April 1999

Portfolio Assessment in Aerodynamics

Nikos J. Mourtos

San Jose State University, Nikos.Mourtos@sjsu.edu

Follow this and additional works at: https://scholarworks.sjsu.edu/aero_eng_pub

Part of the [Aerospace Engineering Commons](#)

Recommended Citation

Nikos J. Mourtos. "Portfolio Assessment in Aerodynamics" *ASEE Journal of Engineering Education* (1999): 223-229.

This Article is brought to you for free and open access by the Aerospace Engineering at SJSU ScholarWorks. It has been accepted for inclusion in Faculty Publications by an authorized administrator of SJSU ScholarWorks. For more information, please contact scholarworks@sjsu.edu.

Portfolio Assessment in Aerodynamics

NIKOS J. MOURTOS

*Department of Mechanical & Aerospace Engineering
San Jose State University, California*

ABSTRACT

A new way of assessing student learning in an aerodynamics course through the use of portfolios is presented. The approach is portable to any engineering course, with a few modifications depending on content.

The main idea is to allow students more responsibility for their own learning. Instead of having everyone in the class perform identical activities (homework, experiments, projects, tests, etc.), a cadre of assignments is made available to them. Students choose and perform (within reason) the ones that suit them better in terms of their own strengths and learning styles. The ultimate goal is for each student to demonstrate a minimum level of competence in analytical, computational, experimental, design, communication, and team skills, while pursuing excellence in at least one from the first four categories.

The paper describes the various assignments and options the students have for achieving the learning objectives of the course. It also discusses my observations on the effects of this approach to student learning, the impact on faculty time, and the response from the students. The results from the first two offerings of the course with portfolios show promise for improving student motivation and learning.

I. INTRODUCTION

The aerodynamics course (AE 162) at SJSU is a second junior semester, three unit course (two lecture hours per week plus three hours of lab for fifteen weeks). It integrates analytical, experimental, and computational aerodynamics. By the end of the course the students are also expected to demonstrate basic design, communication, and team skills. The prerequisites for AE 162 are fluid mechanics (ME 111) and technical report writing (Engr. 100 W). The topics discussed in this class include aerodynamic forces and moments, potential flow theory, airfoils and wings at low speeds, and boundary layers.

The analytical part provides a way for students to demonstrate understanding of concepts and develop calculus-based, problem solving skills. The laboratory serves as a vehicle for hands-on experience and the acquisition of experimental skills. The computational assignments focus primarily on modeling and design through the use of interactive software. Communication skills are practiced throughout the semester in the form of written laborato-

ry and design reports as well as short oral presentations. Experiments and design projects are performed in teams of three students. All students in the class must demonstrate a minimum level of competence in each of the six categories of skills mentioned earlier (analytical, experimental, computational, design, communication, and team).

Cooperative learning is used extensively in class as well as outside of class. As a result, students may earn up to 30% of their points in the course through teamwork and the other 70% by performing individual assignments. However, even in those assignments where individual reports are required, students are still encouraged to work in teams as a way of promoting cooperative learning outside of class.¹

One-half of the points come from a combination of a minimum of analytical, experimental, computational, and design work. For the other one-half of the points, the students are encouraged to choose one of these categories of skills, pursue it further through additional assignments, and acquire a higher level of expertise in those skills. For example, a student who enjoys "hands-on" type of work may choose to perform additional experiments, a student who prefers working with the computer may choose to simulate additional flow fields or undertake additional design projects, while a student who is more inclined towards analysis may choose more challenging, calculus-based problems to solve. Students also have the option of pursuing more than one set of skills at the same time or even maintaining a balance in all categories by performing additional assignments in each and every one of them. This kind of flexibility is only possible through the use of portfolios.

Portfolios have been used as assessment tools for a long time in various fields, such as art and architecture. Their use in engineering education is fairly recent.^{2,3} One of the reasons for this interest in portfolios by engineering educators is undoubtedly the shift in higher education culture from topic-driven, teacher-centered instruction to skill-driven, student-centered learning. ABET Engineering Criteria 2000⁴ is a big contributor to this culture change because of its focus on outcomes assessment.

In aerodynamics students develop their portfolios throughout the course and turn them in for evaluation at the end of the semester. Each portfolio includes all the mandatory assignments and tests which demonstrate a minimum level of competence in each area, as well as the student's chosen assignments based on their area(s) / skills of preference. In addition, students write a reflection on their entire learning experience in aerodynamics. A competency matrix is provided so that students can check off each area / skill by matching specific assignments and scores with the corresponding skill (table 1). A table of contents for a typical portfolio is shown in figure 1.

