



Using Learning through Writing Pedagogy to Improve Laboratory Learning Outcomes

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Abstract

Learning through Writing has been a popular and successful pedagogical advance applied across undergraduate curricula and disciplines. The goal of Learning through Writing is twofold: to improve writing through the addition of informal and formal writing opportunities in a course, and to improve learning through creative and effective writing assignments.

The author received training in Learning through Writing techniques in a series of five day-long workshops offered at his university. As part of a broader education quality improvement campaign, a program of results reporting and outcomes assessment were put in place, including post-workshop coaching and assistance to faculty to adopt the techniques in a course of choice.

The author targeted an undergraduate electric power and machines laboratory to assimilate Learning through Writing techniques and utilized the post-workshop guidance opportunities to help create an effective experience for students.

This paper provides a brief summary of Learning through Writing pedagogy objectives, methods, and outcomes from the learning methods literature. Samples of reported objectives and classroom experiences and outcomes in undergraduate science, mathematics, engineering, and technology (STEM) curricula are given. This paper presents also the author's strategy, planning, applications, and results using Learning through Writing in the chosen laboratory. Lessons learned and continuous improvement objectives and activities are described.

Introduction

Learning through Writing (LtW) has become a popular and successful pedagogical advance applied across undergraduate curricula and disciplines, including engineering curricula, as noted in many articles in the *Journal of Engineering* and other education theory and practicum publications¹⁻¹³. The goal of LtW is twofold: to improve student writing skills through the addition of informal and formal writing opportunities *specific to a discipline*, and to improve learning *in that discipline* through creative and effective writing assignments. An overarching goal, of course, is to improve student preparation for successful communication skills in his/her chosen profession.

LtW evolved from the ubiquitous pedagogies under the titles Writing Across the Curriculum (WAC) and Writing in the Disciplines (WID). Theories of learning in a discipline via writing have been developed through years of experimentation with WAC and WID, resulting in a wide range of suggested techniques for use in LtW programs.

It was not the author's intent to add to the literature of theories of learning in LtW or to report comparative benefits on the use of LtW. The author's sole intent was to observe and measure

improvement in student writing in the discipline, and record student responses to the effects on their learning, through the implementation of LtW pedagogy in a laboratory course. This paper reports results in student writing improvement, and records, with comment, student self-evaluation of the LtW experience and its effects on their writing and learning in the discipline.

Background and Motivation

The motivation and impetus for the writing initiative described in this paper came from the Old Dominion University's (ODU) Quality Enhancement Plan (QEP). As described on the university web site, the intention of the QEP is to improve upper-division undergraduate students' disciplinary writing, i.e., that writing that demonstrates a reasoning process supported by research and reflection on a problem, topic, or issue.¹⁴ Two faculty development and engagement initiatives were initiated: Writing as a critical skill that goes beyond demonstrating proficiency with the mechanics and structure of writing per se, and writing as a means to communicate what has been learned.

Skill in writing is demonstrated by six student learning outcomes of the ODU QEP:

1. Clearly state a focused problem, question, or topic appropriate for the purpose of the task
2. Identify relevant knowledge and credible sources
3. Synthesize information and multiple viewpoints related to the problem, question, or topic
4. Apply appropriate research methods or theoretical framework to the problem, question, or topic
5. Formulate conclusions that are logically tied to inquiry findings and consider applications, limitations, and implications, and
6. Reflect on or evaluate what was learned.

Toward improving these outcomes through LtW, ODU implemented two faculty initiatives: (1) Faculty Workshops designed to teach faculty the techniques identified as the best practices to teach and assess writing, and (2) Action Projects designed to encourage academic programs to develop and implement best practices to improve writing.

