AC 2012-4824: INTRODUCING MEMO WRITING AND A DESIGN PROCESS: A FIVE-WEEK SIMULATOR PROJECT

Dr. S. Scott Moor, Indiana University-Purdue University, Fort Wayne

Scott Moor is an Associate Professor of engineering and Coordinator of First-year Engineering at Indiana University-Purdue University, Fort Wayne. He received a B.S. and M.S. in chemical engineering from MIT. After more than a decade in industry, he returned to academia at the University of California, Berkeley, where he received a Ph.D. in chemical engineering and an M.A. in statistics. He is a registered Professional Chemical Engineer in California. His research interests include engineering education with an emphasis on developing and testing educational materials and learning spaces that stimulate serious play.

Introducing Memo Writing and a Design Process with a Four-Week Simulator Project

Introduction

First-year engineering courses often include design projects to help spark students' interest and to introduce them to the broad range of issues engineers face. These projects introduce students to the many "soft skills" required of an engineer including judgment, idea generation, communication, planning and organization.

This range of skills is difficult to teach to first-year students. It is not unusual for students to want to jump straight to a solution, skipping over steps of background research, problem definition, idea generation, idea comparison, and the systematic development of well-founded conclusions. Moving students toward being more careful practitioners is an important step in their development. Atman, et. al.[1] have observed that one of the key differences between inexperienced student designers and experienced professional designers is the amount of time and care spent in the project scoping and definition phase.

Carrying out and documenting a design process are naturally linked and writing is an important skill for an engineer. However many, if not most, engineering students do not like to write and have difficulty knowing where to start with an engineering report. Students need guidance in both format and structure conventions for engineering writing. They particularly need to understand how to communicate using tables, graphs, diagrams and equations. Something they may not have been taught in high school English or first-year composition.

Writing also helps our students develop their thinking. Brent and Felder[2] note that "The process of writing and thinking are fundamentally and powerfully linked." In addition it helps them develop a thoughtful, careful and detailed approach to engineering problem solving. For more than twenty five years the Writing-Across-the-Curriculum pedagogical movement has explored and developed ways to use writing with in various courses throughout the curriculum. These efforts have included short informal Writing-to-Learn assignments where students reflect on the material covered in journals, logs or short essays. They have also included longer Writing-in-the-Disciplines approaches such as this case of design reports where students are specifically learning the writing conventions of their particular discipline.[3]

Elbow[4] argues that it is often particularly helpful to assign low-stakes writing, using assignments where the level of critique and the grading weight are low. He notes that "Writing feels like an inherently high stakes activity."[4] The particular assignment sequence presented here allows this type of lower stakes writing to take place.

Overview of Approach

In this introductory activity students carry out a project using an online paper airplane flight simulator. Over several weeks they are walked through stages of the design process and introduced to writing different portions of a technical memo report. The strategy is to move students through a writing process consisting of manageable segments and clear guidelines. These segments also provide a clear and logical structure to the final report. Throughout there is a focus on creating figures and tables to present the basic story and then using narrative to connect and explain these visual items. Class time includes significant time spent on small group activities, followed by homework assignments that walk students though successive steps of the project. Multiple aids are used to help students understand the details expected including forms, examples, rubrics and exercises.

Purpose

The purpose of this introductory project is to introduce students to using and documenting a design process. For the design process it is intended to help students:

- understand the concept and use of a simple iterative design process particularly for an exploratory type project
- develop a habit of more detail in the early stages of the project in problem definition and project planning
- develop a habit of using tables and figures to develop their ideas and understanding of a problem.

In addition, this project helps to teach writing techniques for engineering design reports focusing on:

- using figures & tables to present technical data
- writing well organized memos that include an initial summary
- understanding format standards for text, figures, tables and equations
- learning to prepare key report sections including: Summary, Problem Definition, Methodology, Discussion of Quantitative Results and Conclusions & Recommendations

Context

This project is used in an Introduction to Engineering Design that is taught at a regional state university with relatively open admissions. The majority of students commute to campus with approximately 20-30 percent living in the campus residence. The students tend to be busy and often work off campus. Balancing their varied time commitments is a significant issue for many students.

The course is the last in a sequence of first-year engineering classes where students have previous experience in CAD, MATLAB, table formatting, graph formatting, and memo headers. They also have some experience with group projects. In order to enroll in this course, students must be enrolled in calculus-based physics and in their second semester of calculus. The class meets twice a week for 75 minutes in a room specifically designed for team based courses in sections of 24 to 27 students each. This classroom was described in a previous paper.[5]

Project Simulator

An on-line paper airplane simulator is used to carry out this simple project. The simulator is available on line at several websites.[6] A project webpage for setting up this simulator and linking to various assignments and resources is shown in Appendix A and is available online.[7] The simulator allows for a constrained starting problem that is quick to execute.

