2016

Introducing Writing Assignments in Engineering Technology Courses to Enhance Technical Writing Skills and Critical Thinking

Otilia Popescu
Old Dominion University, opopescu@odu.edu

Vukica M. Jovanovic
Old Dominion University, v2jovano@odu.edu

Original Publication Citation

Popescu, O., & Jovanovic, V. M. (2016). *Introducing writing assignments in engineering technology courses to enhance technical writing skills and critical thinking.* Paper presented at the 2016 ASEE Annual Conference & Exposition, New Orleans, LA.

New Orleans JAZZED about Engineering Education

Paper ID #14823

Introducing Writing Assignments in Engineering Technology Courses to Enhance Technical Writing Skills and Critical Thinking

Dr. Otilia Popescu, Old Dominion University

Dr. Otilia Popescu received the Engineering Diploma and M.S. degree from the Polytechnic Institute of Bucharest, Romania, and the PhD degree from Rutgers University, all in Electrical and Computer Engineering. Her research interests are in the general areas of communication systems, control theory, and signal processing. She is currently an Assistant Professor in the Department of Engineering Technology, Old Dominion University in Norfolk, Virginia. In the past she has worked for the University of Texas at Dallas, University of Texas at San Antonio, Rutgers University, and Politehnica University of Bucharest. She is a senior member of the IEEE, serves as associate editor for IEEE Communication Letters, and has served in the technical program committee for the IEEE ICC, WCNC, RWW, VTC, GLOBECOM, and CAMAD conferences.

Dr. Vukica M. Jovanovic, Old Dominion University

Dr. Jovanovic received her dipl.ing and M.Sc. in Industrial Engineering from University of Novi Sad, Serbia. She received a PhD in Technology at Purdue University, while working as a PhD student in Center for Advanced Manufacturing, Product Lifecycle Management Center of Excellence. Dr. Jovanovic is currently serving as Assistant Professor of Engineering Technology, Frank Batten College of Engineering and Technology at ODU. She is teaching classes in the area of mechatronics and computer aided engineering. Her research Interests are: mechatronics, digital manufacturing, manufacturing systems, and engineering education.

Introducing Writing Assignments in Engineering Technology Courses to Enhance Technical Writing Skills and Critical Thinking

Abstract

This study was prompted by the university wide initiative to improve students' technical writing skills across-the-curriculum by introducing low stakes writing assignments as early as in their freshman year. Effective written communication skills are important for engineering education, with critical thinking being one of the most important aspects of the learning process at the college level. However, the efforts in required core curriculum English and communication courses are not always further integrated into engineering curriculum. Introducing a technical paper writing assignment in lower division engineering courses had the purpose of helping students to be better prepared for major writing assignments in their upper division courses as well as for their capstone project. For this study a writing assignment was introduced in an Electrical Circuits course, for electrical engineering technology students at Old Dominion University in fall 2015. At the end of the semester a survey was distributed to the students to evaluate their opinion on the effectiveness of introducing a writing assignment early in their college education. The research also evaluates the students' opinion on how such assignment can help them better understand the concepts studied in class, improve their studying methodology and enhance their critical thinking.

Introduction

Rigorous, logical reasoning has always been the main focus of engineering curriculum[1]. Furthermore, numerous universities have systematic initiatives focused on the improvement of critical thinking and which form the foundation of university wide quality enhancement programs. Many of these programs have as main purpose embedding writing and critical thinking at all levels, starting as early as in the freshman year[1]. A variety of studies, some of them in Electrical and Computer Engineering program[1], some related to students enrolled in the first year design course[2] for example, were gathering longitudinal data on same cohorts of students and have shown statistically significant improvement in students' critical thinking. One of such programs is Quality Enhancement Program (QEP) which is required to be implemented by all accredited schools who falls under The Southern Association of Colleges and Schools (SACS) [1]. Higher cognitive objectives from Bloom's Taxonomy (such as analysis, synthesis and evaluation) or Perry's Scheme of Intellectual Development can be improved by encouraging more writing intensive assignments with emphasize on critical thinking[2,3].