The author attended the first ODU QEP LtW workshop consisting of five day-long sessions. The purposes of the workshops were:

- To explore connections between writing and learning
- To develop assignments that help students achieve course objectives
- To develop strategies for managing written work
- To explore pedagogies that promote learning
- To strengthen teaching and learning communities
- To contribute to the ODU QEP

Faculty developed Action Plans to implement aspects of LtW in select courses, report findings, and results to the QEP lead team, and to use the experience to continue to improve student writing and learning in their disciplines.

Approach

The author chose to implement aspects of LtW in an undergraduate electric power and machines laboratory course, EET365W, required for a 4-year Bachelor of Science degree in Electrical Engineering Technology, for which he was the instructor and that he had taught for several years. The course had been designated already a ‘W’ course in the University’s General Education program requirements, met by the predominant grade weight (greater than 50% of the course grade) of formal and informal lab report evaluations. The General Education requirements for a ‘W’, i.e., writing intensive, course at Old Dominion University are shown in Appendix 1.

Whereas formal term papers, independent research reports, and other suggested best practices in LtW do not apply well in a laboratory course, the author selected to implement so-called low-stakes writing assignments on a weekly basis. The following sections describe the assignments, their evaluation and scoring, outcomes, and results based on assignment scores and student exit surveys.

EET365W laboratory meets weekly for approximately 3-hour lab practicum sessions. Students receive all lab instructions via an on-line course management site so that they can read, print, and prepare for each lab in advance. Lab topics usually lag classroom lecture topics by about two weeks so that students have had lecture, homework assignments, and graded homework feedback all in preparation for the lab experience.

The author has implemented a ‘role rotation’ method in this lab such that each week lab teams of three rotate critical responsibilities – lab circuit and equipment preparation, lab instrumentation and data recording, and lab analysis and reporting. The author’s experience with this approach finds that it encourages focused study by each student each week, and offers increased visibility and improved evaluation of specific student skills, among other benefits to the instructor and advantages for the student.¹⁵

The author referred to published lists of suggested low-stakes writing assignments for writing prompt ideas. Appendix 2 provides one example list of low-stakes writing assignment prompts for implementation in an LtW strategy of improved writing and learning outcomes in a discipline.¹⁶ Not all of the published techniques apply to a laboratory course environment, but the author used all that were appropriate to provide variety and nuance to the series of low-stakes writing assignments and to improve the six QED learning outcomes.

Implementation

The author created low-stakes writing prompts weekly based on the nature of the lab that week and suggested formats, such as those shown in Appendix 2. Some of the assignments were given at the beginning of the lab when students were given 15 minutes to complete the assignment. If any student needed more time, they were encouraged to complete or edit their writing so long as it was submitted before the end of the lab period. Many assignments were designed as so-called ‘ticket out’ assignments, writing that students would undertake and submit after the lab experiment was completed. By experience the author knew which labs historically were

completed in well under the three hours lab session period, and the ‘ticket out’ format was assigned on such weeks. Appendix 3 provides a list of the low-stakes writing assignments, including the QEP LtW targeted learning outcomes, created by the author for the laboratory course.

In the first several lab sessions students were instructed repeatedly on the purpose and scoring of the LtW assignments. The information was provided in the course syllabus also. To be effective, the assignments required some weight (providing some external motivation to improve) but not too much weight (limiting internal grade anxiety or evaluation apprehension in the creative writing process). The average low stakes writing score was weighed only 10% of the course grade, as shown in Table 1. Students reported that 10% was a fair and preferred weight (see student survey responses below).

Table 1. Course Grade Components and Weights

Component	Weight (%)
Laboratory Preparation or Data Gathering Role	30
Formal and Informal Lab Reports	50
Other Written Assignments (LtW)	10
Peer-assessed Team Skills	10

The prompts were introduced approximately weekly using an overhead projection and verbal instruction. The purpose of the low-stakes writing exercise was repeated: to help the student improve his or her technical writing skills and to improve learning of lecture- and laboratory- based knowledge. Each submitted assignment was scored, i.e., marked-up, by the author according to a writing skills rubric made available and reviewed with the students.¹⁷ (See Table 2). Students were provided also a list of common editor’s marks so that they could readily decipher and interpret the author’s comments and corrections.

