Session 1526

ASSESSING STUDENT LEARNING FOR A MATERIALS, MANUFACTURING & DESIGN LAB

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ABSTRACT

A method to assess student learning in engineering design for a Materials, Manufacturing & Design laboratory course at the University of South Alabama is described in this paper. This method uses faculty assessment and student self-assessment, as well as the correlation between the results of the two assessments. Assessment by faculty is based on written design report, lab reports, and homework evaluated by the course instructor, and project oral presentation evaluated by another faculty other than the course instructor. Assessment by students is based on an anonymous retrospective survey and written comments. Assessment results based on 70 students over a two-year period show strong correlation between assessment by faculty and self-assessment by students in demonstrating student learning. The results also seem to indicate that this is a workable assessment method to evaluate student learning engineering design for small engineering departments such as the Mechanical Engineering Department of the University of South Alabama.

INTRODUCTION

A Materials, Manufacturing & Design lab for sophomore students was developed and implemented at the University of South Alabama with a grant from the National Science Foundation Instrumentation & Laboratory Improvement (ILI) program in Fall, 1995. The laboratory course uses a discovery approach to teach students about some concepts of materials science and manufacturing to carry out a design project involving mechanical forming. The design project consists of the design and production of Mardi Gras medallions. Since the Mardi Gras tradition was started in Mobile, Alabama, this design project provides a local tie-in to the student's learning experience. Details of the course have been described elsewhere[1].

Unlike engineering analysis, assessing student learning in engineering design poses a special challenge because there are usually more than one "correct" answer in design. Also, the feeling by the faculty of a personal stake in the outcome of the design project can influence the instructor in evaluating student learning.

A method to evaluate student learning in engineering design that employs more than one instrument and that looks at the correlation between the results of multiple methods of assessments is described below. By "triangulating" the results, a more complete picture about student learning can be constructed.

ASSESSMENT METHOD

There are two objectives to assess in the "Materials, Manufacturing & Design" lab course:

1. Students successfully demonstrate the elements of design via their design projects; and

2. Students demonstrate favorable reactions to the learning experience.

Objective #1 is assessed by the written design report grade, project oral presentation grade, and overall course grade, as well as student responses to a retrospective survey and written comments. Objective #2 is assessed by a student respective survey and written comments.

The written design report is graded by the instructor, while the project oral presentation is graded by another faculty member other than the instructor based on the following categories: Overall Design (30%); Clarity of Presentation (30%); Use of Visual Aid (20%); Team Work (10%); and Handling Questions & Answers (10%). The overall course grade is assigned using the following distribution: Written Report (25%), Oral Presentation (25%); Six Lab Reports in the form of memo's to the instructor accompanied by supporting graphs and figures (40%); and homework assignments consisting of two writing assignments, 1 AutoCAD assignment, and one memo on decision-making in selecting the team's visual design for the Mardi Gras medallion (10%).

Student self-assessment is based on a retrospective survey to measure student self-perception and confidence. In the retrospective survey, students were asked to check one answer from the categories -- Strongly Agree, Agree, Not Applicable, Disagree, and Strongly Disagree -- to the following five questions:

Q1. "I gain new understanding about the engineering design process as a result of course"

Q2. "I gain confidence in my ability to do engineering design as a result of course"

Q3. "I gain confidence in using a computer as an analysis tool as a result of course"

Q4. "I gain confidence in using spreadsheet to perform engineering analysis as a result of course"

Q5. "I am satisfied with the overall format of the course"

Students are also asked to provide written comments to the following two questions:

Q6. "Identify the activity(ies) in course that helps you gain a new insight about engineering design and/or a new skill. Why?

Q7. "Identify the activity(ies) that you think is (are) redundant. Why?"

The retrospective survey was administered on the last day of class by the ME department secretary, in conjunction with an university-wide instructor/course survey. Students filled out both surveys anonymously.

The first correlation to examine is between the written design report grade assigned by the instructor and the project oral presentation grade assigned by another faculty member other than the instructor. A strong correlation between these two grades ensures objectivity in faculty assessment of student learning.

The second correlation to examine is the results of faculty assessment and student self-assessment. Figure 1 shows the four possible correlations between assessment by faculty and self-assessment by student.

In Quadrant I, a student rated the course "high" in his /her perception and confidence ("Agree" and "Strongly Agree" to Q1 to Q4 in the retrospective survey) but he/she received a "low" grade from the instructors (a grade of C, D, or F). Quadrant I, "False Negative," indicates that while the student had a positive feeling about the course, he/she had not really learned.