A screen shot of the main interface of the simulator is shown in Figure 1. The simulator is relatively easy to operate with three independent variables: Angle, Thrust and Elevator. These setting variables are adjusted using the dials on the lower left of the screen. Setting them exactly can be challenging. Angle is the angle of launch relative to the horizontal plane. It can range from -90 degrees to +90 degrees where counterclockwise is the positive direction. It has a varying resolution over that range. Near zero degrees it can be moved in one degree increments. Thrust is the launch force and can be set from 0 to 100 with a resolution of approximately 2 units. The elevator is the angle of the plane's wings from straight across. It can vary from -35 degrees to +35 degrees where clockwise is the positive direction. It has a resolution of approximately 1 degree.

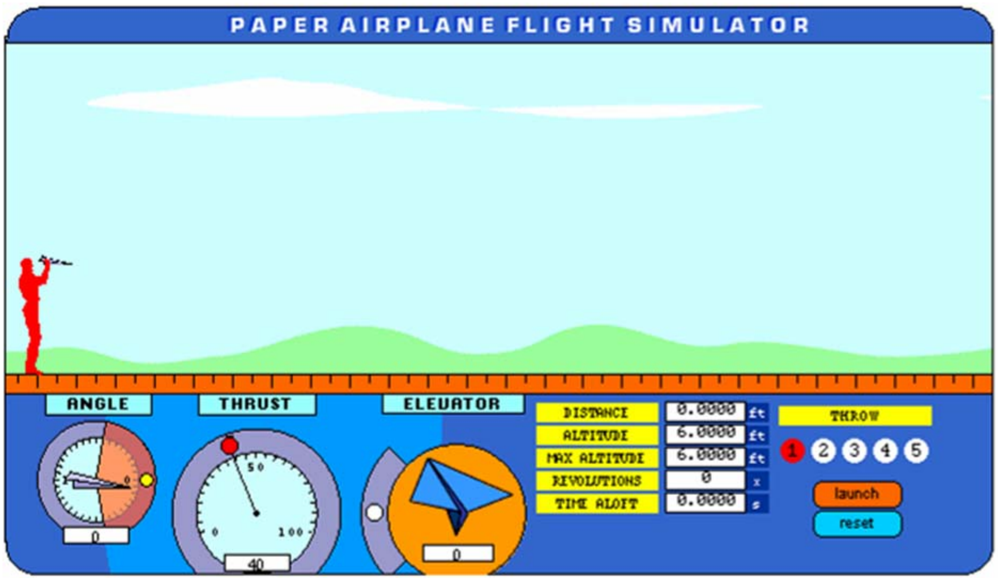


Figure 1: Paper Airplane Flight Simulator Main Screen: Students can adjust the three dials in the lower left of the screen and then push the launch button on the right. The flight is animated on the top screen and the resulting flight statistics and shown in the table near the launch button.

The resulting design problem is an exploratory optimization. It has some interesting complexities in the flights including loops, backwards flights and some flights that look like an error in the programming. These complications add interesting twists to the exercise. While not ideal in a simulator, these characteristics make the simulation a better reflection of a physical project where unexpected results are usual.

Project Stages

Six stages are used for this project with each stage corresponding to one 75-minute class period and a follow up assignment. Every class session has a significant guided activity that allows students to better understand the specific details that are expected. Table 1 shows these stages, and their associated classroom activities, and assignments. The first three stages are all aspects of project scoping: Familiarization, Problem Definition and Project Plan/Methodology. This guides students to spend more time on these important initial activities. Throughout students are encouraged to use figures and tables to aid in developing and writing up a stage. In the section below these class stages are described in detail.

Table 1: Project Classes and Stages

Class	Design Stage	Class Topic	Key Learning Goal	Classroom Activity	Assignment
1	Introduction and Needs Assessment	Design Process Overview	Begin developing a disciplined, detailed approach to design	Compare design processes	Set up simulator & complete 20 runs. Present data and list of observations
2	Problem Formulation	Problem Definition	Develop a complete problem statement that includes an overall goal statement, a breakdown into component sub-goals and clear success criteria	Develop initial goal statement with overall goal, sub-goals and success criteria.	Prepare Problem Definition using the Definition Worksheet Present in a memo with discussion of the logic and priority of the developed goals
3		Project Plan /Strategy	Learn to plan and present plan in detail.	Review strategy possibilities and example strategy	Develop a detailed procedure and strategy, present using figures
4	Abstraction & Synthesis	Working with Quantitative Data	Present results by developing and discussing clear, well formatted tables and figures.	Guided review of example data problem	Execute strategy Develop graphs, Discuss in a memo
		Class on other course topics			
5	Analysis & Implementation	Technical Memos	Prepare a complete technical memo with a clear executive summary, a body broken into sections and clear conclusions and recommendations	Memo Report Discussion	Prepare a memo report of entire project
		Class on other course topics			
6		Peer Review	Avoid common mistakes and understand the detail required in a technical report	Peer Review each other's memos	Revise memo

1. Introduction and Needs Assessment

The project is begun on the first day of class. This class consists of a brief review of the course syllabus and an introduction to design processes from the course text book, Voland' s "Engineering by Design."[8] There are five stages in Voland's design process:

Needs Assessment,
Problem Formulation,
Abstraction and Synthesis (i.e., generating and developing design solutions),
Analysis (i.e., comparison of design alternatives) and
Implementation.