TOPICS	Analytical Homework	Analytical Test part 1	Analytical Test part 2	Analytical Test part 3	Computer Modeling	Creative / Design	Lab Reports
Experiments							
Design Projects							
Aerodynamic Forces							
Pressure Distributions Exp.							
Drag measurements							
Smoke Tunnel Flow Visualiz.							
Your own Experiment / Project							
Similarity							
Your own Experiment / Project							
Review of Fluid Mechanics							
Calibration Experiment							
Wake Profiles Experiment							
Your own Experiment / Project							
Potential Flow Theory							
Fuselage Design / Sim. Proj.							
Your own Experiment / Project							
Airfoils							
Lift and Drag measurements							
Airfoil Design Project							
Your own Experiment / Project							
Wings							
Wing Design Project							
Your own Experiment / Project							
Boundary Layers							
Flat Plate BL Experiment							
Your own Experiment / Project							
Paper Review							
Poem / Sketch							
Reflection							
Total Analytical Points							
Total Experimental Points							
Total Computational Points							
Total Creative Work Points							
Preferred Skills							
Total Points for the Course							
Grade you think you deserve							

Table 1. Competency matrix for aerodynamics (AE 162).

II. CATEGORIES OF SKILLS AND COURSE ASSIGNMENTS

The detailed breakdown of the required and optional work in each category of skills is discussed in the following sections.

A. Analytical Skills

The analytical skills of importance in aerodynamics are the same as those in most engineering courses. Students are expected to demonstrate understanding of concepts by their ability to formulate and solve problems as well as by their critical evaluation of the results they produce. Students are given several opportunities to practice and demonstrate analytical skills in aerodynamics. First and most informally, they are given problems to work out in class,

either solo or in small groups. Next comes the homework. From each topic discussed in class they have to solve and turn in a minimum of two problems, complete with their statements, solution in a step by step, easy to follow format, and some discussion. Finally, for each topic there is an in-class test which consists of three parts:

- Part A is closed book / closed notes and is designed to test basic understanding of concepts with questions / applications. The questions are usually multiple-choice and require critical thinking about the concepts as opposed to simply writing a definition of some kind.
- Part B is open book / open notes and is basic problem solving.
- Part C is also problem solving with open book / open notes, but it is more challenging, may involve open-ended or design problems, and it is taken in teams of three.

TABLE OF CONTENTS

Competency Matrix	
1.	Reflection
2.	Poem / Sketch
3.	Paper Review
3.1	Review
3.2	Copy of the paper
4.	Analytical Work
4.1	Problem Sets
4.1.1	Aerodynamic Forces
4.1.2	Similarity
4.1.3	Review of Fluid Mechanics
	♦ Corrected version (2/27/97)
	♦ Original version (2/20/97)
4.1.4	Potential Flow Theory
4.1.5	Airfoils
4.1.6	Wings
	♦ Corrected version (4/27/97)
	♦ Original version (4/20/97)
4.1.7	Boundary Layers
4.2	Tests
4.2.1	Aerodynamic Forces / Similarity
4.2.2	Review of Fluid Mechanics
4.2.3	Potential Flow Theory
4.2.4	Airfoils
4.2.5	Wings
4.2.6	Boundary Layers
5.	Computer Modeling
5.1	Flow around a cylinder with and without circulation
5.2	The effects of camber on the lift and drag characteristics of an airfoil
5.3	The effects of thickness on the lift and drag characteristics of an airfoil
5.4	Aerodynamic interference between the wings of a biplane
5.5	Aerodynamic interference between wing and empennage
6.	Design Projects
6.1	The design of an airfoil for an ultralight airplane
	♦ Revised edition (4/10/97)
	♦ Original edition (4/3/97)
6.2	The design of the wing planform for a subsonic transport
7.	Laboratory Reports
7.1	Smoke Tunnel Flow Visualization
7.2	Pressure Distributions on a NACA 4412 Airfoil
	♦ Revised edition (3/15/97)
	♦ Original edition (3/8/97)
7.3	Lift and Drag Measurements on a NACA 4412 Airfoil
7.4	Boundary Layer Measurements on a Flat Plate

Figure 1. Table of contents for a typical portfolio.

