

## Writing-enriched Engineering Courses

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# WRITING-ENRICHED ENGINEERING COURSES

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## Abstract:

This paper presents a writing enriched initiative work in progress for the engineering curricula at the Utah Valley University (UVU). The importance of communication skills for engineering graduates has always been emphasized by most local industries. The verbal feedback received from local hiring managers indicate that engineers spend about 60% of their time at the workplace communicating either orally or in written format. This feedback from industry has been taken seriously at UVU, as the importance for improving the reading and writing skills of college students became more apparent. It is helpful to note that the state of Utah had already taken significant steps to fund and support STEM and English programs. Improving students' ability in mathematics, reading, and writing was the motivation for such an action. A program was initiated to support English programs at K-12 levels in the state, but not at higher education institutions. An engineering Initiative program was also established by the state to aid and strengthen STEM programs in schools and colleges. Therefore, in 2017 UVU decided to establish an internal task force to investigate the reading and writing across the curriculum issue. A Writing-Enriched (WE) Committee was formed to examine various methods to implement a communication requirement for all programs across campus. After one year of brain storming, it was decided to ask each program to develop and designate two Writing-Enriched (WE) courses. The form of writing and communication exercises were required to be specific to each discipline and to be taught by a skilled instructor.

The objective of this paper is to discuss how such initiative was established, its implementation procedure, and future assessment process. The paper also includes details of the university WE requirements, established criteria, and university approval procedures. Methods to fulfill the new WE graduation requirements in UVU engineering programs is also discussed. This includes how the two selected WE courses would complement each other. The paper also discusses the benefits and challenges associated with having a lower-level or introductory course as a WE requirement.

Most programs decided to select courses that already contained or required some writing assignments. Although the measurement of success and assessment for such a graduation requirement are difficult to attain, the WE Committee has begun discussing various methods to accomplish that task. This paper provides the results of this ongoing effort, focusing on the two selected courses in the Mechanical Engineering program. It describes how each course was modified to meet the university WE requirements and provides suggestions for future assessments and improvements.

## **Introduction:**

The Writing Enriched initiative at Utah Valley University, UVU, is based on a Writing in the Disciplines (WID) approach. Each discipline requires distinct ways of writing and communicating. Since knowledge in a specific discipline and ability to effectively communicate it are directly connected, writing therefore needs to be taught by members of the discipline.

Effective oral or written communication continues to be an important part of the engineering curriculum across the globe. Because of internet availability, all forms of communication have gained popularity. However, quality has been replaced by casual or short-hand version of communication. A few years ago, the state of Utah took an initiative to improve students' skills in mathematics, reading, and writing. Initially, the funding supported creative programs for students in the K-12 curriculum. In the late 1990's the state decided to begin an Engineering Initiative program to support STEM related fields of study throughout schools, colleges, and universities. The program was enhanced and expanded officially in 2001. However, this program was designed to spark interests in science, engineering, and technology resulting in increased enrollment in STEM related areas at colleges and universities. The UVU administration, with the help of the English Department, realized a need to strengthen and improve students' reading and writing skills. In 2018 WE Committee was established at the university level to handle this task. Some of the faculty representing the College of Engineering and Technology, helped establish criteria for WE courses that were suitable for campus-wide implementation.

The UVU Academic Affairs Office approved the final version of the proposed WE requirements in 2019. The new curriculum change was then announced and departments were asked to submit their changes to the committee for approval by Fall 2020. The committee reviewed proposed changes submitted by each program to ensure the selected WE courses meet the newly established guidelines and criteria. Each proposed change was evaluated, and feedback were provided. Revisions were then submitted by the departments until the final course modifications were in accordance with WE guidelines. New bachelor-degree seeking students beginning their education at UVU in Fall 2021 will be required to complete at least two certified WE courses in their majors. It is important to note that a WE course is a discipline specific class that includes both writing instructions and assignments as important components. In this regard however, WE does not imply "writing intensive." Certified WE courses are not meant to be "writing classes;" instead, writing should be one of several instructional focuses, as required by the new WE initiative.

Since this new initiative is taking effect in Fall 2021, the WE Committee has not established the final assessment criteria. The plan is to have each program submit an assessment process regarding the WE related learning outcomes.