These stages are presented as a cycle emphasizing the iterative nature of design. This design process is compared to two other design processes one from Holtzapple and Reece[9] and one from the Massachusetts State Standards for K12 Engineering and Technology education.[10] Comparing different design processes allows students to see the similarities between these apparently divergent processes. At the end of the class students are briefly introduced to the simulator.

As a homework assignment they are asked to setup the simulator on a computer they will use and then conduct 20 trial "flights" recording the data of each. They are to prepare a memo with the data from these flights and a list of their observations including the range and resolution of the input variables, flight characteristics, and any patterns they observe. Students self-select into pairs to work on the initial four assignments.

This first assignment forms the Needs Assessment stage in the design process, and familiarizes them with the nature of the simulator, its capabilities, and its idiosyncrasies.

2. Problem Formulation: Defining the Problem

The next stage in the design process is Problem Formulation. This phase includes both creating a formal problem definition and developing a project plan. These two aspects are handled in the second and third classes of the term, respectively.

In the problem definition class, students in small groups first discuss what they learned from their initial runs. Next they are walked through developing a problem definition. They are told that the preliminary goal is to find the "best" flight. It is now up to them to decide what the "best" flight means. On small portable whiteboards (Seelcase Huddleboards®)[9] they develop their goal in the following three stages:

1. Overall Goal: They describe their goal in simple narrative.
2. Sub-goals: They breakdown their goal into a numbered list of separate sub-goals. They are asked to develop at least three separate items.
3. Specifications: For each sub-goal they are asked to provide a measurable success criterion.

For each of these stages the stage is explained, students in small groups write on the Huddleboard their ideas for the stage and hang it up so the entire class can see each other's work. Each of these stages is worked through in succession. The various responses at each stage are reviewed before moving on to the next stage.

This three-part setup of the project goal is used to help students understand and include the necessary details to develop a complete problem definition. Later in the course this worksheet is expanded to encourage the use of ten general sub-goal areas that are common to most projects (e.g., goal areas of minimum cost or product safety).[6] It is a more rigid structure than necessary for some industrial projects. However, first-year students benefit from the additional structure. It provides scaffolding to organize their work and encourage them to be more detailed and precise.

The assignment is then to revise and write up a three part goal using the worksheet shown in Table 2. They include this as a table in a memo. In the memo they are instructed to discuss the goal presented, the logic behind it, and the relative priority of the sub-goals. Appendix B shows the rubric for the final report. The rubric for this stage uses the two Problem Definition expectations from this final rubric plus an expectation for the overall presentation and format of the memo. Students continue to work in their self-selected pairs for this assignment.

Table 2: Problem Definition Worksheet

<table>
<tr><td colspan="2">Overall Goals
Write a paragraph succinctly describing the key aspects of the project objective. Make your definition precise as possible and include any major constraints.</td></tr>
<tr><td colspan="2"></td></tr>
<tr><td colspan="2"></td></tr>
<tr><td>Detailed Goals
Make a complete list of goals for the project. Divide each different aspect into separate numbered items</td><td>Specifications
For each item quantify what level will be a successful implementation</td></tr>
<tr><td></td><td></td></tr>
<tr><td>1.</td><td></td></tr>
<tr><td>2.</td><td></td></tr>
<tr><td>3.</td><td></td></tr>
</table>

3. Problem Formulation: Project Plan

The next class continues the Problem Formulation stage by beginning develop a project plan. In particular for this project a detailed written procedure for how to run the simulator and a detailed strategy of what conditions to run are developed.   Students in small groups list the steps required to run the simulator. There are some important data recording steps that some groups miss in their initial procedure. When discussing the procedures students have arrived at these key points can be addressed.   Students are asked how to illustrate their procedure and they quickly figure out that a screen capture of the basic simulator screen (Figure 1) with some additional labeling is helpful in writing up the run procedure.

The rest of the class period is used to examine developing a detailed strategy for how to approach a study of limited runs (usually 60 -75 runs). Students have been asked to read two coin brain teaser problems that are discussed in chapter 4 of the textbook.[8]   These problems have multistep solutions illustrated by a strategy figure. The textbook's solution approach and presentation are reviewed.

The groups are then asked to brainstorm potential difficulties with reaching their goal with in a fixed number of runs (usually 65 – 80).   When reviewing the results of their discussions two particularly difficulties are highlighted by the instructor: how to deal with the multivariable situation and how to cover the vast area of the possible solution space. It is common to calculate the total number of possible solutions. Being as there are approximately 90 launch angles, 50 thrust levels, and 70 elevator angles this results in over three hundred thousand possible combinations.

Possible strategies and how they can be displayed in a figure or table are discussed using examples. Figure 2 shows an example strategy figure that is reviewed in this class. This figure is intended to demonstrate a way to present a strategy visually and is not intended to present a recommended strategy. The definition, range and resolution of the simulator's parameters are reviewed in the Project Simulator section presented earlier. Students are encouraged to use stages in their strategies and all instructor examples include stages.

The assignment after this class is to develop a detailed procedure and strategy for the project. Students are required to use a figure or table to illustrate the overall strategy and to present a table of the planned settings for their first 15 runs of the simulator. Again we are using detailed requirements to encourage adequate detail in planning. The rubric for this stage uses the four Methodology expectations from the final rubric (shown in appendix B) plus an expectation for the overall presentation and format of the memo. Students are continuing to work in pairs.

