Developing a Faculty Learning Community to Support Writing across Different STEM Disciplines

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Developing a Faculty Learning Community to Support Writing across Different STEM Disciplines

Abstract

Writing to learn is one of the very important pedagogical strategies in a variety of disciplines. This concept is not specifically addressed in the majority of engineering courses. Hence, university initiatives such as the Quality Enhancement Plan (QEP), emerging out of accreditation and institutional assessments, are focusing on infusing scholarship from other disciplines (in this case English) for the purpose of student learning improvement. Engineering and Science programs do include various courses in English Composition as the part of the curriculum; however, writing is not embedded in all discipline-specific courses at the upper-division level. The program outlined here focuses on the exploration of possible methods for engineering and science faculty to embed more writing assignments in their STEM courses so that undergraduate students can adequately transfer what they learned from English courses and apply it in their specific discipline once they attain higher proficiency (at the junior and senior level). The project presented in this paper included the creation of a Faculty Learning Community (FLC) composed of English, Engineering, and Science scholars, with the goal of developing writing assignments that enhance student learning while also building off of writing concepts students learn in introductory writing courses. This paper evaluates the effect of the FLC on student learning and on faculty professional development.

Introduction

In his "Wisconsin Experimental College," Alexander Meiklejohn[1] proposed a design for education that aimed to teach democracy and intrinsic appreciation for learning. The pedagogical approaches adopted by the Experimental College included students and advisers living in the same facility, and students working on interdisciplinary projects. These two aspects, together with the experiential education (learning by doing) put forth by education pillar John Dewey,[2] are often considered the seminal ideas for Learning Communities. The adoption of learning communities in the 1970s and 1980s resulted in higher grades, retention, and intellectual development.[3] Not surprisingly, the popularity of learning communities has risen in the last fifty years.[4] The creation of these communities benefit not only the students but also the faculty.[5-7] Therefore, the faculty learning community was chosen as a method of choice for the project presented in this paper to enable infusion of writing studies scholarship (that is not necessarily available to the STEM faculty) into their writing assignments so that they can support student learning and development of writing skills that are developed in the previous years in courses within the English department.

Enhancing Student Learning through Writing

Vázquez et al. (2012)[8] promote writing as a means to determine content that is superior to simply reading a textbook. They contrast *summary* with *explanatory* writing. These two types of writing have different goals and assume audiences with different background levels. Review writing assignments are perceived as exercises on how to arrange facts and tend to focus on reproduction, restatement, and rephrasing of ideas that can be retrieved from the number of

different sources. This usually results in lower quality writing. On the contrary, writing that is perceived as creating an argument often results in higher quality writing.[8,9] According to Coleman *et al.* (1997), students who write *explanations* not only achieve a greater understanding of the subject but also superior writing quality when compared to writing summaries.[9]

Not only are writing assignments useful for learning content, but also they may also be used to reach beyond the classroom. Note-taking or low-stakes writing assignments can provide a path into online digital repositories and ePortfolios that would help students share their work with a much wider audience. This online data sharing of written work might include peer reviews and written instructor's feedback. Those methods are especially important in online student learning communities in which projects can mimic future job tasks as a part of a global workforce. Today, various STEM careers do include online data share of written documents and include collaborative writing tasks.[10]

Writing in Math-Intensive Courses

Students who are taking courses with intensive mathematics often have to create their homework or project reports using software that includes equation editing tools such as Equation Editor in MS Word or LaTeX, both of which influence students' thinking and computation process.[11] A writing process is often defined as non-linear, a process that includes revisions, edits, changes in the structure, and final polishes. It requires a lot of patience and use of in-depth thinking. With writing processes that include mathematical context, the output of student writing is usually a description of problem solution, often in forms of equations, a table, and a visual representation of such solution through a graph or figure.[11] Solving mathematical problems on scratch paper is not the same as solving problems in mathematical software of presenting them through word processing documents.[11] Offering information related to the problem solutions through the use of software might help students to reveal mathematical errors faster than if they are written in handwriting.[11] But writing for such a homework or project involves more than the mathematical equations. Oftentimes discussions of the results, analysis of different solutions or arguments towards one solution versus another requires actual writing, where proper writing skills are necessary to make a precise analysis and to convey the intended idea. Using a mathematical result as an argument is an important skill that students need to develop. Teachers in math-intensive courses are aware of this reality, but are not necessarily equipped with a background in writing pedagogy to help students along in this process. More interdisciplinary work specifically on pedagogy and teaching practices is needed to better meet these needs.