Trends in writing mechanics outcomes were identified through the history of assignment scores. The effect of the writing assignments on learning processes and outcomes were recorded using student surveys. The outcomes of the observations and evaluations are presented in the Results section.

Results

Low-Stakes Assignments Scores and Instructor Observations

The assignments final scores consisted of a simple three-tiered scale: \surd^- , \surd , or \surd^+ , explained to the students as roughly equivalent to a C, B, or A, respectively, and evaluated using a 1.0, 2.0, 3.0 equivalent numerical score sequence, respectively. The idea, in keeping with the low stakes intention and definition of the assignments, was to use a perceived low-stakes grade also.

Two assignments - #4 and #8, see Figure 1 - resulted in repeated and consistently poor outcomes. These two prompts required that students “put in their own words’ (PITOW) definitions or descriptions of electrical phenomena.

Table 2: Scoring Rubric for Writing Mechanics

Trait	Exceptional	Acceptable	Pre-professional	Unsatisfactory
Sentences and paragraphs	<ul style="list-style-type: none"> • Usage of sophisticated sentence patterns. • Paragraphs indicate shift in thought and are used to make sequence of events clear. 	<ul style="list-style-type: none"> • Simple and some complex sentences are used. • Some paragraphing to show sequence of events/ideas. 	<ul style="list-style-type: none"> • Sentence structure is usually correct. • Simple sentences are used. • Little attempt made to paragraph writing. 	<ul style="list-style-type: none"> • Sentences do not make sense. • No paragraphing.
Word choice	<ul style="list-style-type: none"> • Words are used correctly and precisely. 	<ul style="list-style-type: none"> • Acceptable vocabulary. • Words are technologically appropriate. 	<ul style="list-style-type: none"> • Simple vocabulary. 	<ul style="list-style-type: none"> • Incorrect vocabulary.
Spelling	<ul style="list-style-type: none"> • Spelling is correct, including complex and irregular words. 	<ul style="list-style-type: none"> • Spelling is generally accurate. 	<ul style="list-style-type: none"> • Frequent spelling errors. 	<ul style="list-style-type: none"> • Spelling errors interfere with understanding.
Punctuation	<ul style="list-style-type: none"> • A range of punctuation including commas, apostrophes, colons and semicolons is used accurately and effectively. 	<ul style="list-style-type: none"> • Periods and capitals are used correctly and punctuation is beginning to be used within the sentence. 	<ul style="list-style-type: none"> • Frequent punctuation errors. 	<ul style="list-style-type: none"> • Insufficient or lacks punctuation. • Incorrect use of capital letters.

The author noticed students struggled in these two assignments first having difficulty generating their own words, and then displaying poor sentence structure, grammatical constructions, and other writing mechanics as an immediate result. The author concluded that the students had not yet had a need for academic requirement to create their own versions or individual concepts of the phenomena in question, and so struggled in the moment to reword or recreate what, up to that time, they had only to learn and apply in the standard vernacular of the discipline. The trends in writing improvement are shown below both including and excluding these two

uniquely and consistently poor assignments.