## Literature Review:

Writing is an important skill that all engineers should have. Its importance is reflected in ABET accreditation criterion 3 for student outcomes, “an ability to communicate effectively with a range of audiences.”

Wheeler and McDonald [1] stated that writing is a useful tool in engineering if developed well, because it enhances critical thinking skills. Writing is said to be similar to the engineering design process, since both require constant feedback and revision while realizing that there is often no single “correct” solution. The authors emphasized how writing can improve and deepen students’ understanding of technical topics. This was demonstrated when the approach was implemented in a senior-level solid state devices course. It was found that assigning essay-type questions requiring explanation of the topics in a descriptive format reinforced the students’ physical “feel” for the devices. When compared to previous cohorts that did not implement a writing component to the course, students were better able to tie device behavior to the physical mechanisms that gave rise to the behavior.

Researchers at Purdue University [2] performed a paragraph writing exercise for a Fluid Mechanics course in the Fall 2013 term. The work required students to submit a weekly paragraph in addition to regular calculation-based assignments. The paragraph questions included prompts such as “explain a concept” and “provide an example of” which were related to engineering topics covered in class discussions. The exercise was reported to be successful in incorporating engineering writing into a junior-level technical course. The work however, highlighted difficulty in providing detailed grading and feedback to the exercise since assignments of such nature require more than a minimal grading scheme. It was pointed out that this was adopted because the study investigated methods of incorporating an engineering writing component to the current curriculum with minimal disruption to workload of faculty, which would facilitate its adoption and use.

A survey of 190 engineering instructors [3], found that most study participants agree that writing is an important skill to develop in engineering. Many of those surveyed cited not being satisfied with their students’ writing skills. However, the participants also cited that constraints on time and resources kept them from including a more comprehensive writing component to their syllabi, to enhance their students’ writing skills. The study did conclude that the development of resources for instructors such as rubrics, graded writing examples, and strategies for developing writing prompts would aid instructors in including more writing component in their engineering courses.

Highly ranked universities in the nation are among those that have incorporated writing at various levels in their programs. In these universities, students are often asked to write papers for various types of audience in their disciplines. Brown [4], Duke [5], Yale [6], Harvard [7], and others such as Princeton, Columbia, Cornell, and Stanford are a few among many universities to mention. For example, at Brown university [4] students can clear the writing check/s on their records by taking one of four steps:

1. Enroll in a notification writing course which is the same as the basic General Education (GE) requirement, English 1010 or 2010 at UVU.
2. Enroll in a Writing Fellows course.
3. Work with a member of the Writing Center and establish a schedule for one semester.
4. Complete at least three WRIT, Comparative Literature, or Literary Arts courses.

At Duke university [5] students can complete the writing requirements for graduation by successfully completing one University Writing Course. Yale university [6] requires only two course credits in writing for graduation. Harvard university [7] provides more general options for students to fulfil their writing requirements. Their general education requirements are divided into four basic areas. Students must complete one from each category:

1. Aesthetics and Culture
2. Ethics and Civics
3. Histories, Societies, Individuals
4. Science & Technology in Society

Such writing requirements, except the ones at Brown university, do not seem to be different from the GE requirements in most universities. It is noted that in this regard UVU has taken an initiative to address the more thorough writing requirement that covers a wider scope of the curriculum.

Research shows that employers consistently rate writing and communications skills at or near the very top of abilities they want college graduates and new hires to possess but which they consistently lack [8].

A useful model, profiled in Young and Fulwiler's *Programs that Work* [9], can be found at the University of Massachusetts-Amherst. Specifically, the models were for third-year writing courses for anthropology, business, and physics.

- The anthropology course emphasizes, “acquisition of anthropological knowledge and research skills, and on the other, development of an understanding of writing as a personal and intellectual development and as a tool for communication.”
- The business course “attempts to simulate the business environment while recognizing that students are novice writers” and creates two kinds of familiar pressures: “the unrelenting pressure of time and the requirement for unmistakable meaning.”
- The physics course balances a focus on traditional lab reports and term papers with other exploratory forms of writing on topics within the discipline. The instructor explains, “Analogy and metaphor are powerful ways of explaining hard concepts. Moreover, analogies are an intimate part of the structure of physics.”