One of the definitions of critical thinking, introduced by Paul & Elder, is: "Critical thinking is the art of analyzing and evaluating thinking with a view to improving it"[4]. A framework for

critical thinking[4] regards it as the application of standards (such as clarity, accuracy, relevance, logicalness and so on) to the elements (such as purposes, questions, concepts, assumptions or implications for example) as we learn to develop intellectual traits (such as intellectual perseverance, confidence in reason, intellectual integrity or fair-mindedness to name a few).

Other projects were focused on the development of core skills (also known as "soft skills") such as informational literacy and academic writing in undergraduate engineering education, and they use a scaffolded design[5]. To maximize student engagement and comprehension the topics were carefully selected, the questions were rigorously formulated, and the resulting writing assignments were embedded into engineering curriculum from the freshman year[6].

Another approach is to integrate lifelong learning skills through technical writing by coordination of formal, non-formal and informal education, in which learning is part of life and it can take place even outside of formal learning environment such as classroom[7]. Lifelong learning is very important especially for electrical and software engineers because the "half-life" of their engineering skills is driven by very rapid changes in technology, much faster than in other engineering disciplines. While this change is estimated to happen every seven years for mechanical engineers, for electrical engineers it happens every five years, and for software engineers every two and half years, or even faster[7]. It was suggested that students can be motivated to perform better in technical writing classes if they recognize the significance of the given assignments to their future engineering career. Although studies suggest that communication is the most important non-technical skill employers look for in IT graduates, students do not consider this a focus of their studies[8].

The feedback provided to students on their technical reports has also been shown to play an important role in their writing skills development[9]. Taylor[9] found out that engineering professors emphasize writing content (61%) more than its form (38%), as opposed to the writing teachers who are more focused on the form (50%) and less on content (36%). Integration of engineering and non-engineering disciplines such as communication was suggested as a provision of more opportunities for technical writing improvement[10].

Engineering communication at workplace is directly related to the engineer's performance as it is the main vehicle for exchanging information related to decision making, problem solving and responsibilities sharing[11, 12]. Some perceive that many engineers have a love-hate relationship with writing. On the one hand they see writing as the most important skill an engineer can possess, but on the other hand they also see writing or documenting as a necessary evil[11]. Jeyaraj[13] mentions both direct and indirect forms of communication as being important in engineering workplace. As an example, some undergraduate engineering courses use the indirect form of communication present in literature books such as "The Goal" to teach about Lean Engineering principles and the job nature of an engineering manager[14].

Writing-across-the-curriculum approach can be integrated with critical thinking with the help of writing prompts, low stakes writing assignments, problem-based assignments and reflections incorporated into engineering courses[15, 16]. While these approaches are currently widely used in

colleges of arts and science, they are not as much embedded into engineering curriculum[17]. Examples of engineering writing assignments can include tasks related to a job search, journals, or instructions for some simple projects such as paper airplanes[18].

Writing across the Electrical Engineering Technology Curriculum

The Electrical Engineering Technology curriculum at Old Dominion University includes several required writing courses, such as English Composition and Engineering Technology Information Literacy/Research in freshman year, followed in sophomore year by English Composition course that culminates with the preparation of a fully-documented research paper. In upper division years Electrical Power and Machinery Laboratory for example is a writing intensive course which requires written reports. A formal written report is finally required for capstone project.

Old Dominion University started a university wide initiative to improve the students' writing skills with emphasis on upper division undergraduate classes. The university Quality Enhancement Plan (QEP) on Improving Disciplinary Writing (IDW) started in 2012 and one of its components is training faculty through a one-week workshop on the best practices to teach and assess writing. Upon completion of the workshop, the IDW team continues to work with participating faculty to assist them in implementing and assessing writing assignments in their courses.

Since the summer of 2012 several faculty in Engineering Technology department (Electrical and Mechanical Engineering Technology programs) attended the training workshop and started to incorporate more writing tasks into their courses. With funding provided by QEP one of these faculty delivered a workshop, "Student Writing in the STEM Disciplines: A Faculty Learning Community", with the participation of three faculty from Department of English and one other faculty from engineering[19]. All participating faculty in the training workshops had constant support and feedback from colleagues in English department and the University assigned QEP faculty lead. During the workshops, examples or detailed presentations from faculty previously enrolled in the writing workshops were included. The QEP team was sending weekly updates to the enrolled faculty. Participating faculty were required to share with the QEP team their writing assignments and the feedback provided was very important in improving the assignments. While most faculty have low stakes writing assignments in their courses on a regular basis, due to time limitations these assignments are not formally assessed. The workshop training helps the faculty in formalizing these assignments and making them strong learning instruments. Through the workshops, faculty receive examples of grading rubrics, assignment examples and tips from faculty from technical writing, literature and communications such that they can adapt these methodologies with less hurdle. One faculty in Mechanical Engineering Technology developed a technical report assignment template as a result of this workshop which later was disseminated to peers in Mechanical Engineering Technology program for consistency.