Methods

The main idea that drove the creation of this project was to engage faculty in a learning community that would assist them in identifying and crafting of new writing assignments that can be deployed in their junior and senior level courses. The idea was that integrating English faculty with Engineering and Science faculty with specific attention to developing writing assignments would yield productive results for students while also building stronger connections between the scholarship on writing and rhetoric and STEM education. It was exploratory in nature, focused on a grounded theory.[12] There were 3 overarching, conceptual phases in this faculty learning community and our subsequent study:

1) **Discovery**. Driving question: *What are the main communicative practices needed by STEM students in the workplace?* This phase will focus on the identification (through workplace-based research and faculty consulting of workplace "best practices") of the main communicative practices that STEM students will use in their future careers.

2) **Mapping**. Driving question: *What are the main communicative practices currently used by STEM students in upper division courses?* A conceptual map will be created (based off uploaded student work) of the strategies and practices currently being employed in upper-division UG courses.

3) **Development**. Driving question: *What are the writing-based activities that could be embedded into STEM courses to address this gap, if identified, in the current practices?*

A workshop series was delivered in the Fall of 2014 and the Spring of 2015, with a primary focus of researching discipline-specific conventions and curricular writing goals that are tailored to upper-division STEM students. Data collected from faculty who participated in this set of workshops was qualitative in its nature, consisting of sample assignments, student work, and a literature review related to the writing genres in their specific subfields. With the application of grounded theory, faculty developed a theoretical framework that would serve as a baseline for the activities that were embedded in already existing STEM courses. Data included specific sets of information related to the multi-perspective reviews of literature done in a collaborative setting; lists and conceptual mappings of discipline-specific conventions and genres that resulted of multiple discussions among English and STEM faculty during the workshop; professional samples of discipline-specific writing genres provided by participating faculty; student samples of graded writing; and adapted institutional prompts and rubrics that can be applied by the learning community. Writing assignments that were developed during this workshop were implemented in the STEM courses by the faculty who participated in this workshop.

Model of a Faculty Learning Community

This project was funded by the Interdisciplinary Writing Action Project at Old Dominion University, Norfolk, Virginia. The primary purpose of the initiative was to support faculty who wish to learn, develop, and implement learning strategies that improve student writing in the upper-division courses. These courses require higher levels of knowledge, and they are focused on each particular discipline. Hence, continuing to embed writing assignments in classes beyond students' two required general-education courses is necessary to continue preparing them for a future workforce that requires students to transition from the broad academic genres taught in first-year writing to the highly-specialized forms of writing that largely are determined and shaped by disciplinary conventions and expectations. In that way, students can apply the skills they learn in the English Composition courses and use them in their particular disciplinary realm. This learning community was aimed specifically at facilitating that difficult transition by engaging in discussion and creating pedagogical resources.

This project was one of many funded. The assessment and evaluation of the projects are driven by dedicated university faculty that work as part of the Quality Enhancement Plan (QEP). The primary output is integrating developed assignments and projects as regular part of courses. These projects are based on the High Impact Practices (HIPs) identified by the Association of American Colleges and Universities (AAC&U). These activities are then embedded into the writing-intensive courses; collaborative assignments and projects serve as a vehicle of communication for an undergraduate research project; reports are developed related to the undergraduate student internships; and technical reports are developed related to the capstone courses and projects.

The main component of forming a community of scholars was the three-part workshop. Faculty from Science, Technology, Engineering, and Math (STEM) attended these workshops and collaborated in establishing a particular set of writing assignments that they can embed to their existing courses. The main idea was not to replace a current writing instruction provided to undergraduate students in their classes, but moreover to continue it and encase it in their discipline-specific courses. The lead faculty for the workshops in this community were experts in rhetoric and technical writing from the Department of English. Their collaborators on this project were two faculty members from the College of Engineering and Technology. The visiting speaker was Patrick Bahls,[10] a well-known scholar in "writing in the disciplines" (WID) and "writing across the curriculum" (WAC). Workshop participants read and explored his book *Student Writing in the Quantitative Disciplines*.[11] One of the tasks was to investigate and research what kind of writing styles and genres are being used in the engineering curriculum in upper-level courses.