In Quadrant II, the student rated the course "low" ("Strongly Disagree," "Disagree" and "Not Applicable") in his/her perception and confidence, and he/she received a "low" grade (a grade of C, D, or F) from the faculty members. Quadrant II represents "True Negative," which means the course materials were probably inaccessible to the student and might even have a negative impact on student learning.

In Quadrant III, the student received a "high" grade (a grade of B or A) from faculty members but he/she rated the course "low" in his/her perception and confidence ("Strongly Disagree," "Disagree," or "Not Applicable"). Quadrant III represents "False Positive," which means the student probably knew the course materials already, and the course has no impact on student learning.

Finally, in Quadrant IV, the student received a "high" grade (a grade of B or A) from the faculty members and he/she rated the course "high" ("Strongly Agree" or "Agree") in his/her perception and confidence. Quadrant VI represents "True Positive," which means that the students achieved the learning objectives and the course has a positive impact on student learning.

If the identity of each student filling out the retrospective survey is known, then, together with the faculty-assigned grade, assessment of this student is represented by a point in Figure 1. The number of points in Quadrant IV represents the number of students who have achieved the learning objectives, and the total number of points in Quadrants I to III represent the number of students who have not achieved the learning objectives. Even if the retrospective survey is conducted anonymously, a technique described in the Results Section below can be used to determine the minimum number of students in

Quadrant IV of Figure 1, i.e., the minimum number of students who have achieved the learning objectives.

RESULTS & DISCUSSIONS

The assessment results of 70 students who enrolled in ME 211, "Materials, Manufacturing & Design," over two years (Winter 1996 to Fall, 1997) are presented below. Of the 70 students, 62 completed the retrospective survey.

1. Objective #1: Students successfully demonstrate the design process via their design project

The grade distribution for the written report is as follows: 35 students (50%) received the grade A; 33 students (47.2%) received the grade B; 1 student (1.4%) received the grade D; and 1 student (1.4%) received an "Incomplete" due to death in the family. Overall, 68 out of 70 students (97.1%) received a grade B or higher in their written report. The written report grade was assigned by the instructor and author of the paper.

The grade distribution for oral presentation is as follows: 35 students (50.0%) received the grade A; 30 students (42.9%) received the grade B; 4 students (5.7%) received the grade C; and 1 student (1.4%) received the grade "Incomplete." Overall, 65 out of 70 students (92.9%) received the grade B or higher. The oral presentation grade was assigned by another ME faculty than the instructor.

The distribution for the overall course grade is as follows: 38 students (54.3%) received the grade A; 30 students (42.9%) received the grade B; 1 students (1.4%) received the grade C; and 1 student (1.4%) received the grade "Incomplete." Overall, 68 out of 70 students (94.9%) received a course grade of B or higher.

The grade distribution for written report, oral presentation, and overall course grade is shown in Figure 2. There is good correlation between the three grades.

The responses of 62 students to Questions Q1 and Q2 of the retrospective survey are summarized in Figure 3 and described below:

• 35 students replied that they "agree" with the statement "I gain new understanding about the design process as a result of ME 211"; 24 students replied that they "strong agree"; 1 student replied "strong disagree"; and 2 student replied "not applicable" to the statement. Overall, 59 out of 62 students (95.2%) indicated they gain new understanding about the design process as a result of the course.

• 41 students replied that they "agree" with the statement "I gain confidence in my ability to do engineering design as a result of ME 211"; 18 students replied they "strong agree"; 3 students replied they "disagree" to the statement. Overall, 59 out of 62 students (95.2%) indicated they gain confidence in their ability to do engineering design as a result of the course.

Because students filled out the retrospective survey anonymously, the results from student self-assessment cannot be directly correlated with assessment by faculty to evaluate Objective #1. If the identities of the students completing the retrospective survey were known, then the assessment of each student is represented by a point in one of the four quadrants of Figure 1 (True Positive, False Positive, False Negative, True Negative); Objective #1 can be evaluated by noting the number of students in the "True Positive" quadrant.

