Study of a Student Self-Evaluation Process and Its Relationship to Student Grades and Learning Efficiency

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Abstract

Evaluations and surveys of the classroom teaching process are used for many purposes. They may serve, for example, as a benchmark for measuring the effectiveness of university instructors, and in this way are often used by administrators as a justification for reward or punishment of an individual faculty member. This may well be justifiable if the evaluation is well designed and fulfills the necessary requirements of objectivity. Such an assessment may also serve as a basis for providing valuable feedback to the instructor, as well as providing a channel for student input into the evaluation process. It is thus understandable, if not justifiable, that the "multipurpose" application of these evaluation tools necessitates that they be designed in a subjective way, one that often gives raise to conflicts in their use and interpretation. Administrators want an all-purpose tool that unequivocally points out the effectiveness (or weaknesses) of the instructor. Faculty, on the other hand, prefer a measurement device which would help them to meaningfully gauge their teaching performance and their students' learning effectiveness, and more specifically, to increase student knowledge absorption in the classroom over the course of a semester. It is therefore obvious from the conflicting issues arising from the multipurpose application of these assessment and measurement devices, that there is a need for a new approach to evaluating learning efficiency.

Thus, the intent of this paper is to present the results of a newly developed student self-evaluation tool for measuring the performance over time of students in individual classes, a tool designed to assist the instructor in assessing his/her the teaching efficiency, and how actual student performance and knowledge absorption relates to grade distribution. There appears to be a direct relationship between student grades and the self-evaluation process. This relationship and other issues relating to the inherently subjective nature of student self-evaluations and student evaluations in general, are discussed in the paper, and observations are made which could benefit perceptive administrators, faculty, and students.

Introduction

Currently, there has been an increasing emphasis on the performance of students in engineering curricula. This has resulted in a considerable amount of research being done to analyze the performance of students in engineering, particularly at the freshman and sophomore levels. The principal objective of these research efforts has been to determine factors that may influence students in their decisions on whether or not to pursue an engineering education, or to try something different. In discovering these critical factors, researchers are hopeful of success in making the engineering education experience a more enjoyable and less monotonous one for students, thereby improving retention in engineering programs and ensuring later success. This paper reports an effort made to investigate the detailed of the learning efficiency of students in a classroom using the concept of time-varying knowledge absorption measured by student self-evaluation at the beginning and end of a specific classroom experience. The survey form used in this example is included in the appendix. IT is assumed that the increase of student knowledge over the course of a semester can be attributed in large part to the teaching effectiveness of the instructor.

It is common knowledge that engineering is a challenging field of study and requires considerable dedication and effort on the part of students to successfully complete the degree requirements. However, it would be grossly incorrect to say that engineering is an excessively tedious field of study, with no bright career opportunities. If this were the case, it would be difficult to explain why there are so many premier educational institutions, not only in this country but worldwide, offering quality education in engineering. It would be even more challenging to explain the great number of engineering jobs available today, despite recent trends in globalization and its resultant outsourcing, with pay scales ranging from five to six figures and higher.

It is disappointing that, despite these positive aspects, there has been a gradual decline in engineering enrollment in the U.S., and more alarmingly, a decline in retention of those students registered in engineering programs. The extent of this problem is illustrated by the fact that in 1975, attrition among engineering freshmen was about 12 percent, whereas, by 1990 it had increased to over 24 percent [1]. According to Astin [2] , only 47 percent of freshmen in engineering actually graduate with a degree in engineering. Also, the fact that since the mid-1980s there has been a decline in engineering enrollment has further accelerated attrition rates [3]. This decline in engineering enrollment can be attributed to many factors, among them the outsourcing of engineering jobs, and the flattening the expansion curve in engineering numbers, augmented by growing opportunities in career directions far different from science and engineering.

In order to begin to stem the tide of declining numbers in engineering, in order to prepare this country for the expected 25-30 % increase in the demand for engineering graduates by the end of this decade [4], it is important to investigate ways of reversing the trend away from engineering, ways to encourage and facilitate student accomplishment and success in the pursuit of their engineering studies.

To achieve these objectives of increased student accomplishment and resultant retention, a comprehensive, integrated method of teaching and learning in the engineering classroom is needed, one which will heighten student interest provide increased self-confidence in the learning process. There are many ways to attain reasonable success in retaining student interest in engineering subjects, e.g., the increased use of latest technology in the classroom, classroom teaming, facilitation of tutoring programs by the more senior students, and the use of "teaching-by-inquiry" methods. Other ideas include the incorporation of research and industrial experience in the classroom, and the inclusion of innovative open-ended projects. Regardless of the device employed, however, there is an across-the-board need for an improvement in the measurement, assessment and evaluation of student learning efficiency [5, 6].