To establish a basic demonstration of analytical skills, all portfolios must include the minimum of two homework problems from each topic, part A from all the tests, parts B and C from 50% of the tests chosen by the student, and lastly a paper review from a journal of their choice. If a student chooses to use his / her analytical skills to earn the remaining points, he / she must workout two additional homework problems from each topic (usually quite more challenging than the first two) and include in his / her portfolio parts B and C from the rest of the tests.

B. Experimental Skills

The aerodynamics laboratory is equipped with a smoke tunnel, a subsonic wind tunnel, and associated instrumentation. Students are expected to demonstrate not only their ability to use the equipment in the laboratory, but more importantly, their ability to design experiments and interpret their results. A variety of experiments is available, such as flow visualization, pressure, lift and drag measurements, and boundary layer studies.

As a minimum demonstration of experimental skills, all stu-

dents must perform, in teams of three, four experiments complete with laboratory reports. Students who choose to develop further their experimental skills must perform four additional experiments, one of which the team must design from scratch.

C. Computational Skills

As was the case in the physical laboratory, students are expected to develop confidence in designing computational experiments for studying a variety of flow fields and also, in interpreting and evaluating their results. A variety of programs is available on our workstations, both as simulation and as design tools for the course. Typical assignments involve the study of flow fields around cylinders and airfoils, investigations of the effects of camber, thickness, and high-lift devices on airfoil performance, and aerodynamic interference.

As a minimum demonstration of computer-related skills, students must perform five exercises and discuss the results. If computer-related skills is the area of choice for further development by the student, an additional fifteen exercises must be included in the

portfolio.

D. Design Skills

Design skills are usually identified as the ability to:

- a. Tackle open-ended problems.
- b. Generate solutions which meet certain constraints.
- c. Evaluate these solutions using appropriate measures of merit.

The projects available in the course involve the use of appropriate software to design aerodynamic bodies (such as airfoils, wings and fuselages), simulate and evaluate the flow around these bodies, and perform parametric studies. Sometimes students will have their own ideas about design projects and they are allowed to pursue them provided they first consult with me on the nature and scope of their project. All students must perform one design project in a team of three and include the report in their portfolio. Students who choose design as their skill of enhancement must perform four design projects, including one of their own.

It is worth noting, however, that the design experience in the course is not limited to these projects. The laboratory is used as another vehicle for helping students acquire design skills. Students are given demonstrations on how to use all the equipment but are not given detailed procedures on how to acquire their data; they must design their experiments based on what it is they are trying to prove or measure. For example, if the purpose of the experiment is to determine the lift and drag characteristics of an airfoil, they must first consult published data so that they will know before hand what kind of performance is expected for this particular airfoil. Then they must decide at what angles of attack the airfoil should be placed, at what airspeed the tunnel should be run, how many data points need to be collected, and in some cases, what kind of instrumentation to use, to determine with sufficient accuracy all the necessary parameters which define the performance of the airfoil (zero-lift angle, stalling angle, lift slope, maximum lift coefficient, drag coefficient as a function of the angle of attack, etc.). This forces them to come to the laboratory session prepared, otherwise their data will be insufficient and they will have to come back and repeat the experiment. In addition, students who choose to develop their experimental skills must also design an experiment of their own as was mentioned earlier. For example, one team of students designed a flow visualization experiment (using a laser sheet and smoke in the wind tunnel) to study the formation and breakdown of the vortices over delta wings at high angles of attack.

The bottom line is that the students by the end of the semester should be able to demonstrate familiarity with open-ended problems whether they are using a hands-on approach, the computer, or calculus to solve a problem.

E. Communication Skills

Written communication skills are exercised in the course in the following four ways.

- Each team must produce an extensive laboratory report for each experiment that they perform and a design report for each project that they undertake.
- Each student writes a one-page review of a journal article of his/her choice relating to aerodynamics.
- Each student writes a poem on an aerodynamic concept or artifact of his/her choice. This idea was adapted from refer-

ence 5. Students also sketch this concept or artifact in any way that seems relevant to them. This approach integrates humanities with engineering and adds an element of fun to the course, as the students share their poems and sketches at the end of the semester.

- Each student writes a three-page reflection on the course (described in section III).

As far as oral communication skills, the cooperative learning exercises performed in class give students plenty of opportunities to practice small-group communication on a daily basis. Occasionally, students are asked to explain problem solutions on the board in front of the whole class. Finally, upon completion of each design project, each team gives a short formal presentation in class.

Communication is also an integral part of team skills, especially when it comes to reaching a consensus during a team test or design project, being able to defend your opinion while showing respect for others, and being able to see things from the perspective of others who disagree with you.

