Correlating Student's Evaluation of their Learning with Class Performance

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Abstract
Results of a study comparing student surveys of their achievement of a course's learning objectives with the class performance on these learning objectives through graded assignments are presented. The correlation between the two is not as strong as might be expected, though when presented in quartile fashion the student's perception of their learning as represented by the survey results compares favorably with their achievement on graded assignments.

Introduction
As part of the its response to Engineering Criteria 2000, each undergraduate course in the Department of Mechanical Engineering at Michigan State University has a published set of course learning objectives (CLO). At the end of each semester, students complete a course learning objective questionnaire in addition to the university's Student Instructional Rating System (SIRS) form, which is the primary tool used to assess teaching at the university. The course learning objective questionnaire asks the students to evaluate their achievement of the course learning objectives. However, this may not be a true indication of their achievement. In an attempt to assess how true an indicator the CLO survey results are with respect to student learning, a study was undertaken to compare the students' assessment of their learning with their class performance. This study is the focus of this paper.

This paper continues by presenting the course learning objectives for the course used in this study. Next the measurement of students' achievement of the course learning objectives using graded assignments is explained. A comparison of the survey results with the class performance is then presented and discussed. Final remarks conclude the paper.

Course Learning Objectives
For this study a senior level course in heat transfer (ME 410) was chosen. It is a three credit semester course, meeting three days a week for fifty minutes each class session. The course is required for all mechanical engineering majors, and its topical coverage is typical of the required heat transfer course in most mechanical engineering programs. The class was taught in one large section of fifty-five (55) students. The complete set of course learning objectives for the course is shown in Figure 1. These were developed by the faculty that routinely teach the course approximately one year prior to the department's last ABET visit. It will be clear to heat transfer instructors that some of these objectives are not appropriate or are not worded appropriately. This is due to the faculty's inexperience in writing course learning objectives. At the end of each semester, students are asked to evaluate their achievement of the course learning objectives. Simultaneously, this form is also used by the college to gather the student assessment of teaching. This form allows for eighteen supplemental questions that are utilized for the course

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Figure 1 Course Learning Objective for ME 410

1. Students understand and are able to use the conduction, convection and radiation rate equations
2. Students are able to use the conservation of energy to solve problems
3. Students are able to solve one-dimensional heat conduction problems using the energy equation and Fourier's law
   3.1 Students are well versed in the use of the thermal resistance network
   3.2 Students can solve one-dimensional problems in radial systems,
   3.3 Students can solve problem involving some form of energy generation
   3.4 Students are able to solve problems involving extended surfaces
4. Students have an understanding of the analytical and numerical techniques used for solving two dimensional, steady-state and transient heat conduction
5. Students are able to solve simple transient heat conduction problems
   5.1 Students are able to use the lumped capacitance method
   5.2 Students are able to solve problems where spatial effects are important using approximate methods and the Heisler charts
   5.3 Students are able to solve problems with a semi-infinite dimension
   5.4 Students are able to solve simple transient problems with multidimensional effects
6. Students are able to solve problems where convection heat transfer is important
   6.1 Students understand the origin and implications of boundary layers for laminar & turbulent flows, and their impact on convection heat transfer
   6.2 Students are aware of the similarity solutions
   6.3 Students understand the origin of relevant dimensionless parameters
   6.4 Students understand the implications of Reynolds' analogy
   6.5 Students understand the hydrodynamic and thermal considerations for internal flows
   6.6 Students understand the derivation of the energy balance for constant temperature & constant heat flux boundary conditions for internal convection problems
   6.7 Students are able to use convection correlations to solve forced convection problems for external and internal flows
   6.8 Students understand the important physical aspects of free convection
   6.9 Students have knowledge of the governing equation relevant to natural convection
   6.10 Students understand the relevant dimensionless numbers for natural convection
   6.11 Students are able to use Nusselt number empirical correlations to solve natural convection problems
7. Students are able to solve simple radiation problems
   7.1 Students understand concepts such as blackbody , surface emission, absorption, radiosity
8. Students are able to find appropriate view factors, and compute simple radiation exchanges for gray surfaces

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Figure 2 Course Learning Objective Survey for ME 410

ME 2000
The Mechanical Engineering Undergraduate CQI Program
at Michigan State University

<u>Supplemental SIRS Questions: ME 410</u>
Using the bubbles available under the Supplemental Question portion of the SIRS form, evaluate your level of confidence with the following topics. Please use a 5-1 scale with 5 indicating complete confidence and 1 indicating no confidence. Since there are no numbers under the bubbles on the SIRS form, please treat the first bubble for a question as the 5 and the last bubble as the 1 as shown below