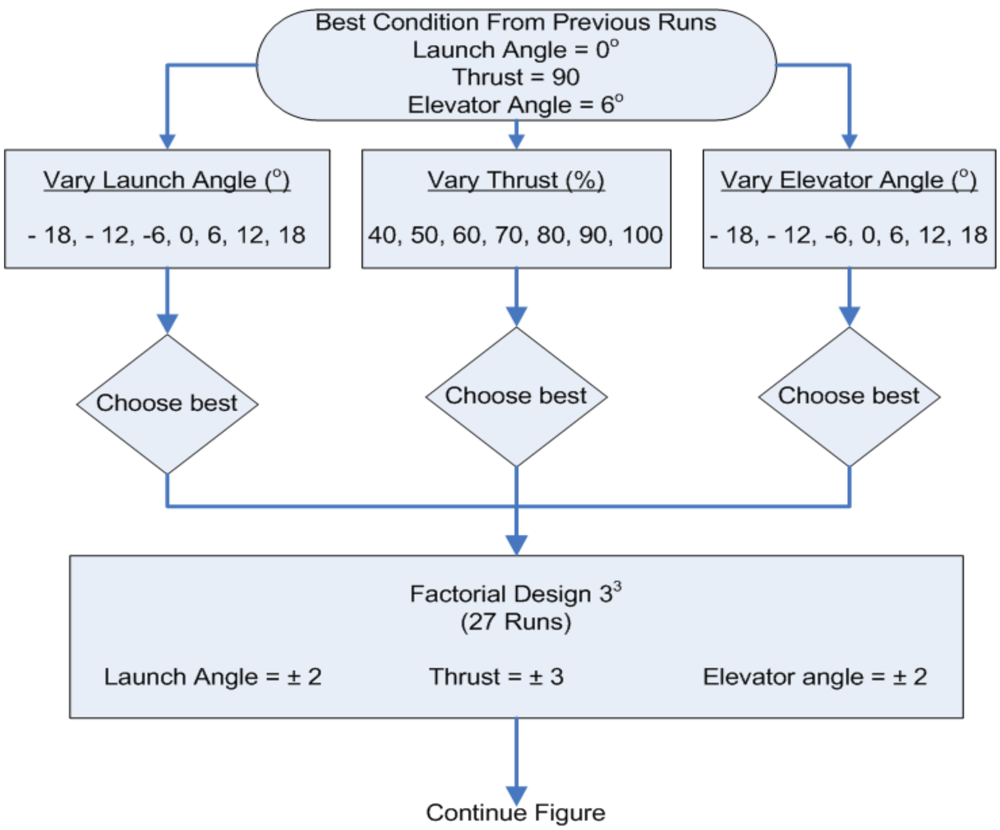


Figure 2: Example Strategy Figure: This figure is used in class to demonstrate how a strategy might be organized and presented graphically. It is not intended to be an example strategy. Other examples are also provided. For definition and range of parameters see the Project Simulator section.

It is important to notice at this point that nearly two weeks of class has been spent on the needs assessment, goal definition, and project planning (formulation). First-year students can have a tendency to skip over these steps and this approach has forced them to spend time before they dive into carrying out the study. The other benefit of this approach is to improve student's eventual write-up of their methodology. In this step students have essentially been required to write their methodology before carrying out the study.

4. Abstraction and Synthesis: Finding Possible Solutions

The next step is to actually run the strategy and review the results. Students should have developed sufficient direction in the strategy to carry out these runs easily. Therefore the fourth class focuses on presenting and analyzing the results. Students are asked in small groups to prepare a proposed organization for an appendix table of all of their data. Students show this structure on the portable white boards (Huddleboards) mentioned earlier. The hang these up for everyone to see and the organization of the appendix table is discussed.

To prepare them for the task of analyzing their data by developing and reviewing tables and graphs, in class students are provided an example data set to look at how to develop a good graphical presentation. The example is data from a flow calibration experiment using an orifice meter.[11] The steps gone through in class are shown in Figure 3. Students are provided with the initial data table (A in Figure 3) and then asked to suggest improvements. They easily come up with improving the number of significant figures, alignment and order of the table (B in Figure 3). They are then guided to developing a graph of pressure (in the form of an uncalibrated raw reading from a data logging system) versus flow rate (C in Figure 3). They generally notice the slight curvature and are told that the expect relationship is that flow rate linearly related to the square root of pressure (i.e., raw reading). This will lead them plotting root of the reading vs flow rate (D in Figure 3). Finally students are guided toward suggesting the division of the data into groups (E in Figure 3) and fitting the linear group (F in Figure 3). Through out this process the instructor has each of these stages prepared but does not present the graph until students have identified the graph needed.

The assignment for this class is to carry out their strategy, analyze the results using tables and graphs, discuss those results and present this information in a memo. Students are asked to develop an appendix table that has the data from all their runs. In analyzing that data set they are to develop a table of the 3-10 of the best runs based on their written goals and specifications. They are to indicate if the runs met the goals and to identify the best run and two alternative runs. In this last step they are carrying out a simplified analysis step, comparing their best alternatives.