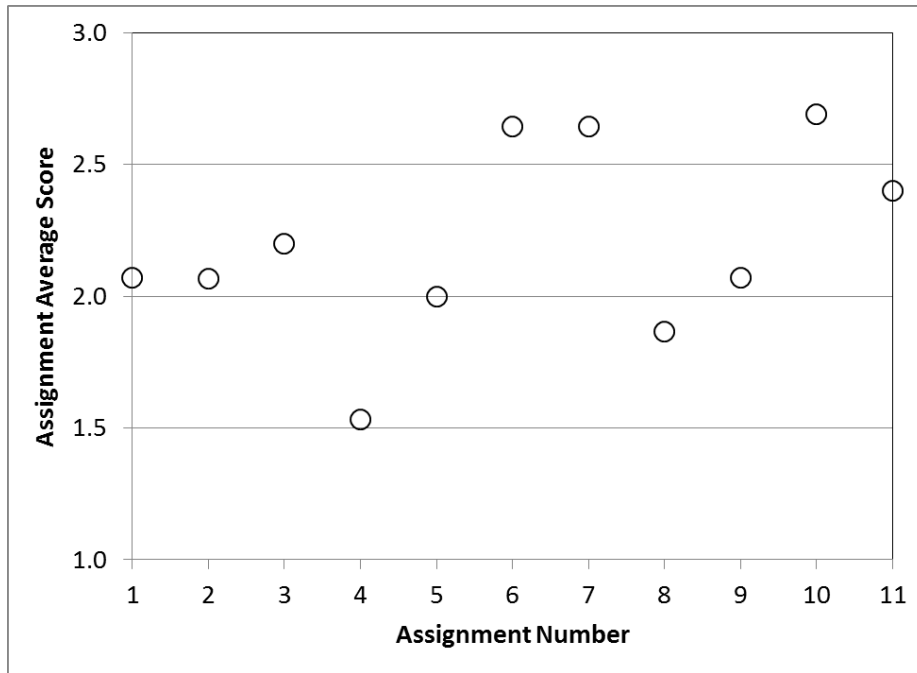


Figure 1. Average Low-Stakes Assignments Scores

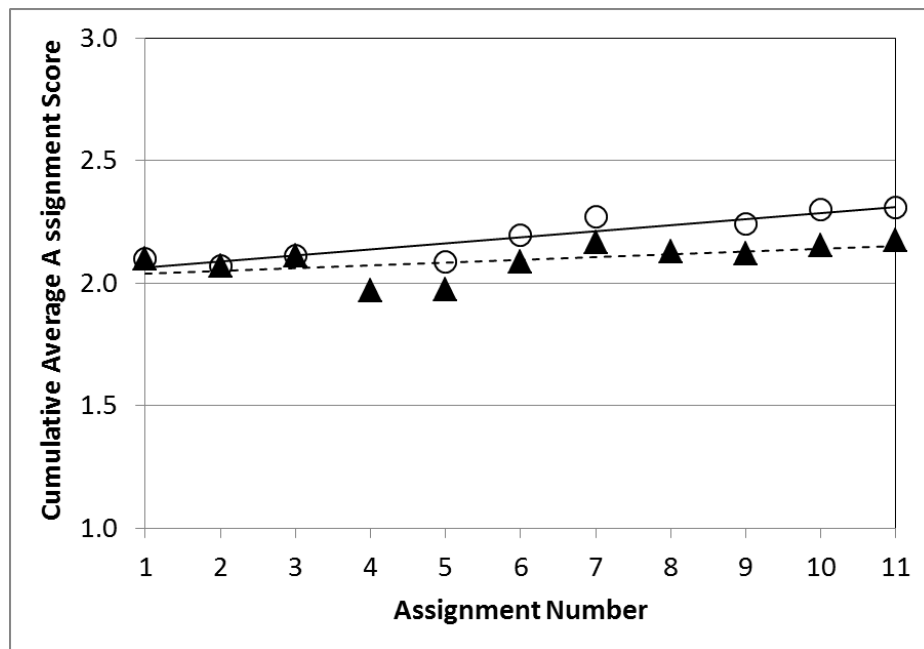


Figure 2. Cumulative Average Low-Stakes Assignments Scores (Solid line indicates Assignments #4 and #8 removed – see text).

Writing skills and mechanics improved through the semester, with cumulative average scores increasing noticeable (see Figure 2). With the two PITOW assignments removed from the data, the overall average scoring trend was more dramatically evident (solid line, see Figure 2). The author observed the following general improvements in student writing: more concise simple sentence structure and meaningful content; improved use of phrases and complex sentences; more careful concern for spelling; reduced use of non-technical or hackneyed words and phrases; improved punctuation; and more confident personal and persuasive style.