A. (5) (4) (3) (2) (1)

A. Ability to use the conservation of energy to solve problems
B. Ability to solve one-dimensional heat conduction problems using the energy equation and Fourier's law
C. Ability to use the thermal resistance network
D. Ability to solve problem involving some form of energy generation
E. Ability to solve problems involving extended surfaces
F. Ability to solve simple transient heat conduction problems
G. Ability to use the lumped capacitance method
H. Ability to solve problems where spatial effects are important using approximate methods and the Heisler charts
I. Ability to solve problems with a semi-infinite dimension
J. Ability to solve problems where convection heat transfer is important
K. Understanding the origin and implications of boundary layers for laminar & turbulent flows, and their impact on convection heat transfer
L. Understanding the origin of relevant dimensionless parameters
M. Understanding the derivation of the energy balance for constant temperature & constant heat flux boundary conditions for internal convection problems
N. Ability to use Nusselt number correlations to solve convection problems
O. Understanding the important physical aspects of free convection and the relevant dimensionless numbers for natural convection
P. Ability to solve simple radiation problems
Q. Understanding concepts such as blackbody , surface emission, absorption, radiosity
R. Ability to find appropriate view factors, and compute simple radiation exchanges for gray surfaces

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learning objectives. Unfortunately, for a course such as ME 410 that has twenty four course learning objectives, so that a survey can only be conducted for a subset of the CLO's. A copy of the survey used for ME 410 is shown in Fig. 2. The students are asked to assess their level of confidence pertaining to the course learning objectives. Although the survey indicates that a 5 to 1 scale will be used, during processing the university scoring office uses a 1 to 5 scale, so that the best rating will be a 1.0.

Student Performance

To obtain data concerning the students' class performance per the course learning objectives, each student assignment was graded with respect to the course learning objectives. That is, the first problem of a homework assignment might involve three different course learning objectives. Whereas the entire problem might be worth ten points, these points were actually assigned and recorded based on partial credit associated with each of the three course learning objectives. As an example consider the final exam shown in Fig. 3. Each problem was worth 50 points. Partial credit for grading was assigned on the basis of the course learning objectives involved in the problem. As an example, for the first problem 20 points were allocated for the course learning objective dealing with the ability to use Nusselt number correlations to solve convection problems (CLO N, using the survey numbering), 15 points for the ability to solve problems involving extended surfaces (CLO E), and 15 points for the ability to use the thermal resistance network (CLO C). Similarly, for problem 2 all 50 points were allocated to CLO R, while for problem 3 the breakdown was 45 points for CLO H and 5 points for CLO G. This grading approach was done for all homework assignments and exams given in the course. Hence a class's average performance for each course learning objective may be calculated. Since a subset of the CLO's are surveyed, only this subset is used in this partial credit grading of assignments. As the survey data and grading data were being analyzed, it seemed that one additional set of data may prove useful, the number of lecture hours spent on each CLO topic. Unfortunately, this was not tracked by the instructor while teaching the course. Though the instructor has a set of detailed notes, it was felt that for the specific class it might be more reliable to borrow the notebook for one of the top students in the class. Since this student dated his notes, it was fairly easy to go through and make this determination.

Data Analysis

Table 1 presents the data collected for this study. The homework scores, exam scores, and survey scores presented represent class averages. We note that only eight of the CLO's are assessed through exam performance and only thirteen through homework performance. It is not unusual that all of the course learning objectives do not appear in graded assignments, but one might expect a better match between the content of graded assignments and the course learning objectives. In order to better observe the presence of a correlation, the survey data was converted over to a percentage using the following equation:

$$\text{Survey \%} = \{5 - \text{survey score}\}/4$$

In Fig. 4 we present a graph of the homework scores and exam scores versus the survey percent. Though there is some correlation, the straight line on the graph indicates a one-to-one correspondence, the correlation is not as strong as one might wish. The correlation coefficient for several of the data sets was calculated and is presented in Table 2. We see that the

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Figure 3 Final Exam for ME 410

ME 410
Heat Transfer
Final Exam

Directions: Work all three problems. Open book, open notes. All three problems are equally weighted.

Problem 1 (50 pts)
An electronic circuit board of dimension 7 cm by 7 cm that produces 15 W is to be cooled with twelve (12) cylindrical fins attached to its surface with a 0.3 mm thickness of an epoxy of thermal conductivity 1.5 W/(m·K). The fins are made of a steel with thermal conductivity 25 W/(m·K) and have a diameter of 6 mm and a length of 8 cm. If air at 22°C is blown over the fin array at 4.5 m/s, determine the surface temperature of the circuit board.