Correlation between student self-assessment and faculty assessment is further complicated by the fact that only 62 out of the 70 students who enrolled in the course took part in the retrospective survey. Nonetheless, if one normalized the results of faculty assessment and student self-assessment, the following procedure can be used to evaluate the minimum percent of students in the "True Positive" quadrant of Figure 1:

Let X1, X2, X3, and X4 represent the percent of students in the True Negative, False Negative, False Positive, and True Positive quadrant, respectively, of Figure 1.

$$X1 + X2 + X3 + X4 = 100\%$$

In response to question Q1, three out of 62 students (4.8%) rated the course "low" (those who picked either "Strongly Disagree," "Disagree," and "Not Applicable") in helping them "gain new understanding about the design process," while 59 out of 62 students (95.8%) rated the course high.

Therefore, $X1 + X2 = 4.8\%$ and $X3 + X4 = 95.2\%$

If the written design report grades were used to assess student learning engineering design, 68 out of 70 students (97.1%) received a "high" grade (Grade A or B) while 2 students (2.9%) received a "low grade" (Grade C or D, F, or "Incomplete").

Therefore, $X1 + X3 = 2.9\%$ and $X2 + X4 = 97.1\%$

Solving these equations give $X4 = 92.3\% + X1$

If responses to question Q2 were used: three out of 62 students (4.8%) rated the course "low" in helping them "gain confidence" in their ability to do engineering design, and 59 out of 62 students (95.2%) rated the course "high,"

Therefore, $X1 + X2 = 4.8\%$ and $X3 + X4 = 95.2\%$

This yields again, in conjunction with faculty-assigned written report grade, $X4 = 92.3\% + X1$

Since X1 cannot be negative, this implies that the minimum value for X4, the percent of students in the True Positive quadrant of Figure 1, is 92.3%. Therefore, it can be concluded that at least 92.3% of the students enrolled in the course met Objective #1 based on written report grade and student self-assessment.

The results for the cases where faculty-assigned oral presentation grade and overall course grade were used, respectively, to correlate with student self-assessment are tabulated in Table 1. The average for the six cases gives an average minimum value for X4 of 90.9%, with a standard deviation of 1.7%.

That Objective #1 has been accomplished by a great majority of students is supported by student written comments. In respond to the question in the retrospective survey, "Identify the activity(ies) in ME 211 that helps you gain a new insight about engineering and/or a new skill. Why?", 50 out of 62 students submitted written comments. Of these, 49 were positive comments and one was a negative comment concerning inadequate time devoted to learning AutoCAD Release 13.

Of the 49 positive comments, 13 were directly related to design. Verbatim some of them are: "I feel that I learn more about designing the coin than any other lab," "By applying the theoretical knowledge we have learned the design/manufacturing process, it has given me new insight into the usefulness of engineering studies and applications," "The step-by-step process enlightened me to how a piece gets developed from an idea," "Laboratory experiments directly correlated real world activities toward problem solving," "The Mardi Gras coin project allowed insight into the design project," and "Throughout this class we have learned many skills. Each and every skill we learned, we applied to our final design project. Without the knowledge we gained in each different lab, we would not have known where to start. The task became very easy once we had an understanding of the skills need to accomplish this task. Each lab seemed to build on each other, leading us to the final design project which we have described in the report. We feel that our design is a good one and could easily be used."

2. Objective #3: Students demonstrate favorable reactions to the learning experience

In question Q5 of the retrospective survey, students were asked to comment on their experience about the course. Thirty-seven students replied they "agree" with the statement "I am satisfied with the overall format of the course"; 21 students replied they "strongly agree"; 1 student replied "disagree"; and 3 students replied "not applicable" to the statement -- see Figure 4. This indicates that 58 out of 62 students (93.5%) were satisfied with course format.

Most of the written comments in the retrospective survey demonstrate student satisfaction with the learning experience: Verbatim some of the comments are: "Industrial application helped me put the course curriculum in focus," "The hands-on approach is much more fun than the typical book learning. Also, you cover a little bit from some upper-level courses," "I gain experience in using hardness machine, roller, micrograph, and engraving the wax block. The reason is that I did all that by myself (include group member) and really gain a feel for that," "Hands-on experiences on what we study theoretically. Our knowledge is put to practice, and therefore we learn more," "Doing 'hands-on training' help me gain the most knowledge"; "Hands-on experiences on what we study theoretically; our knowledge is put to practices, and therefore we learn more."

Concerning the question, "Identify the activity(ies) that you think is(are) redundant. Why?", 12 students provided written comments and 50 students did not reply.