At Michigan Tech, a move was made to develop a course which addresses the university's emphasis on writing in engineering and applied science courses. The resulting third-year course

requires students to work collaboratively in producing full-scale engineering reports in a project-based environment.

UVU could have considered working toward establishing Writing Intensive (WI) rather than WE course in each discipline, and articulating how many of these courses students need to take. A WI course is a common model used at some universities. Drexel's WI program describes such a course as "designed to help students practice writing, give them opportunities to use writing as a tool for learning, and to introduce them to the writing conventions and practices of particular fields or disciplines." The purpose of WI courses is to provide a course in which students will get hands-on experience in writing for their own discipline. For the most part, this takes place in a typical disciplinary course, but one that makes a special emphasis on writing. Such WI-courses must provide practice with

- Research
- Drafting
- Writing Process
- Disciplinary Conventions
- Revision
- Reflection

However, in recognition of the importance of effective writing, UVU lists "communication" as a component of one of its six Essential Learning Outcomes, i.e., the ability to

- Write and speak effectively in a variety of settings (e.g., academic, civic, and professional)
- Appropriately use the conventions associated with writing and speaking
- Acquire an awareness of audience and purpose
- Understand the intent and impact of performed, spoken, written or visual texts.

Regardless of local and national concerns and UVU's explicit prioritization of effective communication, the GE composition sequence set out for universities by the Utah System of Higher Education consists only of a series of two "generalist" freshman-level composition courses: English (ENGL) 1010 and ENGL 2010/2020. This series provides students with essential foundational essay- and research-writing instruction. However, unlike many universities across the nation, UVU has no 3<sup>rd</sup>-year, "advanced," or discipline-based writing courses, except the few that are offered in some majors. Given these facts, it is not surprising that many students graduate from UVU without being able to write in ways that are valued by their disciplines and subsequent employers. Therefore, it was decided that requiring a minimum of one upper-division course would be more practical and beneficial to students.

If students are to learn to write, they must learn to write as particular kinds of authors, for particular audiences, and for certain purposes [10]. These authors, audiences, and purposes change with different situations, different genres, and in different disciplines. The best way, we would argue, for a student to learn to write for biology, e.g., is for the student to write as a biologist and for an appropriate audience. A course in which the student composes essays will largely grant the student some facility in that type of essay. The knowledge that is gained in an

essay course, despite our best intentions and conventional wisdom, does not transfer to these new contexts. This is particularly so with students who are often novice university writers.

### **Method:**

The solution to the problem of a disjointed writing curriculum in which various entities point to others as being the “source” of the failure is multifaceted. But the overall solution is to invite all faculty members to make writing instruction at into what Knowledge Transfer scholars call “Encultured knowledge” [11]. Therefore, it was decided that UVU must create a culture of writing by integrating composition at many stages through low-stake writing. That could be accomplished by taking several steps:

- Making Writing Enriched a new graduation requirement for every bachelor-degree seeking student at UVU. To meet the new WE requirements, every undergraduate program was obligated to designate and modify at least two core courses as WE.
- Place an emphasis on assignments focused on writing. These assignments can vary in emphasis and difficulty level. Some writing assignments can be low stakes, and help students acclimate to the disciplines into which they are matriculating. Minimum of one high-stakes assignment must be required. The concept of “writing to learn” assignments can also be useful. Instead of stressing writing assignments as demonstrating learning or mastery, writing can be a process of learning unto itself.
- Appoint a representative to help faculty derive writing assignments for their courses. Additionally, an advisory committee could be formed as a **resource** to assist faculty, **not** a committee to dictate policy. The writing initiative is meant to **complement** the “generalist” freshman courses, not detract from or in any way replace or disparage those courses.
- The faculty director of the writing center could be made into a liaison for faculty to develop writing assignments in their courses.

The WE committee with the approval of the administration established the following criteria:

1. It was required that both or at least one of the two designated courses to be upper division. The programs were asked to explain the importance of a lower-division course for teaching students to write in their major/discipline.
2. WE courses must be core courses that all Bachelor-seeking majors must take.
3. If not, the department should plan to ensure all students can meet the WE requirements without delays in progress to graduation.

