abilities (Romanelli, Bird & Ryan, 2009). Learning styles can be defined as the process of how students with different cognitive and psychosocial behaviors perceive, learn, interact with, and utilize information more effectively (Romanelli, Bird & Ryan, 2009; Lwande, Muchemi & Oboko, 2021). Many learning style frameworks, such as the Visual, Aural, Read, Write, Kinesthetic (VARK) model, emphasize how learners acquire information through their senses, commonly referred to as multimodal learning styles (Childs-Kean, Edwards & Smith, 2020). A very important skill that future STEM researchers / practitioners must develop is the ability to effectively communicate their research through the writing and presenting process, as learning to communicate effectively is a learning style of its own. (Ley, Kisielewska, Collett & Burr, 2019).

The Visual, Aural, Read/Write, Kinesthetic (VARK) Model

The VARK framework provides a concise model for the students to gain initial skills in scientific writing and encourages learners to actively engage with a research topic aligned with their academic majors using multimodal skills and strategies. The scientific writing course was specifically structured for the undergraduate students to use the VARK framework. This framework emphasizes how learners acquire information styles using "4 perceptual modes: visual (V), aural (A), read/write (R), and kinesthetic (K)" (Chinnapun & Narkkul, 2024, p.895). By utilizing the VARK framework for undergraduate students learning, writing, developing, and presenting process, they

are better prepared to collaborate with a researcher / mentor to potentially pursue the proposed research and prepare a publishable scientific report (Ojeh et al., 2017). The use of the VARK was emphasized by the instructor to help the undergraduate students better understand their research topic while empowering them to utilize their preferred multimodal skills. For example, some students were able to better understand and learn the material using the visual skills (visual: V) when presenting their references, tables, charts, and figures in Module 11, while other students were able to better understand and learn the material by listening (aural: A) to the instructor's lectures. Use of the VARK framework provided tailored one-on-one pedagogy to enhance the learning experiences for the undergraduate students and better prepared them for their oral presentations.

As the instructor reviews the details with each of the undergraduate students (as previously mentioned) the instructor asks structured background questions. For example, What is a current problem that exists in your discipline? How will your research add to the current literature that exists? How will your research be different from other research studies? These types of questions help undergraduate students to better understand the concepts related to the learning and writing process, the writing culture, and how to critically reflect on their goals and research skills, as they engaged with the week-by-week learning modules.

For this scientific writing course, undergraduate students are provided academic learning resources, visualizations, and a writing and presentation-intensive format to exemplify the structure and content per each section. This includes exemplars from peer-reviewed published articles, checklists, lectures and a detailed overview of the APA style format, including an oral presentation by the students on each section of their scientific research manuscript in front of their colleagues.

IMPLEMENTATION

Temple University Student Success Center

For this course, the online resources of the Student Success Center at Temple University (available at the following URL https://studentsuccess.temple.edu/programs/writing) were used to support the realization of the course objectives. The substantial resources of the Student Success Center are very influential for student success in the field of academic writing. More generally, the use of writing centers within the field of STEM education has been well established and has shown benefits for undergraduate and graduate students' academic success (Petrella & Jung, 2008; McGurr, 2020) including improved STEM learning, and pragmatic outcomes such as presentation skills, increased academic engagement and academic performance (Petrella & Jung, 2008). Students are required to attend one session at the Student Success Center to improve their general writing format, develop a better understanding of the APA format, and develop writing strategies to incorporate within their STEM field / major.

Assessments for the oral midterm and oral final presentations

In many fields of research, presentation skills are essential to reaching a pinnacle in such professional abilities such as discussing one's research, sharing research discoveries and / or findings, engaging with an audience, and networking with others in the same field of expertise (Stuart, 2013). A significant aspect of presenting research outcomes in a formal meeting is typically followed by a question-and-answer session involving the presenter and audience.

Implementing a presentation for the oral midterm and oral final examination offers several benefits for the undergraduate students (Corwin, Prunuske & Seidel, 2018), which include, active learning, engagement in learning, receiving constructive feedback from colleagues and instructor, and improved confidence. More importantly, the oral presentation is effective for teaching and evaluating undergraduate students as they develop their communication and pacing skills.

At the midterm, each undergraduate student made an oral presentation of their proposed topic, using a concise format that included the presentation characteristics summarized in the rubric (Table 2) that was used to evaluate the oral midterm presentation.