III. REFLECTION

The last assignment for all students, (and the first one to appear in their portfolios) is a written reflection on their entire learning experience in the course. In many ways, this reflection is the single most important assignment, which shows whether they learned something of lasting value in the class.²

In addition to discussing the material presented in the portfolio, students must include a self-evaluation (i.e., describe their strengths and weaknesses), reflect on what they think they learned in the course, how they learned it, what were the highlights and the challenges for them, and most importantly, how they see the knowledge acquired in the course applied in real life situations, preferably from their own personal experience. As Panitz attests,² this is important for two reasons:

1. It makes students think more deeply about what they are learning.
2. It is a great opportunity to practice communication skills.

An excerpt from a student reflection (Suzan, spring '96) is shown below:

"My husband and I have a Long-EZ (an experimental airplane designed by Burt Rutan) that we built. The canard on this airplane has a so-called laminar flow airfoil. We have a problem with the airplane in that when we fly (at low speeds) in rain showers, we get a nose-down pitching moment that requires additional back pressure on the stick to maintain level flight. When I learned about boundary layers and laminar flow in this class, I was able to explain what was happening: the rain is interfering with the laminar boundary layer (on the canard) causing it to separate so we are losing lift on the canard".

As wonderful as this excerpt may sound, many reflections lack the depth and understanding of what this exercise is all about. This could be, of course, attributed to the students' lack of deeper understanding of the course material or simply their lack of communication skills. It could also be that students are not used to reflecting upon their learning process. Just like with any skill, students must first see the value in reflecting. Proper "reflecting form" must also be modeled for them and then practiced on a regular basis along with instructor feedback. Thus, the "why" and the "how" of reflection must be addressed in class before the students

are asked to reflect.

One of the changes I have implemented based on my experience with end-of-semester reflections, is the requirement that students maintain learning journals. The entries usually take one of the following forms:

- End-of-day reflection. At the end of each class session students are given two to three minutes to reflect in writing on what they learned and how they learned it. The focus may be an interesting point or an outstanding question from the current reading assignment, the lecture, or the problem-solving exercises. In discussing their learning process, students are asked to comment on the things they found most challenging and / or most useful in helping them understand the material. Three or four students are called randomly to share their reflections with the rest of the class.
- End-of-chapter reflection. At the end of each topic (or textbook chapter) students summarize the most important points, the real-life applications of the concepts presented, and what they perceive as the practical value of the material. Once more, they must discuss how they learned the material and what were the challenges in the process.

The idea is to provide students opportunities to reflect in writing on a regular basis, using questions similar to the ones they must answer at the end of the semester. Actually, this process has now become a ritual in every course I teach, whether I use portfolios or not. As a way to ensure that everyone keeps up with the process, journals from five students are collected for assessment at random every week and returned promptly to the students with my comments.

IV. EFFECTS ON STUDENT LEARNING

There are several advantages to using the approach described in this paper for assessing student learning and growth in any engineering course:

1. Portfolios encourage students to take more responsibility for their learning. Not only must they learn new things; they must decide how to learn them and how to apply them. The role of the professor is to provide the opportunities, be a resource, and coach them all the way. Taking responsibility is of paramount importance in any learning process⁶ and is an absolute must for becoming a life-long learner.
2. Portfolios give students strong incentives to improve throughout the course. Students turn in their assignments when they are due during the semester, so they can be graded in a timely fashion. When the assignments are returned to them, suggestions for improvements are made and the students are encouraged to rework their assignments and include the "improved" version (along with the original one) in their portfolio. Solutions for homework problems are not posted. Thus, the burden falls on each student to eventually figure out the solution for each and every problem assigned. This process of giving students opportunities to "approximate", providing feedback, and encouraging them to resubmit their work is also a necessary condition for learning.⁶
3. Portfolios allow students with diverse backgrounds and learning styles to flourish in the course. On the first day of class, students are given the Felder-Silverman index of learning

styles⁷ so that they become aware of their learning style preferences. Research shows that the traditional emphasis on lecturing, analytical homework and exams tends to favor certain types of learners such as the "verbal," "intuitive," "deductive," "reflective," and "sequential" or "type 2" learners (abstract, reflective) in Kolb's learning style model.⁹ Some adjustments can be made in class (for example the incorporation of cooperative learning exercises) as well as in the problems assigned to benefit other types of learners. However, it is the addition of experimental and computational work (flow simulation), which allows the "sensors" the "visuals" the "inductive" and the "active" to really have a go. In addition, it is the open-ended problems and the creativity assignments, which allow the "global" learners to excel. Of course, students should be encouraged and coached to develop a variety of learning styles but they should also be given opportunities to exercise their style of preference especially when they are grappling with new ideas.