Our Faculty Learning Community had conjoint workshops, lead by faculty from engineering and technical writing, building from Dr. Bahls' talk and book. Our primary focus was on technical writing, as opposed to composition or creative writing. The team focused on investigating what kind of different writing-to-learn techniques can be used in STEM courses to strengthen student writing skills. The faculty also used ground-up approaches through annotated bibliography activity. In this task participants were asked to develop resources and draw conclusions about writing practices/assignment design and were also exposed to the collaborative writing in a digital environment replicable to a wider audience (in Google Docs). The data collection phase included a collection of pre-workshop and post-workshop student assignments from participating faculty.

Workshop Impact on Student Writing: Analysis of Quantitative Data

The research team's main post-workshop question was: "Did the discussion and materials generated by the interdisciplinary faculty learning community have a positive impact on students writing"? The research team used the Interdisciplinary Writing (IDW) rubrics to evaluate student writing assignments that are retrieved from faculty before the workshop and after they have modified their assignments based on the material learned by participation in the Faculty Learning Community. IDW Student Learning Outcomes,[12] as defined by the IDW practices at the Old Dominion University, are:

SLO 1. Students will be able to clearly state a focused problem, question, or topic appropriate for the purpose of the task.
SLO 2. Students will be able to identify relevant knowledge and credible sources.
SLO 3. Students will be able to synthesize information and multiple viewpoints related to the problem, question or topic.
SLO 4. Students will be able to apply appropriate research methods or theoretical framework to the problem, question or topic.
SLO 5. Students will be able to formulate conclusions that are logically tied to inquiry findings and consider applications, limitations, and implications.
SLO 6. Students will be able to reflect on or evaluate what was learned.

The pre-test sample included 158 students (n=84) and post-test included 84 student (n=84). Result scores based on the different units are shown in Table 1.

Table 1: Pre-Workshop and Post-Workshop student scores (range: 1-5) based on IDW Rubrics

Student Learning Objective	**Pre-Workshop**	**Post-Workshop**	**+/-**
SLO 1	2.63*	3.07	+0.44
SLO 2	2.42	3.03	+0.61
SLO 3	2.20	2.96	+0.76
SLO 4	2.18	2.98	+0.80
SLO 5	2.23	3.01	+0.78
SLO 6	2.53	3.04	+0.51
Total Rubric Score	**14.25**	**18.11**	

The assignments scored varied widely, as one can imagine from an interdisciplinary learning community. From engineering reports to political science research designs, the genres covered a broad range of academic and workplace writing. Participating faculty noted that there was a dramatic improvement from student work across all six student learning objectives (SLOs), with specific attention to SLO 4, which assesses students on their ability to use a "theoretical frame," or genre. Since the investigators took a genre-based approach to leading the workshops (as many in WAC/WID would do), we are pleased with these outcomes as it shows that students are becoming more cognizant of the idea of genre and also, more pertinently, that the faculty designing the writing assignments foregrounded the "frames" more than they did in their previous writing assignment designs.

In addition to the scoring of student papers, we also asked all FLC participants to complete pre- and post-test qualitative surveys about their perceptions of writing, teaching, faculty learning communities, and English departments and writing departments' roles on campus. Below are some of the key findings we identified, all taken from the post-workshop survey. Note the stark differences in disciplinary language and assumptions about writing.

Workshop Impact on STEM Faculty: Analysis of Qualitative Data

A questionnaire was distributed to the STEM faculty through an online surveying tool (Qualtrics) and consisted of open- ended questions for the purpose of gathering qualitative responses. They were grouped in the following categories:

1) How did the STEM faculty perceive the role of Writing in STEM Classes?
2) What is the perception of STEM faculty related to the effectiveness of writing in the STEM disciplines?
3) What are experiences of STEM faculty related to the teaching of writing skill development?
4) How did the STEM faculty perceive the role of English Department on campus?
5) What is the relation between the industry practice versus academic requirements?
6) What does the effective writing assignment design look like?