4. Course cap of no more than 25 is required.
5. The program must explain how they plan to ensure that all students will receive sufficient time devoted to instruction and feedback.
6. The WE Committee *strongly recommends* that inexperienced writing teachers are not assigned to more than 2 sections/50 students for WE courses per semester, and experienced writing teachers are not assigned to more than 4 sections/100 students for WE courses. If courses are Writing Intensive (meaning they are writing-focused courses), it is recommended that all teachers are assigned to a maximum of 2 courses/50 students per semester, no matter their experience.
7. Instructors are encouraged to have students work with the Writing Center (WC) on campus. The first draft could be reviewed by the staff of the WC providing feedback to the students before submitting the final draft.
8. Every program must include writing-based learning outcomes in their course description. If there is no plan to develop at least one learning outcome related to writing, the following learning outcome for writing must be used: Students will be able to compose a variety of disciplinarily appropriate texts within multiple situations and for multiple audiences.
9. WE Course Requirements are listed in the table below. Each program must list example assignments that show how the course meets the Writing Enriched requirements.

<b>Assignment</b>	<b>High-Stakes</b>	<b>Low-Stakes</b>	<b>Revision</b>	<b>Disciplinary Writing</b>

Table 1. List of course assignments showing how they meet WE requirements.

10. Disciplinary Writing:

Programs must provide a brief explanation for what disciplinary writing tends to look like in their field. This explanation can be used in course certification application. The following questions should be considered while completing the application:

- a) What genres of writing are common practice in the discipline?  
(Examples: memos; case notes; grants; field study write-ups; etc.)



- b) Who generates writing in the discipline, and to whom is that writing directed? (Examples: everyone communicates within teams; heads of projects communicate with supervisors; lower-level employees write reports for supervisors; supervisors keep records for archives; field notes are kept for later write-ups; more formal write-ups are transmitted to supervisors; etc.)
- c) Academic writing often means researched and/or persuasive writing. Is any of this kind of writing common in your field? Do writers need to know how to access information generally available in your field (journals or websites, for example)?
- d) Would the kinds of writing generally practiced in your field be persuasive? Informative? Reportage? How else might you characterize the purposes of the writing done in your field?
- e) What principles govern the readability of writing done in your field—brevity? Thoroughness? Conciseness? Attention to templates and forms? Originality? Etc.

#### 11. High-Stakes Writing:

- a) Assignment description and/or schedule is to be posted in curriculum section of Course Leaf (Curriculum Website), clearly identifying where requirement is met.
- b) Summarize (in one paragraph) how high-stakes writing functions in your course and how you have identified that work in your assignment description/schedule.

#### 12. Low-Stakes Writing:

- a) Attach sample assignment descriptions and/or schedule in Course Leaf, clearly identifying where requirement is met.
- b) Summarize (in one paragraph) how low-stakes writing functions in your course and how you have identified that work in your assignment description/schedule.

In the Engineering Department, two classes that already included substantial amount of writing were chosen as WE courses. The first course in the program, Introduction to Engineering ENGR-1000, was chosen as a lower-division WE course. This course involves projects, teamwork, and report writing. The second course was Thermal/Fluid Experiment ME-3335. In this course students perform several group experiments in Thermodynamics, Fluid Mechanics, and Heat Transfer. Prior to WE designation students in both classes were obligated to write 3-5 page-long team reports according to the format required by the instructors.

After the WE designation, the writing assignments were modified to include several requirements specified by the WE guidelines, as mentioned above, and the technical aspect of the projects and/or experiments.

#### Examples:

The following are examples of a lower-division and an upper-division WE course in the Mechanical Engineering program at UVU. Both courses are three credit hours in the undergraduate program. The learning outcomes and objectives of both courses were modified to

include the WE requirements. It is important to note that before implementation of WE program, students submitted their reports using the same format throughout the semester without feedback from the instructor and revision opportunity.

*1. ENGR-1000 Course Description:*

Introduces engineering problem-solving techniques, design processes, modelling of simple engineering systems using CAD, and systems analysis in Excel. Emphasizes engineering design procedures by incorporating group projects and presentations.