In spite of the importance of writing to communicate effectively regardless of the work field or area of expertise, there is this misconception that writing skills are not essential in engineering, and a lot of students think that technical writing is required only in upper division courses, for writing research papers or completing theses. However, effective written communication skills are critical for future engineers, as they will require technical writing for submitting reports on work projects or for explaining the choices made regarding the procedure or the equipment selected for projects. The motivation for introducing low stakes writing assignments in lower division courses was to enable engineering students to practice technical writing skills early in their college studies and to stimulate them to use more writing in their process of study. In this context, the study presented here considered the relationship between writing assignments and critical thinking.

An Example of Writing Assignment in an Electrical Circuits Course

One of the courses that implemented a formal writing assignment as a result of the IDW workshop was a lower division course, EET200 - Electrical Circuits II, which is very intensive in learning the technics of circuit analysis. This is one of the stepping stone courses and it has a strong mathematical and problem solving content. The course did not include a semester project that could have been used as the main document for a writing assignment and any writing component in the course should not have taken much weight on the grading scale and was not to become a course objective in itself. With that in mind, several low stake writing items were assigned along the semester including discussions or comments in quizzes, tests or homework assignments, and reflection paragraphs on graded tests, while the main writing component of the course was an end of the semester paper that each student had to prepare on a chosen topic. Topics were selected from the material studied in class and the collection of papers resulted from this assignment were compiled into a class portfolio that was made available to all the students at the end of the semester. The portfolio may be used as a study guide for the final exam or as a reference material for future classes. Students were provided with a detailed writing assignment syllabus that included a statement, writing objectives, details of the actual assignment regarding the requirements and formatting, grading procedure, and a calendar of the intermediate due dates of the assignment. The writing objectives were intended to improve students' critical thinking skills, to reinforce learning objectives, to provide opportunities to apply key concepts, and to enable students to practice their information literacy and research skills by selecting and listing relevant references and synthetizing information on the chosen topic.

The topics for this assignment were supposed to be selected from among the concepts studied in class, such as: inductance, capacitance, voltage divider, current divider, maximum power transfer theorem, superposition theorem, mesh analysis, nodal analysis, steady state conditions for capacitors and inductors, Ohm's law for magnetic circuits, effective resistance, or frequency response of basic circuit elements to give some examples. Along with topic selection students were asked to submit a short reflection paragraph about their choice. The final paper was

expected to contain the main results related to the selected topic, which, depending on the topic, could have been theorems, formulas, examples with commentaries, relationships with other concepts, discussions on related applications, or other relevant information for the chosen topic. The writing format was based on that of IEEE journal papers, and students were expected to be concise and to submit a paper of about 2-3 pages. Through this requirement students were expected to demonstrate that they are able to synthetize the information they had and include the most relevant pieces of information in their course portfolio entry. The ability to efficiently summarize the information and make connections between the concept selected and other concepts studied in the class was expected to stimulate critical thinking in this assignment.

Table 1: Rubric used for grading the writing assignment in Electrical Circuits II course