Each of these categories is discussed below.

The Role of Writing in STEM Classes: All participating STEM faculty identified writing as an essential part of the instruction that their students have to receive. Some faculty suggested that the writing is mainly used to summarize the techniques students learned from the class and communicated how well they could apply the skills in a real world application. It helps students express themselves, and it is used to explain concepts. Another class has a research paper during the brainstorming process identifying the past, current and future technology. Some faculty uses scaffolding throughout the assignments starting with the scoping of the concept, preliminary outline, final outline, draft and final paper and feedback throughout the process. Other assignments are an analysis of a research article as well as how to effectively put their thoughts into written words. Writing plays an important role for communication among students and teachers in computer science. Technical writing usually happens in the form of programming comments/technical documents. To enforce writing practice, technical comments and documents are required for every programming assignment. A complete technical report/term paper is required. The technical reports/term papers are collected and graded, where writing assessment will be provided for students.

Effective Writing in the STEM Disciplines: One faculty participant defined “effective writing” as knowing how to convey the idea and explain it. Other suggested that it has to be clear, concise, well organized, supported by the empirical evidence, while another suggested that it serves a purpose of being able to accurately represent sources related to the engineering design process and present them in an academic way. Some see writing as the ability to synthesize and apply course concepts through writing effectively. In computer science, an active writing allows a precise description of programming logic, software product, algorithm implementation, and hardware specifications. They suggest the effective use of structure and adequate citation develop compelling arguments supporting the hypotheses. It has to provide an evidence-based support from the literature review.

The Teaching of Writing: Skill Development: Faculty identified interdisciplinary workshops and reading relevant research as of the most valuable to their skill development related to the teaching of writing. Although STEM faculty used writing as a part of their assignment, they do not identify that they necessarily teach writing to their students. They see it as a central part of the course content as the writing assignment are embedded into their courses. Some saw the downside of embedding writing assignments since some students did not appreciate feedback given to them and that it takes away time that is needed for the course content. They suggested that they emphasize the importance of writing and that it takes a long time to prepare assignments. It requires different skills than for problem-based assignments that can be found in many textbooks for STEM courses. STEM faculty identified the importance of having workshops with faculty from English, Writing Studies, and a use of pre-formed templates as important for their skill development. Some suggested the use of a bank of well-constructed assignment ideas.

The Role of the English Department on Campus: STEM faculty identified the role of English department in the area of educating students to read, express their thoughts academically, and write effectively. They said that they are the tremendous support for one of essential skills for students and faculty from any discipline. English has a crucial role in both undergraduate and graduate levels of instruction. They see importance for the Quality Enhancement Program (QEP) and Interdisciplinary Writing initiatives campus wide. Various STEM faculty are assigned to teach intensive writing courses, and they see value in having mentors from English department to assist them in that process. They acknowledge that they can help both students and faculty to improve their writing and writing teaching skills. The various departments have a different level of interaction with the English department ranging from very little to excellent.

Industry Practice and Genres vs. Academic Requirements: Faculty was split on this answer. Some faculty valued industry-driven approach to the writing examples, others valued more academically-driven writing assignments. Industry practice and genres should inform the writing projects in the upper discipline writing courses. The writing projects should be relevant to the discipline in which they are studying and the career fields in which they are entering so that the skills learned can be applied followed graduation. The academic requirements have to inform projects as these are what provide the foundation for the skills the students must meet and demonstrate to graduate. Other faculty suggested that academic requirements serve the purpose better since they provide direct feedback to students, which are more straightforward and more efficient.

Effective Writing Assignment Design: The process that was identified starts with brainstorming, moves over to the creation of an outline, literature review, first draft completion, feedback, and revision. They identify it as a scaffolded and iterative approach. They suggest starting with the student learning objectives, type of the writing assignment and writing prompts. They see a value of such interdisciplinary workshops in which they will have an overview of real writing assignment samples from faculty from various disciplines. The main reason that STEM faculty identified as important for them to be engaged in such faculty communities is the development of better writing assignments and improvement of students' writing. They see the primary value of sharing resources and development of student writing for work and professional purposes.