Of the 12 comments, there were two complaints about the frequency of writing memo's to the instructor; one complained why individual teams must produce a visual design even though eventually only one visual design will be used; and one complained about the use of AutoCAD Release 13. Three students responded that some activities were redundant, because they had learned tensile testing and microstructure previously. There are positive comments, such as: "None really. You never can learn too much of a thing (engineering skills, especially). The more practice, the better."

In addition, students were also surveyed concerning the impact of the course on their computer skills. The results are shown in Figure 5 and summarized below:

• 35 students replied they "agree" with the statement "I gain confidence in using a computer as an analytical tool as a result of ME 211"; 20 students replied they "strong agree"; 1 student replied "strongly disagree"; and 6 students replied "not applicable" to the statement. Therefore, 55 out of 62 students (88.7%) rated the course high.

• 35 students replied they "agree" with the statement "I gain confidence in using spreadsheet to performing engineering analysis as a result of ME 211"; 22 students replied they "strongly agree"; 1 student replied "strongly disagree" and 4 students replied "not applicable" to the statement. Therefore, 57 out of 62 students (91.9%) rated the course high.

Among the written comments to the question, "Identify the activity(ies) in ME 211 that helps you gain a new insight about engineering and/or a new skill. Why?" there were 18 comments related to communication skills. One of the 18 comments was a complaint, which is "I was dissatisfied with the short time required to master a basic understanding of AutoCAD Release 13, since it would have taken me a longer time to become acquainted with it."

Among the 17 positive comments, two are related to writing and oral presentation skills ("presentation and memo reports,") and 15 are related to computer skills. Verbatim some of them are: "Using AutoCAD in application form," "Use of the computer/programs to design," "The use of Excel has aided me to use data more efficiently," "I learned to use new aspects of computer programming in development of project for the class," "Using the computer to do statistical analysis on a spreadsheet," and "The class also helps you develop your confidence with computers."

CONCLUSION

A viable procedure to evaluate student learning in engineering design based on correlation between faculty assessment and student self-assessment using a retrospective survey has been demonstrated. Since the time it takes to evaluate an oral presentation is relatively short (two hours in this case), faculty members other than the instructor can usually be recruited to provide a basis for comparison. The assessment results based on 70 students who enrolled in the course over a two-year period show a strong correlation between the assessment by two faculty members, and between faculty assessment and student self-assessment. This lends validity to the proposed method of evaluating student learning in engineering design.

REFERENCE

1. "Implementing a Sophomore-Level Materials, Manufacturing & Design Laboratory," Proceedings 1995 ASEE Meeting, Washington, D.C., CD-Rom.

BIOGRAPHICAL INFORMATION

EDMUND TSANG is Associate Professor of Mechanical Engineering at the University of South Alabama where he teaches courses in materials science, freshman engineering, and ethics. He received his B.S. degree (distinction) in Mechanical Engineering from the University of Nebraska in 1973, and his Ph.D. in Metallurgy from Iowa State University in 1977. Dr. Tsang's current professional interests include integrating community service into the engineering curriculum, and K-12 outreach. Address: Mechanical Engineering Department, University of South Alabama, Mobile, AL 36688. Ph: 334-460-7457; Fax: 334-460-6549; Email: <etsang@jaguar1.usouthal.edu>.