This is a Writing Enriched (WE) course. The reports must be individually written and will be returned with feedback from the instructor to help students improve their writing.

*ENGR-1000 Learning Objectives/outcomes:*

By the end of this course students will:

- Apply the engineering design process.
- Employ principles of effective teamwork.
- Communicate effectively through written reports and oral presentations.
- Use Computer Aided Design (CAD) software to create basic engineering models and/or drawings.
- Apply modern software tools for engineering analysis and programming.
- Fabricate prototypes safely using power and hand tools.

*ENGR-1000 Writing Center Visits:*

- With writing individual reports as the biggest contribution of the assessment in this course, we require all students meet online or in-person with the Writing Center at least 4 times in the semester. Ideally these should be a week in advance of each report submission. Writing Center visit deadlines correspond with specific individual report deadlines. Students may attend additional one-on-one visits beyond the required visits. The Writing Center is in the Fulton Library in room FL-208, but you are encouraged to do online meetings as well.
- Submit the copy of the visit receipt from any face-to-face or online meetings on CANVAS under each Writing Center visit assignment to receive credit for these visits.

## 2. ME-3335 Course Description:

Covers temperature, pressure, and flow measurement, along with calibration of thermal/fluid sensors in a lab setting. Focuses on experiments to investigate various phenomena in fluid flow, thermodynamics, and heat transfer. Investigates the performance of pumps, fans, and heat exchangers. Includes substantial amount of writing and satisfies WE requirements. This is a laboratory-based course that will provide hands-on experience to reinforce the engineering theories covered in the introductory Thermodynamics, Fluid Mechanics, and Heat Transfer courses. Weekly labs will be conducted according to section number. Students will complete and submit either a Technical or a Memo report, or a regular Lab Assignment for each lab.

*Writing Enriched:* This course meets the Writing Enriched designation. The Writing Enriched Initiative is based on a writing in the discipline approach for various types of audience. In such a course, students will be required to complete several Low & Medium-stakes and two High-stakes writing assignments. Students will receive feedback on these assignments and will be required to revise and resubmit the High-stakes assignments. UVU has committed to the WE requirement for graduation by Fall 2020.

## ME-3335 Learning Outcomes:

Upon successful completion of this course, students will be able to apply the appropriate engineering theories and experimental instruments to measure and analyze the performance of simple thermo-fluids systems. Students will also improve their writing skill by fulfilling the WE requirements of the course.

1. Perform temperature measurements using thermocouple wires, RTD, and thermistors
2. Perform pressure measurements using manometers, barometers, and various gauges
3. Perform flowrate measurements using mass and time technique, rotameters, and obstruction meters
4. Perform velocity measurements using a pitot tube
5. Determine pump performance
6. Determine Drag and Lift experimentally
7. Analyze simple Internal Combustion Engine performance
8. Perform Free and Forced Convection, Conduction, and Radiation experiments
9. Communicate experimental results in a written engineering format that fulfills WE requirements

## ME-3335 Course Objectives:

Through hands-on laboratory exercises and computational simulations, students will have the opportunity to master the engineering skills necessary to achieve the learning outcome. Specific course objectives are as follows:

1. Utilize physical equipment and instrumentation to acquire data from a variety of simple thermal fluids systems,
2. Pose scientific questions and follow the corresponding procedures in an experiment designed to answer those questions,
3. Obtain experimental data with an appreciation of its uncertainty,
4. Calculate the performance and operating characteristics of a variety of thermal fluids systems,
5. Present significant results in an organized and professional manner using tables, graphs, and schematics,
6. Interpret and critically evaluate experimental/numerical results using appropriate engineering theories.
7. Communicate the accomplished tasks and obtained results very effectively and articulately to various types of audiences using Low-stakes and High-stakes writing assignments.