Conclusion

These qualitative findings reveal that the benefits of a faculty learning community are bidirectional: They improve student writing in STEM courses by connecting previous writing knowledge to professionalization while also changing faculty perceptions of writing and strategies for teaching writing for the better. Faculty that participated in our learning community have suggested that they would prefer to receive training from a writing expert in their field, an interdisciplinary writing expert, and a practitioner/workplace writing expert. They see a value in an interdisciplinarity of such faculty learning communities. Faculty suggested that writing should adequately assess the course objectives, match Student Learning Outcomes (SLOs), and provide assessment information for accreditation purposes (such as ABET, ITEA, etc). Others suggested that examples of assignments such as scaffolds should be shared within a community, while another suggestion was that writing assignments should allow for students to receive the feedback throughout the course. At the same time, writing should include methods as persuading an audience toward an action. It also needs to be rhetorically-sound and grounded in a firm understanding of audience needs and genre conventions relevant to the context. Effective writing assignments in upperclassman engineering classes should be related to the future job, and students, through their writing, should be learning skills they can apply not only in other courses but also in their career fields upon graduation. The writing assignments have to be closely related to the course and should emphasize concepts and fundamentals. Writing assignments should be embedded with the primary STEM content without significantly increasing study load. Faculty suggested the use of grading rubrics as tremendously helpful in this respect.

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References

1. A. Meiklejohn, "Wisconsin's experimental college". The Journal of Higher Education, vol. 1, pp. 485-490. 1930.
2. J. Dewey, "Experience and Nature". 1925. George Allen And Unwin, Limited. 486 pages.
3. Lewis, C., M. Stopel, J. L. Ricords, T. Cherubini, "Institution-wide collaboration: how learning communities can help". In Bernhardt, Beth R., Leah H. Hinds, and Katina P. Strauch, eds. *Something's Gotta Give! Charleston Conference Proceedings, 2011* (pp. 302-306). Purdue University Press, 2012.
4. Matthews, R.S., Smith, B.L., & MacGregor, J. (2012). The evolution of learning communities: A retrospective. In K. Buch & K.E. Barron (Eds.), *New Directions for Teaching and Learning*: No. 132. *Discipline centered learning communities* (pp. 99-111). San Francisco, CA: Jossey-Bass.

5. M. D. Cox, "Faculty learning communities: Change agents for transforming institutions into learning organizations," To improve the academy, vol. 19, 2001.
6. N. S. Shapiro and J. H. Levine, Creating Learning Communities: A Practical Guide to Winning Support, Organizing for Change, and Implementing Programs. Jossey-Bass Higher and Adult Education Series: ERIC, 1999.
7. L. Richlin and M. D. Cox, "Developing scholarly teaching and the scholarship of teaching and learning through faculty learning communities," New directions for teaching and learning, vol. 2004, pp. 127-135, 2004.
8. A. V. Vázquez, K. McLoughlin, M. Sabbagh, A. C. Runkle, J. Simon, B. P. Coppola, et al., "Writing-To-Teach: A New Pedagogical Approach To Elicit Explanative Writing from Undergraduate Chemistry Students," Journal of Chemical Education, vol. 89, pp. 1025-1031, 2012/07/10 2012.
9. E. B. Coleman, A. L. Brown, and I. D. Rivkin, "The effect of instructional explanations on learning from scientific texts," The Journal of the Learning Sciences, vol. 6, pp. 347- 365, 1997.
10. P. Bahls, "Math and metaphor: Using poetry to teach college mathematics," The WAC Journal, vol. 20, pp. 75-90, 2009.
11. P. Bahls, Student writing in the quantitative disciplines: A guide for college faculty: John Wiley & Sons, 2012.
12. A. Strauss, J. Corbin, J. “Grounded theory methodology”. Handbook of qualitative research, 17, 273-85, 1994.
13. Richards, D., McKittrick, M., Jovanovic, V., Romberger, J., Pazos-Lago, M. Pilar ”Improving Student Writing in the STEM Disciplines, A Faculty Learning Community”, ODU - Quality Enhancement Plan (QEP): Improving Disciplinary Writing (IDW) Action Project, Retrieved on March, 30 2017 from: http://stemflc.digitalodu.com/