	Unacceptable	**Marginal**	**Acceptable**	**Max Points**
Title, keywords	Title is not relevant to the topic discussed, keywords are missing or not relevant to the topic, or format is not followed. (0 -5 pts.)	Title is relevant but keywords are not relevant to the topic, missing or not enough. (5-10pts.)	Title is relevant, at least 3 keywords are included and they are very well related to the topic (10-15 pts.)	15 pts.
Main result	It is not clear what is the main result discussed in the paper. The pieces of information included are disconnected and does not form a coherent presentation. (0 -5 pts.)	The main result is somehow stated, but the rest of the information seems to be disconnected with this result (5-10pts.)	Main result is clearly stated, and the rest of the paper is in support of this result. (10-15 pts.)	15 pts.
Amount of information	The paper is missing important pieces of information related to the topic. (0 -5 pts.)	The paper does include the most important pieces of information, but additions to the paper can be made. (5-15pts.)	The paper includes enough information on the selected topic, and it can be used as a reference (15-20pts.)	20 pts.
Related topics	No related topics are discussed. (0 -5 pts.)	Some other topics are mentioned but they are not well chosen, they do not directly relate to the main topic. (5-10pts.)	Other topics related to the selected topic are discussed. (10-15 pts.)	15 pts.
References	No references or irrelevant references listed. (0 -5 pts.)	Relevant references are included, but not in the proper format or not enough of them. (5-10pts.)	Relevant references are included, at least one book and one journal paper, and the proper format is used. (10-15 pts.)	15 pts.
Presentation	Poorly written paper; grammar/spelling errors; no organization; format not followed. (0 -5 pts.)	Paper well written, no grammar /spelling errors, but no section organization or format not followed (ex: no conclusions, introduction) (5-15 pts.)	Paper is well written, format is followed, no grammar or spelling errors, information is well organized in sections. (15-20pts.)	20 pts.
			Total	100

The overall project had a step by step (scaffolding) approach as topic selection was required first, then a list of keywords and a list of references had to be prepared, followed by a draft which was peer reviewed, and the process concluded with the submission of the final paper. Students were

provided with samples of conference and journal papers and were instructed how to use the library databases for relevant references for their selected topic. Particular emphasis was given to the IEEE Xplore database, which is the main resource used by electrical engineers. For this class the assignment emphasized the actual search for references and did not make specific requirements for the actual review of them. Final paper had a 70% weight in the final writing assignment grade and the grading rubric used was included in the assignment syllabus (see Table 1). The remaining 30% of the assignment grade was divided among the other components of the assignment, which had to be submitted during the semester (topic and keyword selection, draft submission, and peer reviews). With each submission step students received feedback on their progress. For the peer review step each student received blind copies of 3 draft papers and they were required to use the grading rubric to provide a grade and to make comments on the assigned draft papers and explain how their grading was done. The peer review grades were not used in the final assignment grade but they were to be used as references to finalize the papers.

Student Feedback on the Writing Assignment

This project was implemented two times in the Electrical Circuits II course, in fall 2014 and 2015 semesters, respectively. Some minor updates were done to the assignment in fall 2015, mostly related to the materials provided to the students, improvement of the grading rubric, and modification of the syllabus to include more details on the grading procedure for the assignment outlining the credit for the partial submissions throughout the semester. In fall 2015 students were also asked to provide feedback on the assignment through an end of the semester survey. Out of 22 students who completed the survey one student did not complete the assignment due to lack of time and of interest in writing, as was mentioned on the survey. Even though this was a sophomore level course, the students' status was distributed with 55% being juniors, 27% sophomores and 18% seniors. While a majority of 86% of the students had prior exposure to technical writing from previous courses, some mentioned in the additional comments that this assignment was helpful in learning about key-words and how to use them for reference searches and better utilization of the electronic resources available in the university library.

The survey includes a list of 16 detailed questions and two separate questions asking for an overall estimate of the assignment. 91% of the students considered that overall this assignment was effective in teaching technical writing skills and 86% of the students considered that overall this assignment was effective in preparing them for future technical writing assignments. The full survey is included in this paper along with the number of answers in each category. From the data included it can be seen that the majority of students agree with the statements in all the questions, and where they were not convinced of the benefit questioned they preferred the undecided rubric, with very few answers in the disagree range. The largest disagreement is seen in the last question, for about 18%, as those students would not like to have more writing assignments in other courses. This came as no surprise since students mentioned with various occasions that they do not enjoy writing assignments. It is important to observe that the largest approval rate of 95%, with 60% in strong agreement, was recorded on the first question, showing