In addition students are asked to look deeper into their data and develop one or two more graphs. Some possible graphs are suggested including a graph that looks at the effectiveness of their strategy (This can be simply plotting a key goal parameter verses run number or versus strategy phase) or a map of where goals were met for two of the independent variables.

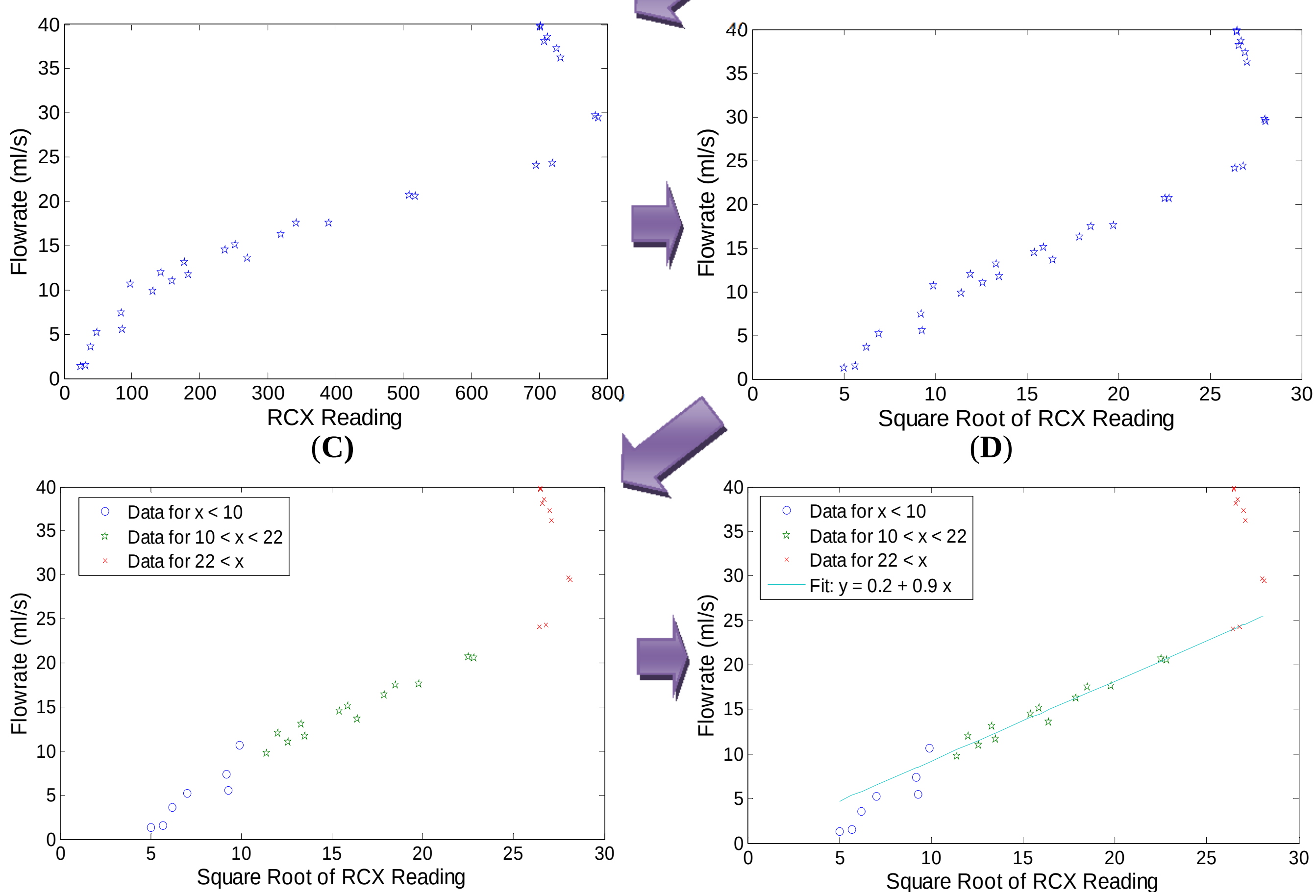
The rubric for this stage uses the four Discussion expectations and the Appendix Table expectation from the final rubric (shown in appendix B) plus an expectation for the overall presentation and format of the memo. Student pairs are usually given a full week to complete this assignment with another topic inserted before the next lecture as part of this project. Students have been asked to bring their initial tables or graphs to this intermediate class to encourage them to continue progress and to allow some peer review of these graphic elements.

Run Order	reading	SqRt Reading	Flow Rate (ml/s)
1	48.5	6.964194139	5.192
2	726.5	26.95366394	37.286
3	787.5	28.0624304	29.521
4	713	26.70205985	38.558
5	86	9.273618495	5.500
6	702	26.4952826	39.768
7	320.5	17.90251379	16.273
8	130.5	11.42365966	9.834
9	32	5.656854249	1.507
10	39	6.244997998	3.646
11	732	27.05549852	36.150
12	783	27.98213716	29.673
...			

