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# Using Writing as a Learning Tool in Engineering Courses

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# Using Writing as a Learning Tool in Engineering Courses

**Summary**
Successful engineers must be able to identify innovative approaches to solving real-world problems. For this reason, the ability to move beyond memorization and think critically is an essential skill for engineering students. Writing is an effective pedagogic tool for helping undergraduate students to develop such critical thinking skills (Bean, 2011). Moreover, research shows that short writing activities can help engineering students deepen their understanding of complex concepts so that they are prepared to engage more critically with course content (Kågesten & Engelbrecht, 2006; Welch Gradin & Sandell, 2002; Wheeler & McDonald, 2000). Yet despite the proven value of writing activities, they are not commonly used in engineering courses. In this workshop, participants explore the benefits and challenges of using writing activities in engineering courses at the undergraduate level. Participants are introduced to a number of writing activities that can easily be integrated into engineering courses, by either instructors or teaching assistants, in order to engage students in course material and encourage students to think critically about course concepts. By the end of this workshop, participants should feel comfortable using writing activities in their own teaching practice, as well as describing the learning benefits of using writing activities in engineering.

**Keywords**
writing, writing-to-learn, writing activities, engineering education

# Using Writing as a Learning Tool in Engineering Courses

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SUMMARY

Successful engineers must be able to identify innovative approaches to solving real-world problems. For this reason, the ability to move beyond memorization and think critically is an essential skill for engineering students. Writing is an effective pedagogic tool for helping undergraduate students to develop such critical thinking skills (Bean, 2011). Moreover, research shows that short writing activities can help engineering students deepen their understanding of complex concepts so that they are prepared to engage more critically with course content (Kågesten & Engelbrecht, 2006; Welch Gradin & Sandell, 2002; Wheeler & McDonald, 2000). Yet despite the proven value of writing activities, they are not commonly used in engineering courses. In this workshop, participants explore the benefits and challenges of using writing activities in engineering courses at the undergraduate level. Participants are introduced to a number of writing activities that can easily be integrated into engineering courses, by either instructors or teaching assistants, in order to engage students in course material and encourage students to think critically about course concepts. By the end of this workshop, participants should feel comfortable using writing activities in their own teaching practice, as well as describing the learning benefits of using writing activities in engineering.

KEYWORDS: writing, writing-to-learn, writing activities, engineering education

## LEARNING OBJECTIVES

By the end of this workshop, participants will be able to:

- describe the concept of 'writing-to-learn' and explain the benefits of using informal writing activities in engineering courses;
- share ideas on informal writing activities appropriate for engineering courses;
- design at least one informal writing activity suitable to their teaching context.

## REFERENCE SUMMARIES

Bean, J. (2011). *Engaging ideas: The professor's guide to integrating writing, critical thinking, and active learning in the classroom* (2nd ed.). San Francisco, CA: Jossey-Bass.

In this book, Bean makes a compelling argument for the use of writing-to-learn activities in the university classroom across the disciplines. Bean defines writing-to-learn activities as "the kind of exploratory, thinking on paper we do to discover, develop, and clarify our own ideas" (p.120). Bean argues that integrating this type of writing into the university classroom encourages active learning, critical thinking and the development of communication skills. Bean's book provides a strong theoretical basis supporting the use of informal, exploratory writing in the university classroom, as well as practical advice on integrating writing-to-learn activities into the university classroom. The concepts in this book serve as the foundation of this workshop, offering a theoretical basis for the use of writing activities in university classrooms across the disciplines. This workshop also makes use of the tips

offered in this book in order to provide participants with practical ideas about how to use writing activities in their own teaching practice.

Kågesten, O., & Engelbrecht, J. (2006). Supplementary explanations in undergraduate mathematics assessment: A forced formative writing activity. *European Journal of Engineering Education, 31*(6), 705-715.