that students understand the importance of technical writing for engineering careers. With such a strong overall agreement we will not include a more detailed statistical analysis of the responses. However, it is important to review the questions and what they tested. The first seven questions are mostly related to technical formatting and the use of references. The majority of students agree that this assignment was a good instrument for teaching these skills. Questions 8-10 ask about the relationship between this writing assignment and studying the course material and the majority of students agreed that the assignment was helpful in this respect as well. The answers for questions 11-12 show the agreement that the assignment was successful in stimulating critical thinking, requiring students to address connections between different concepts. The peer review process, tested by questions 13-14, was also considered beneficial for both receiving feedback on one's own draft as well as for providing opportunity to learn from evaluating others' work. It is encouraging that 77% of the students enjoyed the assignment and agree that it was a good experience (question 15). In their additional comments some students mentioned that they would have wanted this assignment to count more towards the final grade of the course, as it was only weighted for 5%. Also worth noting is the fact that the largest number of undecided answers, 41%, were on question 6 asking how this assignment helped to learn the use of databases and electronic library resources to search for reliable information. While the instructor put a lot of effort in explaining the importance of peer reviewed publications, in their final papers many students still included websites as references and did not search for peer-reviewed reference papers published in journals and conference proceedings.

Conclusions and Future Work

Introducing a technical writing assignment in a lower division electrical circuits course was a positive experience for the instructor as well as the students. The majority of the students participating in the survey agreed that technical writing is important for their career and that the writing assignment used in the study supported the learning process and stimulated their critical thinking. The benefits of using writing in the college education, and the relationship with critical thinking are largely discussed in literature. The results of this study reinforce these aspects, showing that engineering technology students also understand the importance of writing for their education. In the future, implementations of this project may emphasize critical thinking more, as a requirement for the paper could be to select and solve a course related problem and to discuss the concepts involved, the alternative solutions, or an evaluation of the results.

Survey on Writing Assignment

To evaluate the effectiveness of introducing a Writing Assignment in a low level engineering class it **is necessary to ask for honest responses from students that participated in this assignment. Your co-operation is very much appreciated. Your responses are confidential and only anonymous comments and aggregate results will be disclosed.**

Check One: 15-❑ Male 7 -❑ Female

Indicate your major: _____

Which best describes your status: 0-❑ Freshman; 6-❑ Sophomore; 12-❑ Junior; 4-❑ Senior.

What percentage of classes in this course did you attend?
__-__ 0-25% __-__26-50% __2__51-75% __20__ 76-100%

Prior to this class, did you have any assignment involving technical writing?

3-❑ No 19- ❑ Yes

Did you complete your writing assignment for this class?
1-❑ No 21-❑ Yes

If you answered "no" to the previous question, please indicate the reason for not completing the assignment:

_____

Overall, do you find the writing assignment in EET200 class effective in teaching you about writing a technical paper?
2-❑ No 20-❑ Yes

Overall, do you find the writing assignment in EET200 class effective in preparing you for the writing part of future projects?
3- ❑ No 19- ❑ Yes

Please respond to each question on the <u>back page</u> by checking the corresponding column.

		Strongly Disagree	Disagree	Undecided	Agree	Strongly Agree
		1	**2**	**3**	**4**	**5**
1	I consider technical writing important for engineering careers	-	-	1	8	13
2	I find important to learn about scientific paper format	-	-	4	6	12
3	Introducing writing assignments in 200 level classes is beneficial for my success with future projects.	-	1	1	11	9
4	This assignment helped me understand what scientific paper format means.	-	-	4	11	7
5	This assignment helped me understand what key words are and why are they important.	-	-	8	7	7
6	This assignment helped me learn how to use the library data bases when searching for reliable information.	-	1	9	7	5
7	With this assignment I learned about different types of reliable references and how to properly list them.	-	-	4	11	7
8	This writing assignment helped me learn how to select the main results related to a topic and to prepare a summary of them.	-	1	3	15	3
9	I consider that preparing the summary for my selected topic helped me better understand the subject.	-	-	5	11	6
10	Learning how to extract main results/formulas helps me better study for an engineering course.	-	1	6	8	7
11	This assignment asked me to find related topics/concepts to a selected topic and I find this beneficial for my understanding of the concepts.	-	-	3	14	5
12	I consider that finding connections between different concepts stimulates my critical thinking.	-	1	4	9	8
13	I found peer review helpful because I got feedback on my draft	-	1	5	8	8
14	I found peer review helpful because I learned from doing reviews on other students' drafts	-	2	3	10	7
15	I enjoyed this assignment and I consider it a good learning experience	-	2	4	9	7
16	I would like to have more such writing assignments in other classes	1	3	6	8	4

Additional Comments:

Thank you!