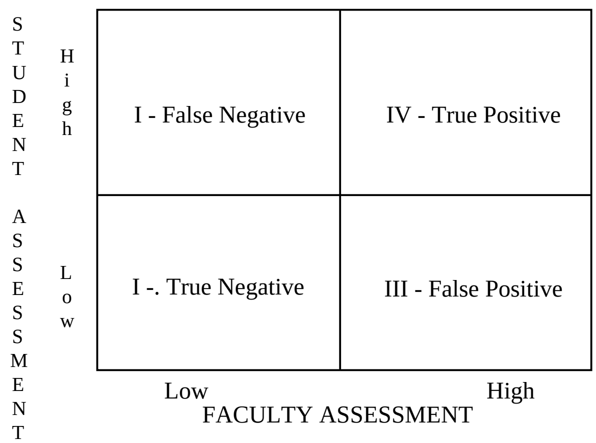
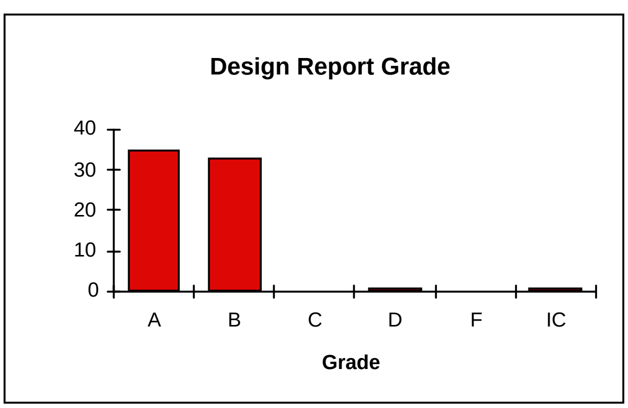
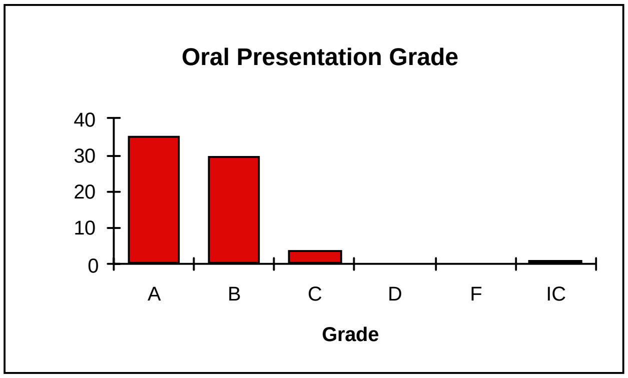


Figure 1. Four possible correlations between faculty assessment and student self-assessment on learning.





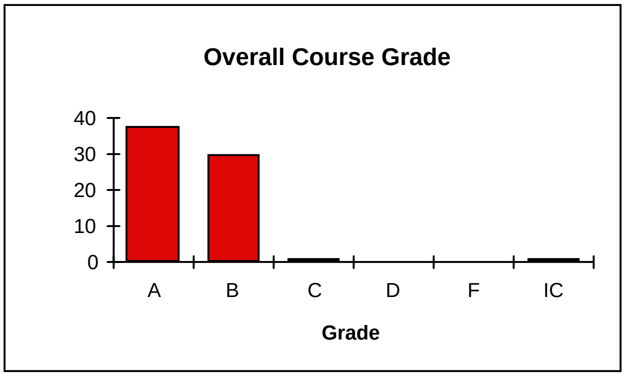
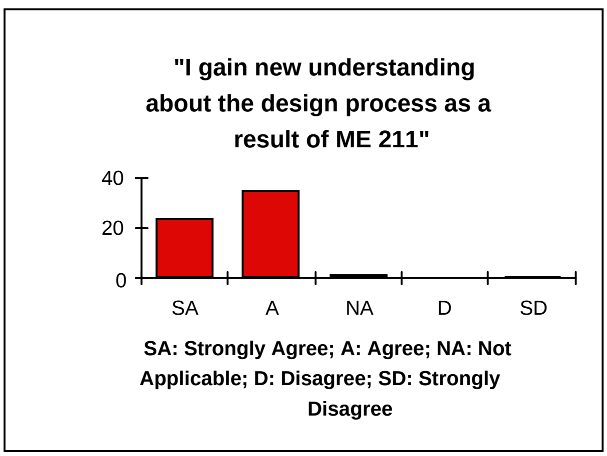


Figure 2. Grade Distributions assigned by faculty members



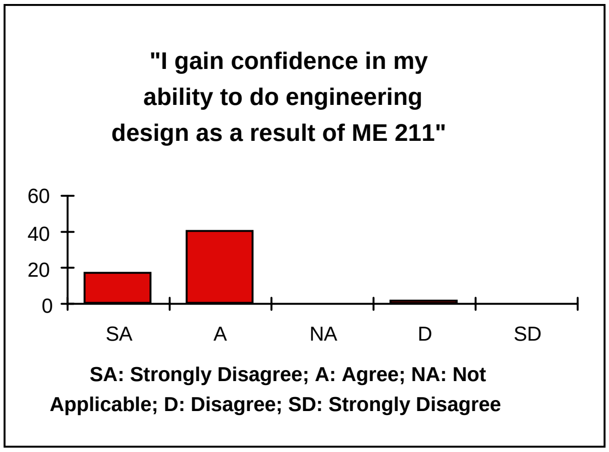


Figure 3. Responses of students to survey on design

Table 1. The minimum percent of students in the "True Positive" quadrant in correlating student self-assessment with faculty assessment on student learning.