The focus of this article is on the ability of writing activities to enhance student learning in engineering, maths and sciences. Recognizing the ability of writing to deepen student learning in science and mathematics, the authors of this study integrated optional formative writing activities into their course design. If students chose to participate, the writing activities guided students in reflecting on their own solutions to complex mathematical problems. The authors recorded course results of the students who participated in the activities, as well as interviewed the students. The results of this study suggest that written reflection enhances student learning in two ways. First, written reflections helped students to develop a deeper and more comprehensive understanding of complex concepts and processes. Second, written reflections exposed weaknesses and gaps in student knowledge, which was useful for both student and instructor. Workshop facilitators can use this article as evidence of the benefits of using writing activities in engineering classes, as well as to demonstrate how writing can be integrated into mathematical classes.

Welch, L., Gradin, S., & Sandell, K. (2002). Enhancing engineering education with writing-to-learn and cooperative learning: Experiences from a software engineering course. Proceedings of the 2002 *American Society for Engineering Education Annual Conference & Exposition*.

This article reviews the use of writing-to-learn activities to improve student learning in engineering courses. More specifically, the article describes how writing-to-learn activities were employed in an upper-level software engineering course with the goal of providing students with the critical thinking skills needed in the software engineering profession. Based on their experience using writing-to-learn activities, the authors conclude that writing-to-learn activities improve student learning, as well as student engagement. The authors also suggest that writing-to-learn activities serve as a useful tool for promoting critical thinking and problem solving skills. It is important to note that the authors did experience some student resistance to the use of writing-to-learn activities in their course. However, by the end of the term, the authors found that most students had come to recognize the benefits of such activities in relation to their own learning, engagement and retention of knowledge. This article provides empirical evidence to support the benefits of using writing activities in engineering classes as discussed in this workshop.

Moskovitz, C., & Kellogg, D. (2011). Inquiry-based writing in the laboratory course. *Science Education, 332*(6032), 919-920.

This research article addresses how writing activities can be used in courses with laboratory components. The authors propose using short writing activities to teach students how to write without affecting the quality or quantity of course material. The authors recognize the

inadequacies of the traditional lab report—students follow a 'cookbook' formula when writing lab reports and they do not learn how to engage with material critically or communicate science effectively. Accordingly, the authors of this study have developed a process that integrates short writing tasks into lab courses in a manner that helps students learn to better communicate science. More specifically, these short writing activities teach students how to illustrate data clearly and present results in a clear and compelling manner. While this article does not focus specifically on traditional writing-to-learn activities, it does provide practical advice for engineering instructors who wish to introduce short writing activities into their labs. Workshop facilitators can use this article to demonstrate how writing activities can be used in laboratory courses.

Wheeler, E., & McDonald, R. L. (2000). Writing in engineering courses. *Journal of Engineering Education, 89*(4), 481-495.

The purpose of this article is to provide specific examples of how writing-to-learn activities can be employed in engineering courses. Based on their own experiences, the authors conclude that incorporating writing activities in engineering classes engages students in the learning process and appeals to the needs of students with different learning styles. Furthermore, the authors illustrate how short writing activities provide an opportunity for engineering students to develop and use critical thinking skills—skills that are crucial in the engineering profession. The authors begin by providing an overview of writing-to-learn from an engineering perspective. Next, they provide a number of useful classroom examples for integrating writing activities in engineering. The authors conclude with a valuable discussion about practical issues that engineering instructors may face in relation to the use of writing activities, including resistance from both students and other faculty members. Ultimately, this article is a useful resource to engineering instructors, offering a compelling overview of writing-to-learn in relation to engineering education. Facilitators use this article to support the value of writing as an effective pedagogic tool in engineering courses.