Presentation components and attributes	Meets expectations	Partially meets expectations	Does not meet expectations
Title accuracy	Title contains accurate information and clearly represents the content of research reported in the presentation.	Title contains partially accurate information and clearly represents the content of research reported in the presentation.	Title contains inaccurate information and/or does not clearly represent the content of research reported in the presentation.
Title formatting	Title is bold and centered with authors' names appear one single-spaced line below the title.	Title is bold and not centered with authors' names appear one double-spaced line below the title.	Title is not bold and not centered with authors' names appear one double-spaced line below the title.
Abstract formatting	The word Abstract is centered and bolded below the title and the main paragraph of the abstract should not be indented and should not have any citations of other	The word Abstract is either centered or bolded but not both and has no citations.	The word Abstract is either centered or bolded but not both, and has a citation.
Abstract accuracy	The Abstract is accurate, highlighting the most relevant information from the research.	The Abstract contains partially accurate information, highlighting the most relevant aspects of the research.	The Abstract does not fully contain accurate information and does not fully highlight the most relevant aspects of the research.
Keywords formatting	The term *Keywords* is italicized, aligned to the left followed by a colon, and the keywords are written in lowercase.	The term *Keywords* is italicized but not aligned to the left followed by a colon, and the keywords are written in lowercase.	The term *Keywords* is not italicized or not aligned to the left or not followed by a colon, and the keywords are written in upper and/or lowercase.
Keywords accuracy	*Keywords* accurately represent the research reported in the presentation.	*Keywords* partially represent the research reported in the presentation.	*Keywords* inadequately represent the research reported in the presentation.
Introduction: Topic identification	Clearly introduces the topic.	Partially introduces the topic.	Does not clearly introduce the topic.
Introduction: Problem identification	Clearly identifies a problem.	Partially identifies a problem.	Does not identify a problem.
Literature review	Literature review highlights research from a peer-reviewed author(s) that identifies what has been written on a subject or topic	Partially highlights research from a peer-reviewed author(s) that identifies what has been written on a subject or topic.	Does not highlight research from a peer-reviewed author(s) that identifies what has been written on a subject or topic.
References	References are fully consistent with APA format.	References are partially consistent with APA format.	References are not consistent with APA format.
APA formatting	Is consistent with APA order, structure, and format.	Some aspects of the presentation are consistent with APA formatting.	Is not consistent with APA order, structure, and format.

Table 2. Rubric for evaluating undergraduate students' midterm oral presentation.

In addition, the Peeters, Sahloff, and Stone, (2010) Rubric was also used to evaluate undergraduate students' oral midterm presentation. The Peeters, Sahloff, and Stone, (2010) Rubric included 2 dimensions related to the quality of their oral delivery: Nonverbal skills and verbal skills. For example, the nonverbal skills included eye contact,

notecards / notes, facial expression, composure, gestures / distracting mannerisms, and posture; and the verbal skills included enthusiasm / vocal pitch, articulation / pronunciation, rate of speech and volume. Undergraduate students were provided 5-8 minutes to present their concise proposed research. At the midterm, each undergraduate student made an oral presentation of their proposed topic, using a concise format that included the presentation characteristics summarized in the rubric (Table 2) that was used to evaluate the oral midterm presentation.

Based on the evaluation of each undergraduate students' performance, using Rubric 2, and the Peeters, Sahloff, and Stone, (2010) Rubric, they were provided oral and written constructive feedback by the professor. Based on that feedback, they prepared and presented a more complete oral final presentation at the end of the semester, as evaluated by using a more detailed rubric shown in Table 3. The additional items in the rubric are as follows: Methods formatting, Methods accuracy, Visual formatting, and Visual accuracy.

Results of the assessment using the rubric including constructive feedback to the undergraduate students

Using the rubric in Table 2, the mid-term oral presentations of 130 undergraduate students were analyzed (19 undergraduate students in 2023; 48 in 2024; and 63 in the 2025 academic year). During the mid-term oral presentation, undergraduate students have the option to use either Microsoft PowerPoint, Prezi, or Canva. Undergraduate students were provided advice regarding the quality of their oral presentations using the rubric in Table 2 and the Peeters, Sahloff, and Stone (2010) Rubric, to particularly guide the improvement of their final presentation at the end of the semester. The rubric in Table 3 was used to evaluate the final oral presentation. The results of applying the rubric for the oral midterm are shown in Table 4.

Presentation components and attributes	Meets expectations (Percentages)	Partially meets expectations (Percentages)	Does not meet expectations (Percentages)
Title accuracy	58	22	20
Title formatting	55	32	13
Title affiliation(s)	69	26	5
Abstract formatting	59	30	11
Abstract accuracy	51	33	16
Keywords formatting	53	29	18
Keywords accuracy	65	15	20
Introduction: topic identification	57	20	23
Introduction: problem identification	33	18	49
References	32	28	40
APA formatting	41	29	30

Table 4. Results expressed as percentages of applying the rubric to the sample of 130 undergraduate students' oral midterm presentations.