Impact on Instructor Workload

Creating the instructions for the low-stakes writing assignments took only about a half-hour per week. As these assignments are now available for re-use in follow-on courses, with continuous improvement, such preparation time is not a hardship in any case.

The scoring of the weekly low-stakes writing assignments did require significant extra time and effort by the author. Because these were low-stakes assignments – most often less than 100 words – and with only 15 students registered in the class, grading time routinely added less than two hours per week compared to the course taught without LtW enhancement.

It is interesting to ponder, and in the future attempt to measure, if the low-stakes writing assignments might so improve learning outcomes and writing mechanics that grading the course formal lab reports might require less time. Perhaps the potential time saved grading the formal labs might be equivalent or more than the added time required to grade the low-stakes writing assignments. The outcomes then would be a break-even or net reduction in course grading workload.

Student Surveys

The students were surveyed in the last laboratory session on their experience and outcomes of the newly implemented low-stakes writing assignments. The survey is provided in Appendix 4.

All fifteen students completed the survey, and the responses were overall very positive. The results of the survey are summarized here.

Question 1.

All surveys included the response that the purpose of the low-stakes assignments was to improve writing skills. Most included the idea that the assignments would help in understanding the lab material or electrical concepts in general. Many mentioned that they assumed the assignments were given to help boost the heavily-weighted writing component of the ‘W’ course grade.

Question 2.

All but one student reported either that their writing improved and/or that the low-stakes assignments helped them better understand the lab material or electrical concepts. Comments included: “It forced me to reflect on the lab, which helped reinforce the material”; “Helped me understand the labs better and helped me absorb what I learned from the lab.”; “It reinforced ideas that were important.” The one negative comment was; “The weekly assignments did not

provide me with any new instruction”.

Questions 3 and 4.

The predominant ‘like’ response to the assignments was the potential boost to the course grade. The predominant ‘NOT like’ response to the assignments was that they didn’t like writing in general.

Question 5.

The nearly unanimous response was that the grading was fair and accurate.

Conclusions

Instructor observation and the cumulative average assignment scores indicate that this implementation of low-stakes assignments in a Learning through Writing context was successful in improving writing skills in the discipline, and, from surveyed responses of students, was successful also in improving the student learning process and outcomes.

The author learned an important lesson in developing prompts in this first implementation of LtW in a laboratory setting: that students might not be ready to “put in their own words” concepts and phenomena they have yet to contemplate outside of the standard language and discipline of use in their electrical courses to date.

As part of the author’s university quality enhancement programs, and the Learning through Writing program specifically, the author is seeking the advice and assistance of the program leaders to review the results of this first implementation and consider extensions or improvements based on the observed outcomes and student responses.

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Appendix 1

University General Education requirements for a Writing-Intensive Designated Course

Criteria for Writing Intensive courses include:

1. Students demonstrate, in a series of individual (not group) assignments, their mastery of the subject in a discipline, through the writing of formal documents.
2. For each writing assignment, the instructor provides feedback to the student, evaluating content and writing style (organization, development, logic, coherence and mechanics).
3. Types of documents for writing assignments include laboratory reports, critiques of performances, proposals, case studies and others appropriate to a particular discipline.
4. Writing assignments comprise more than half of the overall course grade.

Appendix 2

Suggested Low Stakes Writing Prompts

1. Abstract writing

Purpose: To focus thoughts and summarize ideas; to reinforce course readings; to develop critical thinking skills

Procedure: Remove any identifying marks from a paper (e.g., title, author's name, abstract, journal reference, reference list) and have students read the paper and write an abstract.

Example: Read the following journal article and write an abstract for it, summarizing the main points of the author(s) in your own words. Remember to identify the main thesis, the data collecting procedure, the findings, and the conclusions in your abstract.

2. One-sentence summaries

Purpose: To reinforce class concepts; to gauge students' comprehension of the lecture; to involve students in summarizing material; to highlight defining features of a concept.