CONTENT AND ORGANIZATION

| Duration (min) | Subject | Activity | Purpose |
|---|---|---|---|
| 2 | Introduction | Introduce yourself to participants and discuss the objectives and structure of the workshop | Engage participants in the purpose, objectives and structure of the workshop |
| 5 | Pre-Assessment | Ask participants to complete pre-assessment questions on handout (see Appendix A for more detail).<br><br>Ask participants to introduce themselves. During introductions, ask participants to briefly report on their answers to the pre-assessment questions. Inform participants that any terms from the pre-assessment that they are not familiar with will be introduced and discussed during the workshop. | Explore personal attitudes, past experiences, and current understandings of writing-to-learn.<br><br>Gauge participants' prior knowledge of the topic and to reveal misconceptions about writing-to-learn that can be addressed during the workshop.<br>(For example, it may become clear during this activity that some participants do not see the value of using writing activities in engineering courses. The facilitator can address this bias during the workshop.) |
| 8 | Writing Activity #1 'Finish the list…' | Give participants a few minutes to complete Writing Activity #1 on the handout (see Appendix A). This writing activity asks participants to list ways that engineers use writing during their education and in their profession.<br><br>Afterwards, facilitate a brief discussion with participants, asking what they included on their lists. Track participants' contributions on the white | Practice participating in a writing-to-learn activity; to share ideas on informal writing activities appropriate for engineering courses<br><br>Determine what types of writing activities are familiar to the participants<br><br>Show participants that writing activities are |

| | | | |
|---|---|---|---|
| | | board in order to develop a more comprehensive list as a group. | already used in their discipline, and that the ability to write is a skill that engineers use in their profession |
| 7 | Writing-to-Learn | Short presentation: Introduce the concept of writing-to-learn, drawing from relevant education literature. For the definition of writing-to-learn, use the definition from Bean (2001, p. 120).<br><br>Discuss the benefits of writing-to-learn across the disciplines (refer to Bean, 2001). Discuss the benefits of writing-to-learn for engineering students specifically, referring to references included in summary above. Emphasize the connection between writing-to-learn and critical thinking. | Discuss the concept of 'writing-to-learn', as well as the benefits of using writing activities in the classroom. Using education literature and referring to empirical studies, review the benefits of writing-to-learn across the disciplines, including engineering |
| 15 | Writing Activity #2 'Explain a concept' | Participants complete another writing activity, such as 'Explain a concept' (see Appendix A for more detail)<br><br>Afterwards, ask participants to share their written response with a partner<br><br>At the end of the time period, regroup and ask participants to discuss, as a group, the benefits of this type of writing activity.<br><br>Discussion prompts could include:<br>• How could integrating this type of writing activity into your course benefit your students?<br>• How could integrating this type of writing activity into | Practice participating in a writing-to-learn activity; share ideas on informal writing activities appropriate for engineering courses<br><br>Illustrate how writing-to-learn activities can be used to deepen student's understanding of complex course concepts |

| | | | |
|---|---|---|---|
| | | your course benefit you as an instructor or TA?<br>• What are some possible challenges you might face when integrating this type of writing activity into your course? How could you deal with these challenges?<br>• What are some alterations you could make to this writing activity in order to make it serve the learning needs of your students more adequately? | |
| 15 | Examples of writing activities | Presentation: Explain the various types of writing-to-learn activities that could be used in the engineering classroom (See Appendix B for more detail)<br><br>Offer tips on how to introduce and structure writing-to-learn activities. For example, when introducing a writing-to-learn activity, the instructor should:<br>• Provide rationale for the activity;<br>• Provide an oral or visual prompt to guide the student;<br>• Provide clear instructions and a time line;<br>• Clarify next steps and marking criteria if applicable.<br>See additional references (such as Sorcinelli & Elbow,1997) for more tips. | Share ideas on informal writing activities appropriate for engineering courses<br><br>Discuss tips and strategies for effectively using writing-to-learn activities in their own teaching practice |
| 15 | Writing Activity #3 'Design a Writing-to-Learn Activity' | Give participants time to design a writing activity that could be used in their own teaching practice. Instruct participants to refer to their activity handout for names and descriptions of | Design a writing-to-learn activity that they could use in their own teaching practice |