Constructive feedback

In addition to the rubric feedback provided by the instructor, undergraduate students met with each other and practiced their presentation every other week, prior to the oral midterm and oral final presentation. Constructive feedback (student-to-student and instructor-to-student) provided each student with personalized information based on direct observation, intended to help them achieve their best potential for developing self-awareness, professional development, self-improvement, articulation, and pacing (Brooks, 2022). Additionally, undergraduate students were highly encouraged to increase their proficiency in composing their oral presentation, by

Presentation components and attributes	Meets expectations	Partially meets expectations	Does not meet expectations
Title accuracy	Title contains accurate information and clearly represents the content of research reported in the presentation.	Title contains partially accurate information and clearly represents the content of research reported in the presentation.	Title contains inaccurate information and/or does not clearly represent the content of research reported in the presentation.
Title formatting	Title is bold and centered with authors' names appear one single-spaced line below the title.	Title is bold and not centered with authors' names appear one double-spaced line below the title.	Title is not bold and not centered with authors' names appear one double-spaced line below the title.
Abstract formatting	The word Abstract is centered and bolded below the title and the main paragraph of the abstract should not be indented and should not have any citations of other	The word Abstract is either centered or bolded but not both and has no citations.	The word Abstract is either centered or bolded but not both, and has a citation.
Abstract accuracy	The Abstract is accurate, highlighting the most relevant information from the research.	The Abstract contains partially accurate information, highlighting the most relevant aspects of the research.	The Abstract does not fully contain accurate information and does not fully highlight the most relevant aspects of the research.
Keywords formatting	The term *Keywords* is italicized, aligned to the left followed by a colon, and the keywords are written in lowercase.	The term *Keywords* is italicized but not aligned to the left followed by a colon, and the keywords are written in lowercase.	The term *Keywords* is not italicized or not aligned to the left or not followed by a colon, and the keywords are written in upper and/or lowercase.
Keywords accuracy	*Keywords* accurately represent the research reported in the presentation.	*Keywords* partially represent the research reported in the presentation.	*Keywords* inadequately represent the research reported in the presentation.
Introduction: topic identification	Clearly introduces the topic.	Partially introduces the topic.	Does not clearly introduce the topic.
Introduction: problem identification	Clearly identifies a problem.	Partially identifies a problem.	Does not identify a problem.
Literature review	Literature review highlights research from a peer-reviewed author(s) that identifies what has been written on a subject or topic	Partially highlights research from a peer-reviewed author(s) that identifies what has been written on a subject or topic.	Does not highlight research from a peer-reviewed author(s) that identifies what has been written on a subject or topic.
References	References are fully consistent with APA format.	References are partially consistent with APA format.	References are not consistent with APA format.
APA formatting	Is consistent with APA order, structure, and format.	Some aspects of the presentation are consistent with APA formatting.	Is not consistent with APA order, structure, and format.
Methods formatting	Methods is clearly organized and well-detailed and methods and materials are explained.	Methods is partially clearly organized, but some aspects of the methods and materials are not clearly explained.	Does not clearly explain the methods and materials.
Methods accuracy	Methods are accurately designed and fully explained.	Methods are partially accurate but may not be fully explained.	Methods are not accurately designed and/or are not fully explained.
Visual formatting	Visuals are easy to interpret and visualize and are labeled and formatted correctly.	Visuals are labeled but are difficult to interpret; or are too small; or are not formatted correctly.	There are no visuals.

Table 3. Rubric for evaluating undergraduate students' final oral presentation.

using the "3 Ps": (1) planning; (2) practice; and (3) persistence (Madsen & Starnes-Ott, 2017). The results of using the rubric to evaluate the undergraduate students' final oral presentations are shown in Table 5.

Presentation components and attributes	Meets expectations (Percentages)	Partially meets expectations (Percentages)	Does not meet expectations (Percentages)
Title accuracy	63	34	3
Title formatting	60	34	6
Title affiliation(s)	69	28	3
Abstract formatting	63	31	6
Abstract accuracy	53	40	7
Keywords formatting	59	26	15
Keywords accuracy	69	14	17
Introduction: topic identification	60	20	20
Introduction: problem identification	45	25	30
Methods formatting	46	30	24
Methods accuracy	44	34	22
References	42	33	25
APA formatting	68	25	27
Visual formatting	60	33	7
Visual accuracy	47	44	9

Table 5. Results expressed as percentages of applying the rubric to the sample of 130 undergraduate students' oral final presentations.