(A)

Reading	Square Root (Reading)	Flow Rate (ml/s)
25.0	5.0	1.3
32.0	5.7	1.5
39.0	6.2	3.6
48.5	7.0	5.2
85.0	9.2	7.4
86.0	9.3	5.5
98.0	9.9	10.7
130.5	11.4	9.8
143.0	12.0	12.0
159.5	12.6	11.0
...		

(B)



(E) (F)

Figure 3: Example Data Analysis Figure Development. Students are asked for improvements at each stage and can be guided through improving the initial table (A) by format and order changes (B) and then drawing a graph (C), trying different scaling (D), dividing the data into groups (E) and fitting the linear region (F).

5. Analysis and Implementation: Putting it all together
Once students have completed the execution and analysis of their runs all they need to put the entire project together is an overall structure for their reports and knowledge of how to prepare a conclusions and recommendations section.

For the overall structure students are provided with a detailed handout on a structure for technical report memos. This handout is based on a summary-divisions-wrap structure.[12] Students are asked to start their memos with a first page summary of the entire work. Next is the "divisions" portion which is where they edit together their previous assignments into a will organized body that is divided into the sections Problem Definition, Methodology, Results and Discussion.

The wrap is a recommendations and conclusions section. Some time is taken in class to discuss this section. It is required that this section be presented as a numbered list to emphasize the difference from a typical five-paragraph theme conclusion. Students are given a small group activity to practice writing conclusions for the calibration study used to show graph development (F in Figure 3). Students are given one week to prepare this final technical memo using the entire rubric shown in Appendix B. This final report and its revision in the next stage are done individually.

6. Peer Review
The day they come to class with their prepared memos they are paired off and asked to trade memos for a peer review process. First students are asked to simply read through the memos putting a straight underline under narrative they think is particularly well done and a squiggly underline under passages that might need some work. They are encouraged to include only one or two of each mark on each page. Once most reviewers have completed this stage a peer evaluation checklist is handed out and the reviewers are asked to complete it. The questions included this checklist are shown in Appendix C. Once this review is complete a small amount of class time is allocated to authors reading over the peer review and asking questions of the reviewer. Reviewers are encouraged to not volunteer additional information unless asked allowing the author to control how much additional feedback they receive.

Students are then given one week to revise their memo and turn it back in.

Project Development and Observations
This project has developed over the past four years. The simulations can be run in a short period of time and initially a shorter version of this project was used. The project has been revised to respond to systematic weaknesses found in the students final reports.

Goal Definition: One of the first issues addressed was weaknesses in the students' definition of goals. It was difficult to get most students to provide a complete definition including details and numerical specifications. Since adding the worksheet nearly all students provide these important details in both this project and a subsequent team project.

Methodology: Before including a requirement that a methodology be written up before carrying out runs, students tended to simply do a run and guess what to do for the next run with no real plan or pattern. Their methodology write ups where primarily narratives of what they did not the logic and techniques they used. Adding the requirement of writing a method before carrying out the study improved the quality of the presentation in these sections but student strategies were still not often well thought out. In response the full lecture on strategy with examples was added as well as a requirement that students diagram their strategies and present the specific run plans for the first fifteen runs. This approach has resulted generally well thought-out and detailed strategies.

Details: The final peer review class was added late in the process of developing this project. Prior to its addition students lost significant points because of format mistakes or items missing from their final report. Adding the peer review dramatically reduced the number of points students were missing for parts being left out of their presentation. It clearly helped first-year students begin to understand the demands of engineering writing.

There are two issues that are currently being worked on. First, student use of quantitation in the discussion is less than desired and an explicit quantitation requirement will be added to the rubric expectations for the First Page summary, the Discussion and the Recommendation/Conclusions sections next semester. Second, the quality and detail in the conclusions and recommendations could be improved and ways to improve instruction in this are being explored.

Work is continuing on this project and more formal assessment is planned in the future. Rubrics used in this project and a subsequent design project are being aligned so that student performance over the two projects can be tracked. In addition, a student survey of student attitudes and understanding of technical writing is being prepared.

References:

1. Atman, C. J., R. S. Adams, M. E. Cardella, J. Turns, S. Mosborg, and J. Saleem, "Engineering Design Process: A Comparison of Students and Expert Practitioners," *Journal of Engineering Education*, 96(4), October 2007.
2. Brent, R. and R. Felder, "Writing Assignments – Pathways to Connections, Clarity, Creativity," *College Teaching* 40(1), 43-47 (1992).
3. Romberger, J., "Writing Across the Curriculum and Writing in the Disciplines," *Purdue University Online Writing Lab (OWL)*, http://owl.english.purdue.edu/handouts/WAC/, (2000) accessed December 2006.
4. Elbow, P., "High Stakes and Low Stakes in Assigning and Responding to Writing," *New Directions in Teaching and Learning*, 69, p 5-13, (Spring 1997).
5. S. S. Moor, "Engaging Spaces for First-year Engineering: A Tale of Two Classrooms**,"** *Proceedings of the 2010 American Society for Engineering Education Annual Conference & Exposition*, Louisville, KY (June 2010).
6. Author unknow, "Paper Airplane Flight Simulator," available at OneMoreLevel.com, http://www.onemorelevel.com/games/papersim.html, n.d., accessed 1/2012 or Oigami Kids, http://www.origami-kids.com/paperairplanes-2-simulatoren.htm, n.d., accessed 1/2012
7. Moor, S. S., "Paper Airplane Simulator Project," http://engr.ipfw.edu/~moor/SimSetup.html, 2/2012, accessed 3/2012.
8. Voland, G., *Engineering By Design*, 2nd Ed., Pearson Prentice Hall (2004).
9. Holtzapple and Reece, *Foundations of Engineering 2nd Ed.*, McGraw-Hill (2002).