Procedure: At the end of class, identify a particular concept discussed in class and have students summarize it in one sentence. Alternatively, do not give them a particular concept; simply ask them to summarize the lecture in one sentence, picking the most salient points. One guideline you can offer is that a one-sentence summary should answer the 5 W's (who, what, when, where, why).

Example: Write a one-sentence summary (using the 5 W's) about Fink's Model of Active Learning, which we discussed in class today.

3. Headlines

Purpose: To retain and explain concepts; to summarize key concepts

Procedure: After discussing a concept or event, have students write newspaper-style headlines summarizing it. This activity may be particularly appropriate in a discussion on research, controversial issues, or historical developments.

Example: Write a headline that summarizes our class on high-stakes versus low-stakes writing.

4. Directed Paraphrasing

Purpose: To personalize ideas; to explain concepts; to develop critical thinking

Procedure: Students are asked to write about a particular concept taught in class in their own words. A variation of this would be to have students paraphrase as if they were explaining concepts to a particular audience (e.g., an industry leader; an elected government official, etc.).

Example: In your own words, write what the difference is between high-stakes and low-stakes writing as if you were explaining it to a first-year undergraduate student.

5. Definitions

Purpose: To explore ideas; to personalize ideas; to focus thoughts

Procedure: Students must develop a definition for a course-related word (dictionary format) or must write a comprehensive but precise paragraph or a set of paragraphs on a particular course related concept (encyclopedia entry).

Example: Write an encyclopedic entry for “low-stakes writing assignments,” complete with a definition, a description of different types of low-stakes writing assignments, and an explanation of how these assignments can be effectively utilized in a classroom setting.

6. Application Cards

Purpose: To develop critical thinking; to explain and apply concepts; to retain concepts

Procedure: Distribute 3x5 cards to your students. Have them write a real-world application for a theory, principle or procedure they have learned about in class on the card and either submit them to you or share them with one another. The small card is optional – using lined paper is fine too – but the card indicates to the students that they should be concise.

Example: A colleague in your field is interested in learning more about using writing as an effective learning tool. Explain to this colleague how to run a writing exercise that you plan to use in your classroom.

7. Editorials

Purpose: To explore opinions and personalize ideas; to explain concepts; to focus thoughts and summarize ideas; to engage in critical thinking

Procedure: Have students select a particular course topic, identify major issues, take a position, and write an editorial for the local newspaper defending their position.

Example: Support or refute the following claim: “Writing exercises have a place in every university classroom.” Write in a journalistic style.

8. Online Discussion Groups

Purpose: To personalize ideas; to focus thoughts; to explore ideas

Procedure: Divide the class into small groups of 4-6 students. Set up an online discussion board and have each group discuss course issues online. Each group then selects a member to summarize its discussion. The summaries are posted to the main class list, where you and the entire class can read them. You will want to monitor the group discussion, especially toward the beginning of term. See the CTE Teaching Tip entitled “Online Discussions: Tips for Instructors.”

Example: On the course discussion board, discuss with your group experiences you have had with high- and low-stakes writing assignments, and together identify the pros and cons about each. Have one member of your group post the pros and cons to the course e-mail list.

9. Letter Writing

Purpose: To retain concepts; to explain concepts; to personalize ideas

Procedure: Have the students write a one- or two-page letter describing course concepts. Be specific about to whom the letter should be addressed to.

Example: Have students write a letter to a friend who has been sick the past week and explain what the friend has missed. A variation of this would be to write a letter to a confused friend who wants to switch his or her major (English). Have students explain why (or why not) their friend should switch his or her major to their major (Science). This variation would have students look at the subject as a whole, rather than summarize course concepts.

10. Personal Response Exercise

Purpose: To retain concepts; to personalize ideas; to explore concepts

Procedure: Students write about concepts taught in class through sharing personal opinions/ experiences that relate in some way to those concepts.