| | | | |
|---|---|---|---|
| | | writing-to-learn activities. Then, ask participants to complete the writing activity template (see Appendix A for more detail)<br><br>Afterwards, ask participants to share their activity idea in small groups. Ask participants to provide feedback to one another, considering the following points:<br>• What are the potential learning benefits of the writing activity that your peer has designed?<br>• Does the proposed writing activity support the proposed learning objectives?<br>• What are some possible challenges that your peer may face when integrating this writing activity into their course?<br>• How could your peer deal with these challenges? | Provide peer feedback on the design of their writing-to-learn activities from peers |
| 10 | Tips for assessing writing-to-learn activities | Short presentation**:** Discuss assessment of writing-to-learn activities. Emphasize the importance of keeping these activities informal and low-stakes. See WAC Clearinghouse for ideas. | Discuss tips and strategies for effectively using writing-to-learn activities in their own teaching practice |
| 10 | Conclusion and summary | Conclude the workshop by:<br>• Summarizing key benefits of using writing-to-learn activities in engineering courses;<br>• Highlighting challenges that engineering instructors might face when using writing-to-learn (i.e. additional workload, lack of knowledge about teaching | Integrate the workshop concepts and key points as the take-away message of the workshop |

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| | | writing), as well as possible solutions;<br>• Referring participants to additional literature on writing-to-learn in engineering. | |
| | Question and answer | Respond to any questions or comments participants may have about writing-to-learn activities and their use in engineering courses | Clarify aspects of the workshop that may remain unclear |
| 3 | Writing Activity #4 'Exit slip' | Provide each participant with a cue card or small slip of paper. Ask participants to spend two minutes completing Writing Activity #4 (see Appendix A for more detail). Inform participants that the facilitator will collect the 'exit slips' on their way out the door | Experience an informal writing activity that could be appropriate for engineering courses<br><br>Gather written feedback from the participants on the workshop, including ideas for how to improve the workshop for future offerings |
| **Total Time:** 90 minutes | | | |

PRESENTATION STRATEGIES

The primary objective of this workshop is to introduce engineering educators, both instructors and teaching assistants, to the benefits of using writing-to-learn activities in the engineering classroom. The workshop begins with the facilitators providing a theoretical basis for the use and value of writing activities. However, the majority of the workshop focuses on the practical application of writing-to-learn activities, allowing participants to engage in these activities themselves. Recognizing that many engineering educators may not be familiar or experienced in using writing as a learning tool, the workshop has been designed to provide participants with experience engaging in writing-to-learn activities. In this sense, participants experience a 'learning-by-doing' approach. Literature on writing-to-learn often advises instructors to engage in writing activities alongside the students as a means of teaching through example and bi-directional learning. The facilitator of this workshop should consider this advice as part of the workshop presentation strategy.

This workshop has also been designed to allow for substantial discussion and interaction between participants. The discussion-based approach provides opportunities for participants to express and explore (with one another and the facilitator) challenges, concerns or questions that may arise throughout the workshop about integrating writing activities into their own teaching practice. These challenges may include a lack of knowledge

in teaching writing, a lack of experience in assessing writing, concerns about workload, or student disinterest in writing. The facilitator should be well-versed on the academic literature that considers writing-to-learn in engineering education (such as the sources summarized above and those listed below). Having a firm grasp on the academic literature will enable the facilitator to answer questions and comments that arise during large-group discussions. Furthermore, the facilitator of this workshop will need to be present and active to help address these challenges, concerns or questions during small/large group discussions. This can be achieved by circulating through the classroom to engage in small group discussions with participants or to answer questions. The facilitator of the workshop will also have to facilitate large-group discussions following writing activities to help participants debrief and share their ideas with one another.

ADDITIONAL REFERENCES

Cummings, K. & Murphy, M. (2007). The effectiveness of incorporating conceptual writing assignments into physics instruction. In L. McCullough, L. Hsu, & P. Heron (Eds.), *2006 Physics Education Research Conference Proceedings, 883* (pp. 61-64).

Sorcinelli, M. D., & Elbow, P. (Eds.) (1997). Writing to learn: Strategies for assigning and responding to writing across the disciplines. *New Directions for Teaching and Learning*, *69*. San Francisco: Jossey-Bass.