Methodology

In order to determine the efficiency of the teaching and learning process in the classroom, a comparison had to be drawn between the knowledge content of students at the beginning of the class selected for assessment, and their knowledge content at the end of the semester. To do this, the authors/instructors developed a set of key questions for the class, and they administered this set of questions at the very beginning of the semester, asking students to declare their individual knowledge content of the subject matter in this course before the first class lecture. This constituted the initial, or data-gathering, part of the investigation.

The second part of the assessment process involved comparing the performance of the students from this class after attending an entire semester. The data presented and analyzed in this paper pertains to students enrolled in a class in the year academic 2005-06. Basic statistical calculations were used to compare the performance of the students and performance trends between these two points in time.

Due to limited population of the group members, the conclusions drawn from the data obtained from this one class is limited, and thus can only be used as a working hypothesis for further research. However, the results achieved from this limited sample space were significant to warrant reporting at this early stage. The objective of this initial phase (Phase I) of the continuing assessment is to develop measurement and assessment procedures and correlations which may be used in the conduct of a much larger test in the near future. This second phase, critically dependent on the first, is presently in work and constitutes a continuing effort on the part of these authors. The results of Phase I, the data-gathering activity for academic year 2005, is shown in Table 1. As shown in this table, there is a strong correlation between the final grades earned by the students, and their final scores in the self-evaluation process (G-F). The value of the correlation coefficient, 0.66, justifies the methodology and the comparisons made between the two sets of data.

The focus of Phase II of this search for new and innovative ways to improve the classroom instruction process will be to concentrate on an expanded population of the test group, viz., on a number of groups in different classes, in order to test the proposed correlation between appropriate factors in these classes (the factors will vary according to the nature of each class), so as to identify as many relevant factors as possible and their relative importance, thereby building a substantial database for various types of engineering classes and establishing increased credibility for this methodology.

Data Collection and Analysis

The presence of a time gap between the beginning of a class and its end, in which an intense learning process should have occurred, provides the opportunity for detailed assessment of student learning performance in the key areas of that specific class, and how this performance varies (and hopefully increases) over the course of a semester. The purpose of this evaluation exercise was to identify the knowledge gained by both individual students and the group or class for a particular course. By identifying the learning impact parameters for the course, it was reasoned that such an analysis might perhaps suggest changes in emphasis or direction that could be made in subsequent semesters by the instructor which would increase the learning performance and retention of these students.

This led to a thorough successive evaluation and data analysis of both the individual and group results for each key issue included in the student self-evaluation form, as shown in the appendix to this paper. For example, a significant deviation between the student's increased value over the course of a semester for a particular parameter, and the class average value, might indicate a high learning efficiency achieved by this individual student in this area.

The survey instrument used in this process was designed for collecting information from students at two points in time, i.e., at the beginning and end of the course. This survey was not designed to allow students to express their opinions about reaching the goals of the course, or the desired course outcomes, but rather, it queries them on how well this course has prepared them for their professional careers. The survey questionnaire was designed around 43 questions related to key issues relating to the particular course chosen for its initial application, and several control questions. Students completed the survey by answering the same questionnaire on the first and last days of class. All items were evaluated on a five-point, with a rating of "5" given for highest competence achievement, and a "1" for the lowest.

The data collected were processed and analyzed, and the average values, which resulted, were used for assessing the learning outcomes from the class, by analyzing the student or class gains in each particular

Table1. Averaged Data from the Student Self-Evaluation Process

Student	Final Grade (G)	Average Final Score	Average Start Score	Relative Increase (F)
1	66.98	3.429	1.714	50%
2	76.71	4.595	2.643	42%
3	80.19	3.310	1.810	45%
4	81.51	3.405	2.833	17%
5	79.13	4.190	1.952	53%
6	78.62	4.381	2.310	47%
7	60.73	2.119	2.310	-9%
8	81.29	3.595	2.143	40%
9	99.90	4.786	2.738	43%
10	100	4.548	2.140	53%
11	71.30	4.310	2.643	39%

Correlation	Correlation Coefficient
G-F	0.664

area over the course of instruction. In this particular case, it was an introductory course in Mechanical Engineering Technology taught in the fall of 2005.

The results of this survey are summarized in Table 1. The average scores for each item of the survey of eleven students range from 1.7 to 2.9. The final data take demonstrates the increase in average value for students from an overall initial average of 3.3 to final class average 4.8 (in the range 1 to 5). The only exception to this was with student No. 7, who registered a starting value of 2.31, which, astoundingly, declined 9% during the semester to a final value of 2.12. It can only be assumed that this student lost interest or was preoccupied with outside problems and failed to provide a realistic measure of his learning progress over the course of the semester. The data associated with Student No. 7 was thus considered a spurious data point for the intent of this study.