Example: Write about the most memorable writing assignment you’ve ever had to complete as a writer.

11. Journals

Purpose: To personalize ideas; to retain of concepts; to explore concepts

Procedure: Students write in a journal on a regular basis about particular concepts learned in class. The writing can be open-ended (write about a certain aspect of a course for a certain length of time) or guided (students respond to content-specific questions developed by you).

Example: Identify and discuss your ideas on three significant concepts that stood out for you in this week’s readings.

12. Poems

Purpose: To encourage creativity; to personalize ideas

Procedure: Have students create a poem that expresses their feelings about a particular topic. This exercise can be a great way to lighten the mood. Be sure to allow time for students to share their poems with one another.

Example: Write a poem describing your views on writing. This can be in any poetic format that you wish.

13. Memory Matrix

Purpose: To retain concepts; to personalize ideas; to explain concepts.

Procedure: Students complete a two-dimensional diagram for which the instructor has provided labels. Having information laid out visually can help students to prepare for a test or see how different concepts fit together.

Example: Based on the readings for today, fill in the following matrix....

Appendix 3

Low-Stakes Writing Assignment Prompts used by the Author

Lab	Laboratory Title	Low-Stakes Writing Prompt	QEP LtW Outcome
1	DC Machine Resistances	<p>1. In two to three sentences, describe what you learned using the lab station.</p> <p>2. In one or two sentences, describe what you are curious about (want to know more about) still.</p>	1, 2, 6
2	3-Phase Transformers	Describe your expectations of this lab's Role-Rotation assignments and assessment methods. Be specific. What do you expect will be different compared to more traditional labs?	1, 6
3	Autotransformer	<p>1. Describe a procedure that went very well. Specifically mention the equipment, actions taken, and the results.</p> <p>2. Suggest reasons that things did go so well.</p>	2, 3, 4, 5
4	1-Phase Transformers	<p>Define the following, in your own words, but with technical precision. Assume your audience is an EET student just starting EET365W lab.</p> <p>1. 3-phase Voltage</p> <p>2. Power Factor</p> <p>3. Transformer</p>	1, 4
5	Capacitor Start Induction Motor	Describe a lab procedure or activity that is now 'second nature' or 'just common sense' for you, that was not so when you began EET365W. Be specific.	1, 4, 5
6	AC Motor Drives	<p>Write a short memo or letter to a student new to 365W. Describe two challenges the student likely will encounter. For each challenge, suggest at least two specific things the student could do to better prepare to meet that challenge.</p>	2
7	Synchronous Motor	Describe TWO (2) major concepts of synchronous motor operation or performance demonstrated in lab today.	1, 2, 3
8	Synchronizing An Alternator with the Power Company	<p>Electrical energy is provided to your home via an alternating current (AC) system, at 60 Hertz. Explain the concept of alternating current such that a person unfamiliar with electricity or electrical concepts would understand. Hint: Consider what YOU have come to understand today compared to when you knew little about electricity or electrical engineering yourself. That is, put yourself in the other person's shoes.</p>	1, 2
9	Load Characteristics of DC Motors	<p>Consider the Peer Assessment process we have used in EET365W (assessment required for ABET accreditation). Describe how you have responded to your progress scores.</p>	5, 6
10	Speed Control of a DC Shunt Motor	Report on a problem you experienced in lab. State what alerted you to the problem, explain your corrective action, and suggest a long term lesson to be learned.	1, 2, 3, 5, 6

Appendix 4

Learning through Writing (LtW) Student Survey

1. What was the purpose of our weekly low-stakes, informal writing assignments?

1. _____

2. _____

3. _____

2. How did the weekly low-stakes, informal writing assignments help you in your learning?

3. What did you like about the LtW exercises?

4. What did you NOT like about the LtW exercises?

5. What did you think about the grading of the LtW assignments? (Consider, for example, how the assignments were scored, that they comprised 10% of the course grade, etc.)