Problem 2 (50 pts)
We wish to determine the radiation heat transfer to a turkey cooking in an oven. The oven is a cube of dimensions L x L x L. The turkey may be modeled as a sphere of diameter D_1 at a temperature T_1 with emissivity ε_1. The top and bottom of the oven have heating elements that are each producing a heat flux of q''_{coils} and have an emissivity ε_{coil}. Two side walls are adiabatic, while the other two side walls are exposed to room air at T_{room} with convective heat transfer coefficient h_{room}. All four side walls have an emissivity ε_{side}. Write all of the radiation heat transfer equations that would be needed to solve this problem. You may assume that the view factors for this problem are known.

Problem 3 (50 pts)
A turkey of diameter 0.5 m and initial temperature of 293 K is cooking in a convection oven at 505 K with a heat transfer coefficient of 40 W/(m^2·K). Determine the time it will take to fully cook the turkey to a temperature of 440 K.

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Table 1 Data on Course Learning Objectives

Course Learning Objective	**Class Averaged HW Scores**	**Class Averaged Exam Scores**	**Class Averaged Student Surveys**	**Days of Lecture**
A. Ability to use the conservation of energy to solve problems	80.3	68.0	1.56	1.25
B. Ability to solve one-dimensional heat conduction problems using the energy equation and Fourier's law	81.1	NA	1.46	3.5
C. Ability to use of the thermal resistance network	80.0	81.6	1.37	4
D. Ability to solve problem involving some form of energy generation	71.4	NA	1.71	1
E. Ability to solve problems involving extended surfaces	77.5	67.6	1.9	4
F. Ability to solve simple transient heat conduction problems	NA	NA	1.71	NA
G. Ability to use the lumped capacitance method	80.0	86.0	1.68	2
H. Ability to solve problems where spatial effects are important using approximate methods and the Heisler charts	74.0	72.8	2.37	1.5
I. Ability to solve problems with a semi-infinite dimension	71.7	NA	1.88	1
J. Ability to solve problems where convection heat transfer is important	68.6	NA	1.61	
K. Understanding the origin and implications of boundary layers for laminar & turbulent flows, and their impact on convection heat transfer	NA	NA	1.98	0.5
L. Understanding the origin of relevant dimensionless parameters	NA	NA	1.88	0.5
M. Understanding the derivation of the energy balance for constant temperature & constant heat flux boundary conditions for internal convection problems	NA	NA	1.9	0.5

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Table 1 Data on Course Learning Objectives (continued)

Course Learning Objective	**Class Averaged HW Scores**	**Class Averaged Exam Scores**	**Class Averaged Student Surveys**	**Days of Lecture**
N. Ability to use Nusselt number correlations to solve convection problems	71.7	76.7	1.62	5.5
O. Understanding the important physical aspects of free convection and the relevant dimensionless numbers for natural convection	77.5	76.0	1.74	2
P. Ability to solve simple radiation problems	NA	NA	1.76	0.5
Q. Understanding concepts such as blackbody , surface emission, absorption, radiosity	81.7	NA	1.83	3
R. Ability to find appropriate view factors, and compute simple radiation exchanges for gray surfaces	69.8	73.0	1.74	5

Figure 4 Class Averaged Homework and Exam Scores versus Survey Score (in percent)