10. Massachusetts Department of Education, "Science and Technology/Engineering Curriculum Framework – Strand 4: Technology/Engineering," http://www.doe.mass.edu/frameworks/scitech/2001/standards/strand4.html Spring 2001, accessed: January 2010.
11. SS. Moor, P. R. Piergiovanni and M. Metzger*, "Learning Process Control with LEGOs," *Proceedings of the 2004 American Society for Engineering Education Annual Conference & Exposition, Salt Lake City, UT* (June 2004).
12. Eisenberg, A., "Memos and Memo Reports," in *Effective Technical Communication, 2nd Ed.*, McGraw-Hill, (1992)

Appendix A: Resource Webpage

Below is the layout of the instruction website for this project. Underlines show where links to websites or handouts for students are located.

ENGR 199: Paper Airplane Simulator Project

Paper airplane simulator sites: 1 2

Setup - for this simulation to run you need to:

1. Install a shockwave player on your system - Shockwave Player
2. You may need to install the decompression XTRA on your system. You can install a range of XTRAs to Shockwave using this link: http://www.platoweb.com/Wasatch/preload.asp
3. Now you can go to one of the links at the top of this page and run the simulator.

Memo Standards: Format Structure

	Assignment (link to assignment memo)	**Due:**
1.	Needs Assessment: Setup and Initial runs	Wed., Jan. 11th
2.	Problem Definition: Assignment Problem Definition Worksheet	Wed., Jan. 18th
3.	Run Strategy	Wed., Jan 25th
4.	Study Execution and Analysis A. Completion of runs, summary tables and initial graphs B. Execution and analysis memo	 Mon., Jan. 30th Wed., Feb. 1st
5.	Preparation of Technical Memo	Wed., Feb. 8th
6.	Revised Technical Memo - Peer Review Checklist	Wed. Feb. 15^{th}

Appendix B: Memo Rubric

Area		Expectation	Fully Meets	Deficiencies					Area/ Section Present	Missing or Trivial
				1 or 2 minor	A Major or >2 Minor		Multiple Major			
1st Page	Format	• Complete header that matches the example memos • All individuals titled equivalently and spelled out correctly • Subject is specific (unique – Follows text format guidelines) • Format is consistent & follows guidelines • Clearly and neatly presented with no spelling or grammar errors • Presented in third person	10	9	8	7	6	5	4	0
1st Page	Content	• purpose clearly spelled out in 1st paragraph • includes key conclusion(s) or recommendation(s) • briefly describes method used • focus is on the results (> half of the text is about what resulted, was learned) Complete summary of project uses space available well (fills the first page with the most important information)	10	9	8	7	6	5	4	0
Body	Format	• Follows text format guidelines • Clearly and neatly presented • Format is consistent throughout (line & paragraph spacing, margins, type size …) • Discussion is present tense & 3rd person (procedure steps only may be in command voice)	5	4.5	4	3.5	3	2.5	2	0
Body	Content	• Has appropriate titled sections (divisions) • Includes at least the following sections: o Problem Definition ○ Methodology ○ Results & Discussion • Prose flows smoothly and logically with appropriate background & transitions	5	4.5	4	3.5	3	2.5	2	0
Problem Definition	Figure	• Worksheet presented as a table containing: o general goals statement paragraph easily readable by a lay audience o list of at least 3 clear and distinct sub-goals in complete sentences, o unambiguous measurable specification(s) for each goal • Table is a label with "Table," a number, & brief title • Appears in first available space after paragraph of 1st mention • Table does not cross a page break	5	4.5	4	3.5	3	2.5	2	0
Problem Definition	Discussion	• Discussion of the above table including: o specific reference to the table by number o reasons goal was chosen (goal logic) o prioritization of sub-goals • at least 200 words • clear • complete • well written	5	4.5	4	3.5	3	2.5	2	0
Methodology - Procedure	Figure	• Includes a helpful, well-prepared, and labeled procedure diagram • Follows format guidelines (axis labels, legends, use of symbols, Xeroxible …) • A caption is placed below figure with a sequential number • Caption includes a figure description of several sentences • Appears in first available space after paragraph of 1st mention • Proper pagination (i.e., figure does not cross page break) • Easily read: font, layout and overall size are appropriate	5	4.5	4	3.5	3	2.5	2	0
Methodology - Procedure	Discussion	• A clear description of procedure used to run a simulation • Explicitly references graphic at beginning of discussion • Discussion is > 100 words. • The procedure presented provides complete and clear information on how to run simulator and/or references details available elsewhere	5	4.5	4	3.5	3	2.5	2	0
Methodology - Strategy	Figure or Table	• A figure or table illustrating the strategy for choosing conditions • Graphic element is clear, and creative contributes to understanding the strategy • Follows distributed format guidelines including Figures: axis labels, legends, use of symbols, Xeroxible … Tables: row and column labels, units, reasonable significant figures … • Caption in correct place with sequential number • Descriptive caption (several sentences) for figures, • Appears in first available space after paragraph of 1st mention • Proper pagination (i.e., figure does not cross page break) • Easily read: font, layout and overall size are appropriate	5	4.5	4	3.5	3	2.5	2	0
Methodology - Strategy	Discussion	• A clear narrative discussion of above graphic is included • Explicitly references above graphic at beginning of discussion • Discussion is > 100 words • Overall strategy is clear and detailed • Strategy can easily guide all 70 runs, providing a clear basis for all decisions • Strategy has a clear & sound logical basis	5	4.5	4	3.5	3	2.5	2	0