Some interesting observations can be made by comparing the grades in the last four offerings of the course (table 2). In fall '93 and fall '94, grades were assigned strictly using a "one-thousand" point system with absolute standards (for example, a minimum of 850 points was necessary for an A- in the course). All students performed identical assignments. In spring '96 and spring '97, grades were based solely on my evaluation of the student-portfolios submitted at the end of the semester. Students had a choice of assignments as discussed earlier. The following observations can be made:

1. Students are more likely to receive a passing grade in the course when portfolios are used. This conclusion can be drawn from the fact that only 10% of the students did not receive a passing grade by the end of the semester in spring '97, none in spring '96 (although some caution should be used in interpreting the data from this particular semester due to the unusually small class size), while the percentages in fall '94 and fall '93 were 19% and 14% respectively. This is an indication that using portfolios motivates students to work harder. Unfortunately, when one examines the number of C's and D's in the course, no clear trends are observed.
2. The number of B's decreased and the number of A's increased significantly when portfolios were introduced in the course. This indicates that some of the students who would normally get B's under the old grading system, are willing and able to utilize the learning opportunities offered to them to achieve an A in the course. At first, one might be tempted to conclude that the new grading system simply makes it easier for the students to earn higher grades. However, a closer look at the data clearly shows that this conclusion is not supported because the percentage of students who received D's in spring '97 also increased to a record high, indicating that the amount of extra work required to earn the high grades is not welcome by all students.
3. Overall, the class GPA jumped from an average of 2.5 in the semesters with traditional grading to an average of 2.95 in the semesters with portfolio assessment. Assuming that grades do reflect student learning of the material as they should, this jump in GPA shows that offering a choice of assignments along with opportunities to rework and resubmit these assignments, will motivate the majority of the students to work

	NO PORTFOLIOS	NO PORTFOLIOS	PORTFOLIO ASSESSMENT	PORTFOLIO ASSESSMENT
	Fall '93	Fall '94	Spring '96	Spring '97
Number of students in class	37	27	9	20
overall class GPA	2.53	2.47	2.94	2.96
A's	9 or 24%	7 or 26%	3 or 33%	11 or 55%
B's	15 or 40%	9 or 33%	2 or 22%	3 or 15%
C's	5 or 14%	5 or 19%	4 or 45%	1 or 5%
D's	3 or 8%	1 or 3%	0 or 0%	3 or 15%
I's + F's + W's	5 or 14%	5 or 19%	0 or 0%	2 or 10%

I: Incomplete

F: Fail

W: Student withdrew from the course

Table 2. A four semester grade comparison in aerodynamics (AE 162).

harder and perform better. It should be noted that the difficulty level of assignments in different categories is comparable so that students do not choose one category of skills versus another based on convenience. Actually, the choices students have made so far for their additional assignments are fairly balanced throughout the whole spectrum of skills. This indicates that choices are made based on learning style preferences.

V. DOES PORTFOLIO ASSESSMENT REQUIRE MORE FACULTY TIME?

It is no secret that authentic assessment of student learning is more time consuming than the traditional approach of "one-shot" homework, reports, and exams. Thus, it should not be surprising that portfolio assessment requires more faculty time especially at the end of the semester when the portfolios are collected and reviewed. After all, students also spend more time revising their assignments and organizing their portfolios. This extra time, on the other hand, does not have to be excessive for the instructor. The grading of the analytical assignments is usually straightforward and quick. A student assistant can easily grade these assignments and the extra time required to grade revisions is negligible. On the other hand, the instructor usually grades design and laboratory reports and it does take a significant amount of time to go through each report and provide feedback to the student. However, for revisions one should not have to read the entire report but only the sections, which were revised. This process is

not nearly as time consuming as it is reading the entire report for the first time.

Another approach, which has been tested successfully, is to invest initially some time in developing very thorough criteria / guidelines for grading design and laboratory reports and have a trustworthy student assistant do the actual grading.

Regardless of the approach followed to grade individual assignments, the time to review each portfolio at the end of the semester can be minimized if (i) all assignments included in the portfolios have been previously graded, and (ii) both "old" and "new" versions for each revised assignment are included so that the instructor can easily see any improvements / corrections made. This being the case, the focus of the review is on checking progress and growth rather than on grading individual assignments.