### **ME-3335 Experiment Schedule (Spring 2020)**

<b>Week</b>	<b>Lab</b>	<b>Subject</b>	<b>Lab Exercise</b>	<b>Submit</b>
1	1	Fluids	Introduction and Drag/Lift	LA
2	2	Fluids	Pump Performance	Memo
3	3	Fluids	Pumps (Parallel/Series)	LA
4	4	Fluids	Fluid Friction Flow	Memo
5	5	Fluids	Flow Rate Measurement	LA
6	6	Thermo	Hydrostatic Pressure	TR
7			Discuss Heat Transfer Lab Projects	
8	7	Thermo	Internal Combustion Engine	Memo
9	8	Thermo	Temperature Measurement & Uncertainty	LA
10	9	Thermo	Pressure Measurement & Uncertainty	LA
11	<b>Spring Break</b>			
12	10	Heat	1-D Conduction & Free Convection	TR
13	11	Heat	Conduction	Memo
14	12	Heat	Free/Forced Convection	LA
15	13	Heat	Radiation	Memo
16			Make-up	
17	<b>Finals</b>			

**Note:**

LA = Lab Assignment (Medium-stakes Writing)

Memo = Memo Report (Low-stakes Writing)

TR = Technical Report (High-stakes Writing)

*Writing Guidelines:*

1. **Lab Assignment-** This type of report addresses the specifications for “Medium-stakes Writing” designation:
  - a. Informal individual writing designed to produce fluency through multiple opportunities for practice
  - b. A short summary of the lab procedures, methodology, results, discussion of results, and conclusions
  - c. This type of report must be written for a classmate as the audience and cannot exceed 4 pages (double space) in length
  - d. The Low-stakes assignments develop the type of skills necessary for successful completion of the Technical Reports
  - e. Students will receive feedback for this type of report
  
2. **Memo Report-** Is a very summary of the work performed. This type of report addresses the specifications for “Low-stakes Writing” designation:
  - a. Includes one paragraph of summary/abstract of the entire lab experiment and one or two paragraphs of results and discussions
  - b. This kind of report is written for an engineering supervisor, teaching assistant, or professor as the audience and cannot exceed one page (single space) in length
  - c. This is a team effort (teams of three to four people) and each group needs to submit only one report
  
3. **Technical Report-** In this type of report, students will write clearly and objectively using conceptual and analytical knowledge and skills learned in related topics covered in this course and previously taken courses. This assignment addresses the specifications for “High-stakes Writing” designation:
  - a. Formal writing designed to develop an ability to write highly technical and research papers as they pertain to the profession of engineering
  - b. A detailed and objective explanation of the lab procedures, methodology, results, discussion of results, conclusions, and recommendations
  - c. This type of report must be written for a general audience who is not necessarily in the field of the author and cannot exceed 8 pages (double space) in length
  - d. Students will receive detailed feedback for this kind of report and will be required to revise and resubmit for full credit
  - e. This is also a team effort (teams of three to four people) and each group needs to submit only one report

4. Students may receive assistance at the **Writing Center** on campus. For each type of report, extra information and details of calculations must be included in the Appendix section of the report. Each section of the reports must be clearly labeled. A guideline for each report will be provided to students on Canvas at the beginning of the semester.

### **Assessment Process:**

Since the university-wide WE project is in its infancy, a comprehensive assessment procedure has not been established yet. However, it has been decided to allow each program to establish their own assessment process which will be reviewed and allowed to be implemented after the final confirmation by the WE Committee has been issued.

From the experience obtained thus far, it is recommended to prepare and consult with the programs and colleges before requiring such a change in the curriculum. At UVU a hesitation by the programs and instructors was observed. The involvement of the deans and the enforcement by the administration of the final curriculum change would be beneficial.

### **Conclusions:**

Eventhough the WE requirement officially will start in fall 2021, some programs such as ours have begun this initiative since spring 2020. The addition of WE to both of these courses has not caused any issues for either the instructors or students. Thus far, the result has been very promising. The university WE committee intends to collect a report from all the programs across the campus and assess the results beginning in fall 2022. The assessment mechanisms and details have not been established by the University WE Committee yet. Being a member of the Committee and having the first-hand knowledge, it has been proposed to have each program assess how they meet their specified learning outcomes as they pertain to the WE requirements. Then, a thorough assessment of the entire initiative will be conducted by the WE Committee.

Having taught such courses for three semesters, it is highly recommended to have students write low, medium, and high stakes reports broken up into individual and group assignments.

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