Appendix B: Memo Rubric (continued)

Area		Expectation	Fully Meets	Deficiencies					Area/ Section Present		Missing or Trivial
				1 or 2 minor	A Major or >2 Minor		Multiple Major				
Discussion - Best Runs	Table	Table of top results, identifying "best" run and at least two alternatives Neatly formatted following all table format guidelines: • Includes all settings and resulting responses • Table is a label with "Table," a number, & brief title above table • Appears in first available space after paragraph of 1st mention • Proper pagination (i.e., figure does not cross page break) • Appropriate number format, significant figures and units used	5	4.5	4	3.5	3	2.5	2	0
	Discussion	• Clear discussion of the best runs table • Explicitly references above graphic at beginning of discussion • Discussion is > 100 words • Relates best runs to problem definition	5	4.5	4	3.5	3	2.5	2	0
Discussion - Additional	Figure	• A clear well prepared discussion section graph is included • Follows format guidelines (axis labels, legends, use of symbols, Xeroxible …) • A caption is placed below figure with a sequential number • Caption includes a figure description of <u>several</u> sentences • Appears in first available space after paragraph of 1st mention • Proper pagination (i.e., figure does not cross page break) • Easily read: font, layout and overall size are appropriate	5	4.5	4	3.5	3	2.5	2	0
	Discussion	• Clear discussion of analysis figure • Explicitly references above graphic at beginning of discussion • Discussion is > 100 words • Figure main point and details clearly reviewed	5	4.5	4	3.5	3	2.5	2	0
Recommend. & Conc.	Format	• A numbered list of conclusions and a numbered list of recommendations *or* A numbered list of conclusions and recommendations • Presented using clear complete sentences in 3rd person • Outside of numbered list, follows same format as the rest of the body	5	4.5	4	3.5	3	2.5	2	0
	Content	• Each item is specific and detailed (usually several sentences or paragraphs in length) • Recommends "Best' condition and •at least two viable alternative conditions • Appropriate recommendations & conclusions included from additional analysis appropriate to specific report (strategy effectiveness, patterns seen, …) • Clear basis for all conclusions & recommendations covered in the body of the report (no surprises)	10	9	8	7	6	5	4	0
Appendix Table		Appendix table of 70 new run conditions and results (may include familiarization runs) Neatly formatted following all table format guidelines: • Includes all settings and resulting responses • Table is a labeled with a brief title above table on each page • Appears at the end of the document, starting on a new page • Proper pagination (i.e., for an appendix: figure starts on a new page • and column headers are repeated if more pages are needed) • Appropriate number format, significant figures and units used	5	4.5	4	3.5	3	2.5	2	0

Appendix C: Peer Review Questions

Initial Memo Checklist

Review the memo in the light of these questions.
Provide gentle constructive feedback and suggestions to the author. Do not revise.

First Page (comments expected)

- Is the header complete (including To, From, cc, Date, Subject)?
- Are all individuals names presented equally?
- Is the purpose clearly spelled out in the first paragraph?
- Is there a full summary on the first page?
- Does the summary include a description of method or approach used?
- Does the summary include the bottom line (the key conclusions/recommendations)?
- Is advantage taken of space available to prepare a complete presentation (i.e., is the first page well used)?
- Does memo follow format guidelines in class and handouts? Is the format consistent?

Whole Story (comments expected)

- Can the basic story be understood from figures and tables alone?
- Are figures and/or tables used, clear, and formatted correctly with proper labels, numbers and captions (at least three figures and tables in results & discussion, and at least one in methodology)?
- Are figures and tables mentioned by number and then discussed, using at least 100 words discussing the content of the figure for at least three figures in the results & discussion?
- Is the memo logical organized with appropriate subheadings (including at least Methodology, Results & Discussion, and Conclusions &Recommendations)?
- Is it clear and concise? Does it use proper grammar and spelling?
- Is the presentation results oriented (i.e., not history oriented)? Is the methodology (procedure and strategy) written so it works both as what was done and what could be done in a future trial?
- Is there a table with a clear general goal statement plus detailed sub-goals and specifications presented and discussed?
- Are best and alternative conditions clearly presented and justified?
- Are clear conclusions and/or recommendations included in numbered list format?
- Are the conclusions and/or recommendations logical and specific?