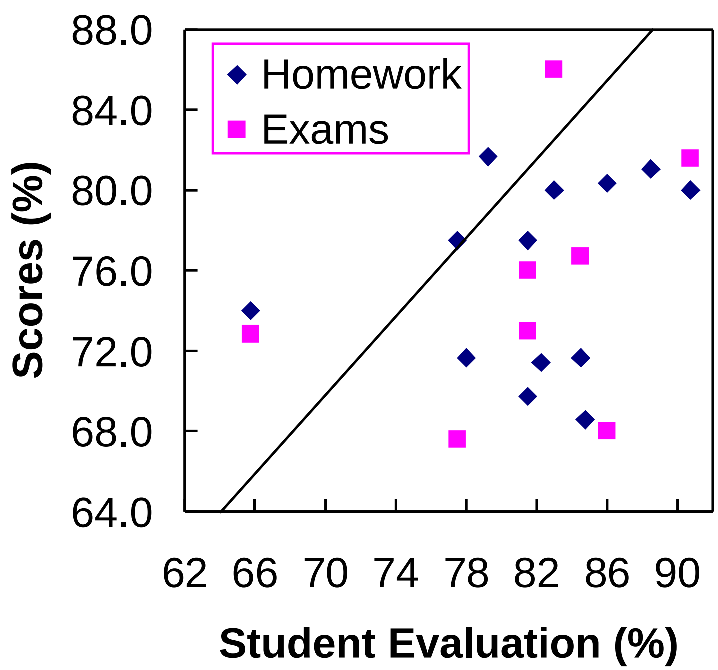

Table 2 Correlation Coefficient for Various Data Sets

Data Sets	**Correlation Coefficient**
HW/Survey	0.2453
Exam/Survey	0.3517
Lecture days/Survey	0.4112
HW/Exam	0.2166
Exam/Lecture Days	0.0367

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correlation between the survey and either the homework score or exam score is not very strong, since a correlation coefficient of one would indicate very strong relationship between the data sets, while a correlation factor of zero would indicate no relationship exists between the data sets. For the three pairs of data sets that include the survey data, the correlation coefficient varies from 0.25 to 0.41, certainly not a strong correlation. However, the correlation coefficient between the homework scores and exam scores is only 0.22, and the correlation coefficient between the exam scores and lecture days is a miserable 0.04. The results for last two data sets is very counter-intuitive, as most instructors would argue that a strong correlation exits between homework scores and exam scores and between exam scores and lecture days. It would appear that part of the difficulty lies with the closeness of the data, as it all falls within a small range, 64% to 88%.

Another approach in analyzing this data involves ranking the CLO's for each data set. That is, for the survey data, the CLO with the lowest score (closest to one, but reflecting the highest student confidence level) is ranked number one, the CLO with the next lowest score is ranked number two, and so forth until the CLO with the highest score is ranked eighteenth. Similarly, rankings are achieved for the other three sets of data, the homework grading, exam grading, and days of lecture, except that the ranking is done in descending order for these data sets. These rankings are given in Table 3. For each data set a course learning objective was identified as being in top quartile (and assigned a 1), the second quartile (assigned a 2), the third quartile (assigned a 3), or the bottom quartile (assigned a 4) with respect to ranking. These assignments are shown in Table 4. A relationship between the student performance and the student opinion is now recognizable. Generally, the homework scores, exam scores, and survey scores lie in the same quartile for a given course leaning objective. This observation, along the graphical results shown in Fig.4, supports the argument that the student perspective concerning their learning is consistent with their performance on graded assignments.

Certainly, a better approach than using class averages would be to track the correlation between student perception of learning and class performance on an individual student basis. That is, for each course learning objective, one could map the relationship between survey results and exam and homework scores individually for each student in the class. Unfortunately, since the student survey also serves as the tool for evaluation of teaching, the university requires the surveys to be anonymous. Hence, it is impossible to correlate the exam and homework scores for an individual student with their survey response, and the only option is to use class averages.

Final Remarks

A study has been undertaken that shows when results of student performance on course learning objectives is compared with the results from a student survey on course learning objectives, the students seem to do a good job of assessing their learning. By demonstrating that the CLO surveys portray an assessment of student learning, the department is convinced that it has a valuable assessment tool for its continuous quality improvement process that can effectively identify problems in achieving specific course learning objectives. One weakness in this study is the inappropriateness of some course learning objectives. Its is important for the department to address this problem. A second weakness involves the inability to identify survey data with a specific student. This could be addressed by separating the CLO survey from the teaching

Table 3 CLO Ranking

Rank	HW	Exam	Lectures	Survey
1	Q	G	N	C
2	B	C	R	B
3	A	N	C	A
4	C	O	E	J
5	G	R	B	N
6	E	H	Q	G
7	O	A	G	D
8	H	E	O	F
9	I		H	O
10	N		A	R
11	D		D	P
12	R		I	Q
13	J		P	L
14			L	I
15			M	M
16			K	E
17			J	K
18			F	H

Table 4 Quartile Assignments for the CLO's

CLO	HW	Exam	Survey
A	1	4	1
B	1	NA	1
C	2	1	1
D	4	NA	2
E	2	4	4
F	NA	NA	2
G	2	1	2
H	3	3	4
I	3	NA	3
J	4	NA	1
K	NA	NA	4
L	NA	NA	3
M	NA	NA	4
N	3	2	2
O	2	2	3
P	NA	NA	3
Q	1	NA	3
R	4	3	3

evaluation survey. Then the relationship between an individual student's perception of their learning and their class performance could be explored.

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