Fry, S. W., & Villagomez, A. (2012). Writing to learn: Benefits and limitations. *College Teaching, 60*(4), 170-175.

Hoffman, M. E., Dansdill, T. & Herscovici, D. S. (2006). Bridging writing to learn and writing in the discipline in computer science education. In *ACM SIGCSE Bulletin* (Vol. 38, No. 1, pp. 117-121).

Reynolds, J. A., Thaiss, C., Katkin, W., & Thompson, R. J. (2012). Writing-to-learn in undergraduate science education: A community-based, conceptually driven approach. *CBE - Life Sciences Education, 11*(1), 17-25.

## APPENDIX A: Workshop Handout

Writing as a Learning Tool in Engineering

**LEARNING OBJECTIVES**

By the end of this workshop, participants will be able to:

- Describe the concept of 'writing-to-learn' and explain the benefits of using informal writing activities in engineering courses;
- Share ideas on informal writing activities appropriate for engineering courses;
- Design at least one informal writing activity suitable to their teaching context.

**Prior Knowledge Assessment:**

| Concept | A) I have never heard of it! | B) I have some idea what it is. | C) I have a clear idea of what this is. | D) I can explain what this means. |
|---|---|---|---|---|
| Low-stakes writing | | | | |
| Writing-to-learn | | | | |
| One minute paper | | | | |
| Concept mapping | | | | |
| Logbook | | | | |

**WRITING ACTIVITY #1: Finish the list**

In engineering, undergraduates do the following writing activities:

- 
- 
- 
- 

When undergraduates graduate from engineering, they are expected to write:

- 
- 
- 
- 

**WRITING ACTIVITY #2: Explain a concept**

In the space below, explain [this concept] to a friend of yours that has never taken a science or engineering class at the university level.

**WRITING ACTIVITY #3: WTL Activity Planning Template**

Think about a concept in engineering that first year students have difficulty understanding. Now, imagine that you have been invited to guest lecture on this concept.

Refer to the list of WTL activities. What WTL activity could you use during your guest lecture to help the students learn this difficult concept? How would you structure this activity? Describe your plan below.

**Concept to be taught/learning objective:**

**WTL activity to be used:**

**Time:**

**Instructions:**

**Material/resources needed:**

## APPENDIX B: Example Writing-to-Learn Activities for Engineering Courses

1. Think-Write-Pair-Share: Pose a question or a prompt to students; prompt students to think about their answer individually for a minute; students write their responses; students discuss their responses with a partner.
   - Write the mass balance equation for the contaminant in the given lake.
   - Develop the proton balance equation for the following reaction.
   - Describe critical path method.

2. Concept mapping: Students illustrate information from a class into a visual concept map.
   - Draw a concept map for the topic of consolidation.

3. Explain a Concept
   - Explain 'Newtonian fluid' to a peer who was absent.
   - Summarize 'assimilative capacity' in a letter home to your parents.

4. One-minute paper: Give students the topic for the one-minute paper. Next, give students one or two minutes to think about the topic without writing anything, and then give students one minute to write as much as they can.
   - What was the most significant concept in this chapter?
   - What are the two most important points you will take away from today's tutorial?
   - What is the most important concept that must be considered when designing a landfill?

5. Email the author: Working in small groups, have students compose an email to the author of an article or textbook, explaining a question they have about the content. After reviewing the email, have students send the email.

6. Microtheme: A microtheme is a mini-essay written in-class on a focused topic from class. A microtheme must include an argument, much like an essay. Give students a prompt and five minutes to write.
   - Justify whether current air quality regulations in Ontario is sufficient for environmental protection. What changes would you make?
   - Of the following, select a modeling software/programming language (depending on discipline) that is most suitable for the given problem. Justify your selection.

7. Double-entry notebook: A double-entry notebook allows students to keep lecture notes on one side and reflect on their own notes on the other.

8. Write an exam question: Have students prepare exam questions that could be used in quizzes, midterms, and finals.

9. Logbooks: Logbooks require students to complete frequent short entries in which they summarize and assess material or connect course topics with their own observations.