References

1. K. C. Welch, J. Hieb, and J. Graham, "A Systematic Approach to Teaching Critical Thinking Skills to Electrical and Computer Engineering Undergraduates," *American Journal of Engineering Education,* vol. 6, pp. 113-123, 12/01/ 2015.
2. R. M. Marra, B. Palmer, and T. A. Litzinger, "The Effects of a First-Year Engineering Design Course on Student Intellectual Development as Measured by the Perry Scheme," *Journal of Engineering Education,* vol. 89, pp. 39-45, 2000.
3. R. Irish, "Engineering thinking: Using Benjamin bloom and William Perry to design assignments," *Language and Learning Across the Disciplines,* vol. 3, pp. 83-102, 1999.
4. R. Paul and L. Elder, *The miniature guide to critical thinking: Concepts & tools* vol. 2: Foundation Critical Thinking, 2001.
5. J. Wilkes, J. Godwin, and L. J. Gurney, "Developing Information Literacy and Academic Writing Skills Through the Collaborative Design of an Assessment Task for First Year Engineering Students," *Australian Academic & Research Libraries,* vol. 46, pp. 164-175, 09// 2015.
6. P. K. Agrawal, "Integration of critical thinking and technical communication into undergraduate laboratory courses," in *Proceedings of the 1997 American Society for Engineering Education Annual Conference and Exposition*, 1997.
7. H. Idrus, A. M. Noor, and M. N. R. Baharom, "Motivating Engineering and Technical Students to Learn Technical Writing by Inculcating Lifelong Learning Skills," *International Journal of Learning,* vol. 18, pp. 191-201, 12// 2012.
8. J. Armarego, "Enhancing Writing Skills in IT Students," *International Journal of Learning,* vol. 18, pp. 1-15, 11// 2012.
9. S. S. Taylor, "'I Really Don't Know What He Meant by That': How Well Do Engineering Students Understand Teachers' Comments on Their Writing?," *Technical Communication Quarterly,* vol. 20, p. 139, 04// 2011.
10. J. D. Ford and L. A. Riley, "Integrating Communication and Engineering Education: A Look at Curricula, Courses, and Support Systems," *Journal of Engineering Education,* vol. 92, pp. 325-328, 2003.
11. C. Prusty, A. K. Dwivedy, and J. Khuntia, "Why and How Do Engineers Communicate?," *IUP Journal of Soft Skills,* vol. 9, pp. 45-50, 2015.
12. B. Richards, H. Alnajjar, A. Ader, R. Adrezin, B. Isaacs, and P. Tempel, "Integrating critical thinking and writing curriculum into freshman engineering," *age,* vol. 6, p. 1, 2001.
13. [13] J. Jeyaraj, "Engineering and Narrative: Literary Prerequisites as Indirect Communication for Technical Writing," *Journal of Technical Writing & Communication,* vol. 44, pp. 191-210, 2014.
14. E. M. Goldratt and J. Cox, *The goal : a process of ongoing improvement*: Great Barrington, MA : North River Press, c2004, 3rd rev. ed., 20th anniversary ed., 2004.

15. J. C. Bean and M. Weimer, *Engaging ideas. [electronic resource] : the professor's guide to integrating writing, critical thinking, and active learning in the classroom*: San Francisco : Jossey-Bass, 2011, 2nd ed., 2011.
16. J. M. Williams, "The engineering portfolio: Communication, reflection, and student learning outcomes assessment," *International Journal of Engineering Education,* vol. 18, pp. 199-207, 2002.
17. B. Gunnink and K. L. S. Bernhardt, "Writing, critical thinking, and engineering curricula," in *Frontiers in Education, 2002. FIE 2002. 32nd Annual*, 2002, pp. F3H-2-F3H-7 vol. 2.
18. J. E. Sharp, B. M. Olds, R. L. Miller, and M. A. Dyrud, "Four Effective Writing Strategies for Engineering Classes," *Journal of Engineering Education,* vol. 88, pp. 53-57, 1999.
19. V. M. Jovanovic, M. McKittrick, P. Pazos, D. Richards, and J. Romberger, "Comparatively Mapping Genres in Academic and Workplace Engineering Environments," *age,* vol. 26, p. 1.