Thirty to forty-five minutes is usually enough to carefully review a well-organized portfolio. Making the portfolio more selective could further decrease this time. For example, students could be asked to submit only their best x-number pieces of work as their representative accomplishments in the course, with pre-specified numbers of assignments in each category (analytical, experimental, computational, and design work).

VI. STUDENT RESPONSE

Students were interviewed one by one at the end of each semester and asked to provide feedback on the use of portfolios as a learning and as an assessment tool. A synthesis of their responses

showed that most students favor portfolios over traditional grading for the following reasons:

- Students like the idea of having some choice over how to earn their points in the course.
- Students like the fact that a low score on a problem set, a project or a lab report does not automatically condemn them to getting a low grade in the course. Many of them do jump at the opportunity to use my feedback, rework assignments and include the revised editions in their portfolios.
- Students like the fact that a great deal of the points towards their grade does not necessarily have to come from rushed, stressful, in-class exams. Granted, a minimum of 35% of their points will come from tests but the rest of the points may come from a variety of assignments they enjoy much more. Ironically, these time-consuming and more difficult to grade assignments are also the ones which more closely prepare the students for the real world.

Of course, just like anything new, portfolios are not automatically accepted by all students. Some of them are not used to the idea of "being responsible" for their own learning. They want to be told specifically what to do, when, and how. Some will not take advantage of the opportunity to rework assignments. They want to turn them in, whether right or wrong, and get them over with. These are the students who perform poorly in the course (with or without the use of portfolios) and fortunately, represent a minority of the student population. Problems involving student attitudes will, given enough time and persistence on our part, diminish as the teaching and learning culture changes in higher education.

Future plans include the development of a questionnaire for a more quantitative assessment of student attitudes towards course portfolios.

VII. CONCLUSION

A new approach for assessing student learning and growth using portfolios was tested in my aerodynamics course twice (spring '96 and '97). The results, in terms of student motivation and performance, were positive enough to warrant the permanent installation of portfolio assessment in the course. The majority of the students prefer portfolios to traditional grading because they enjoy the variety of learning opportunities offered to them.

As a final note, I would like to comment on the portability of this approach to other engineering courses. One of the essential elements, which makes the use of portfolios successful in my aerodynamics course, is the integration of the various approaches in the solution of problems (i.e., the analytical, experimental, computational, and of course, the element of engineering design). It is exactly this variety which allows the students choices of assignments. But these are natural elements in any engineering course. Besides, any engineering subject can be appreciated best when it is presented by the teacher and experienced by the learner from all of these different angles. In summary, portfolios can be great learning and assessment tools in any engineering course.

REFERENCES

1. Mourtos, N.J., "The Nuts and Bolts of Cooperative Learning in Engineering," *Journal of Engineering Education*, vol. 86, no. 1, January 1997, pp. 35-37.
2. Panitz, B., "The Student Portfolio: A Powerful Assessment Tool," *ASEE Prism*, March 1996, pp. 24-29.
3. Christy, A.D., and M. Lima, "The Use of Student Portfolios in Engineering Instruction," *Journal of Engineering Education*, vol. 87, no. 2, April 1998, pp. 143-148.
4. "Engineering Criteria 2000: Criteria for Accrediting Programs in Engineering in the United States," 2nd ed., Engineering Accreditation Commission, Accreditation Board for Engineering and Technology, Inc. Baltimore, MD, January 1998, <http://www.abet.org/EAC/eac2000.html>.
5. Millan, H.L., "Poetry in Engineering Education," *Journal of Engineering Education*, vol. 85, no. 2, April 1996, pp. 157-161.
6. Mourtos, N.J., "A Model of Learning as it Applies to Engineering," *Proceedings, ASEE Frontiers in Education Conference*, 1996.
7. Felder, R.M., Index of Learning Styles, <http://www2.ncsu.edu/unity/lockers/users/f/felder/public/ILSpage.html>.
8. Felder, R.M., and L. K. Silverman, "Learning and Teaching Styles in Engineering Education," *Engineering Education*, April 1988, pp. 674-681.
9. Harb, J.N., S.O. Durrant, and R. E. Terry, "Use of the Kolb Learning Cycle and the 4MAT System in Engineering Education," *Journal of Engineering Education*, vol. 82, no. 2, April 1993, pp. 70-77.
1. Mourtos, N.J., "The Nuts and Bolts of Cooperative Learning in Engineering," *Journal of Engineering Education*, vol. 86, no. 1, January