	Based On Results from		
	Written Report Grade	Oral Presentation Grade	Overall Grade
Based on Response to Q1	$X_4 = 92.3\%$	$X_4 = 88.1\%$	$X_4 = 92.3\%$
Based on Response to Q2	$X_4 = 92.3\%$	$X_4 = 88.1\%$	$X_4 = 92.3\%$

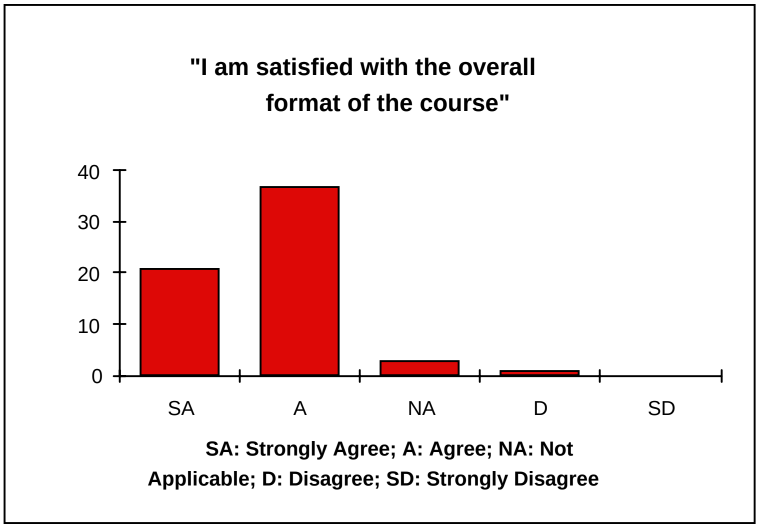
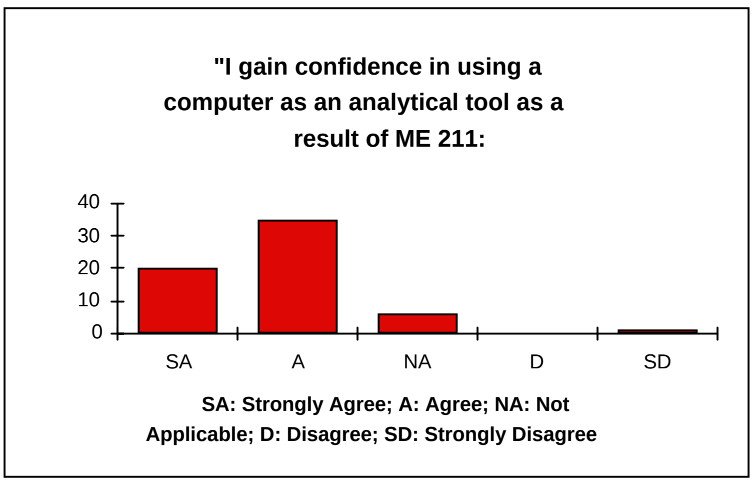


Figure 4. Response of students to survey on overall course format



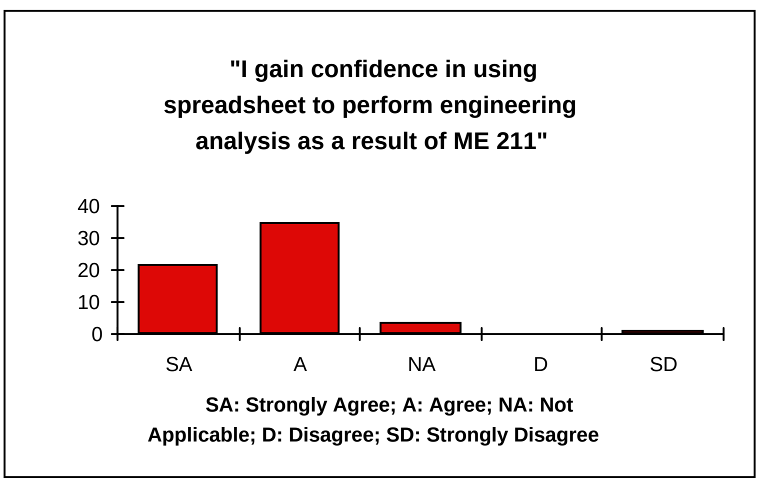


Figure 5. Responses of Students to survey on computer usage