Oral and written feedback advice from the instructor to the undergraduate students

Based on the assessment results of applying rubrics in Table 2 and Table 3 and the Peeters, Sahloff, and Stone (2010) Rubric, each undergraduate student was given oral and written constructive feedback from the course instructor. Some of the common feedback themes are as follows:

- Your title page was not properly formatted
- The term Keywords must be proceeded by a colon, not a semicolon and the first word is capitalized, aligned to the left in alphabetical order
- There was a lack of references in the introduction
- A visual is present, but there is no mention of it prior to introducing it
- Visual is not properly labeled
- Your literature review was not properly formatted and/or is not labeled
- You have definitions listed, and this should be written in paragraph form with citation
- Your references are not properly formatted using APA format
- The abstract and introduction should not have bullets
- The abstract and introduction should be centered and bold
- The Methods should be written in paragraph form
- You did not include a dimension for the Likert scale survey
- You did not include a questionnaire
- You used the term conclusions, when you did not perform the research
- Your pacing was too fast
- You were not looking at the audience
- You were reading verbatim
- You are not properly citing using APA format

Discussion

The focus of developing this scientific writing course was to introduce undergraduate STEM students to the genre of academic writing formats, while specifically using the APA format as the preferred style for the course. Undergraduate STEM students were encouraged to choose a research topic in their field of expertise that aligned with their major and begin the IMRAD writing structure. Although the majority of undergraduate students that major in a STEM field are rarely taught how to present their research interest and accomplishments (Corwin, Prunuske & Seidel, 2018), most undergraduate students are interested in improving and enhancing their writing and presentation skills and strategies (McRell, Wilson & Levkoff, 2021).

The results reported in Tables 4 and 5 indicated that the midterm and final oral presentations were largely successful. For example, for the Presentation components and attributes: Title accuracy, with respect to the rubric criterion of not meeting the expectations, there was a considerable improvement with a decrease from 20% in the undergraduate students' oral midterm to 3% for their oral final presentation. Bowman and Kinnan (2018) point out that there are several factors that characterize an effective title, including length of the title, punction use, proper grammar use, and clearly stating the point of the article. Some of the students at the midterm had difficulty with developing and improvising their titles because they did not review the advice from their instructor. There was other evidence of improvement for the Presentation components and attributes titled: References, with respect to the criterion of not meeting expectations. The percentage midterm presentations was 40% and the percentage at the final presentation was 25%. Although there was evidence of student success, there was also evidence of some challenges. For example, for the Presentation components and attributes titled: Introduction: topic identification there was a minimal decrease from 23% for the oral midterm presentation, to 20% for their oral final presentation of not meeting the expectations. This appears largely due to the students not fully understanding how to convey basic information, using the simple present tense. For the Presentation components and attributes titled: Introduction: problem identification, and with respect to the criterion of not meeting the expectations, there was a decrease from 49% for the oral midterm presentation to 30% for their oral final presentation. This improvement most likely was due to the students not initially comprehending how to identify a problem in the field of research.

Teaching scientific writing skills to undergraduate STEM students such as this particular course is promising and requires any college level instructor to modify their pedagogy, curriculum, rubrics, and learning needs for their students. This course can easily be adapted and implemented with other courses at the undergraduate and graduate level in academia.

Conclusions

Building on existing research in the field of scientific writing, curriculum development, and pedagogy, and based on the undergraduate students' experiences presented in this research, one of the benefits of this scientific writing course was to positively influence and increase the level of scientific writing proficiency, presentation skills, collaboration, and research interests among STEM undergraduate students. These educational aspects include careful attention to planning and preparation, appropriate classroom instruction, allocating one-on-one time with the student, and the willingness to seek and provide feedback from the students of how they perceived their experience with the course. As previously described, receiving constructive feedback during the writing and presentation process was one of the key factors that helped improve overall undergraduate student writing.

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Adam Stefanile says: As a lifetime urban educator, I believe the need to educate students beyond a unidimensional approach of increasing diversity by preparing students from underrepresented groups in STEM by developing pedagogical strategies that embrace the diversity of each student. I have demonstrated, and continue to demonstrate, this in an urban classroom by engaging students in computer-based learning utilizing genomic/genetic interactive websites that address their personal characteristics (genome) as well as ethical, legal, and social challenges. Utilizing an inclusive pedagogical framework has fostered the development of my students as a community of learners that embrace their differences and are able to use these differences to support their learning. A consistent goal of my pedagogy is to maintain efforts to promote the development of communication and interdisciplinary STEM skills, which will lead to the integration of classroom diversity and collaborative learning.