The average class scores for items related to the course key issues for the start and finish points are illustrated in Fig. 1, where it is observed that all values are in the range of 20-90%. This type of histogram provides the opportunity to easily distinguish the difference between the start and finish average values of the class for each established issue.

This provides the instructor immediate feedback on the starting level of knowledge for the class and its learning intensity, as well as a measure of the knowledge gained by students by the end of the semester. In the design process of the questionnaire, control questions were used for which the students' start and end knowledge content was expected be high, and their learning gain limited. The control questions used (#s 4, 25, and 36) ultimately provided results, which fully confirmed these expectations.

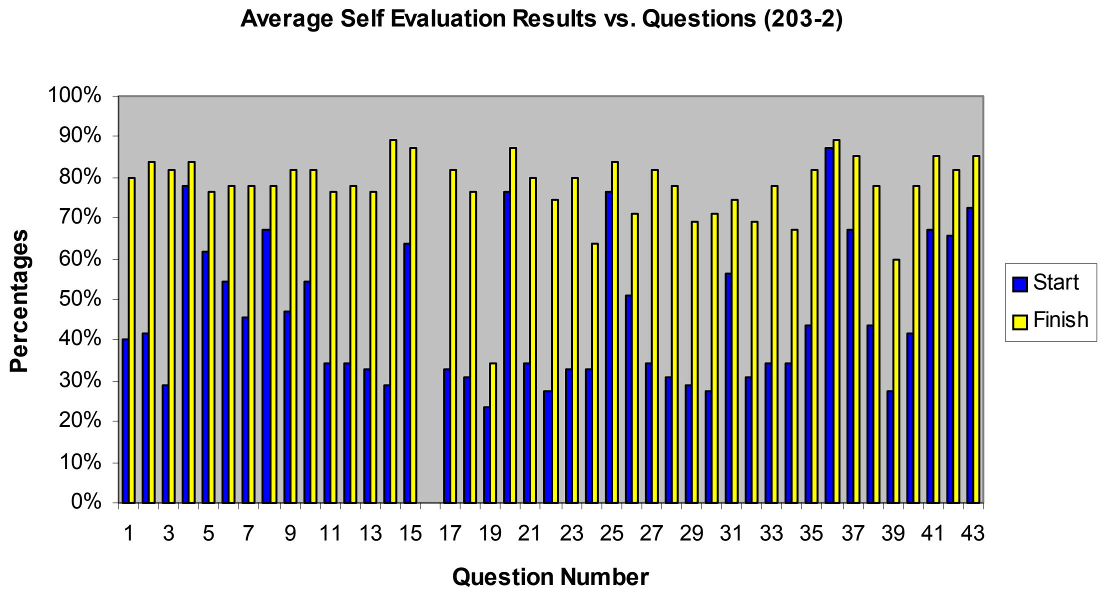

Fig 1. Average Results for Student Self-Evaluation -- Start and Finish Values for the 43 Questions.

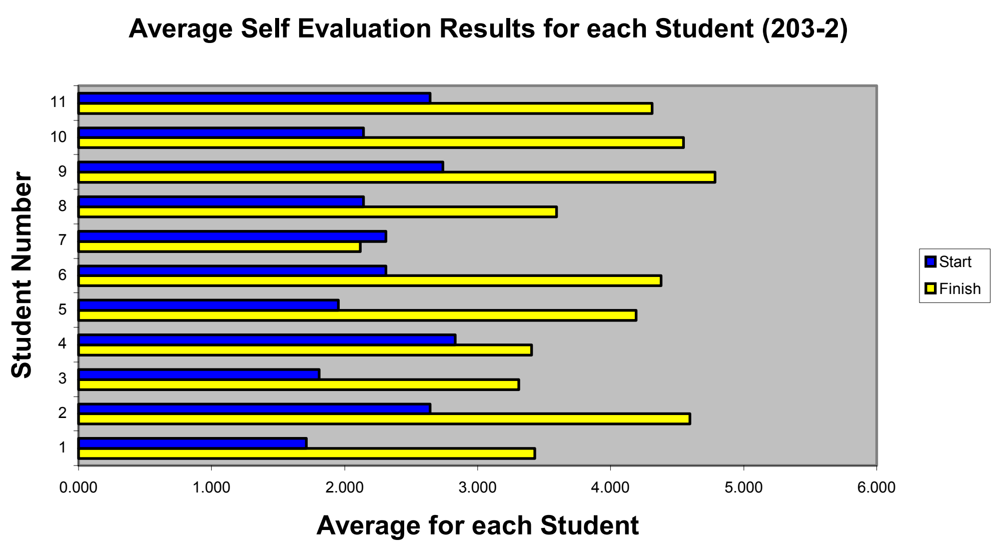

Fig 2. Average Values of Student Self-Evaluation at Start and Finish Points in the Semester for Each Individual Student.

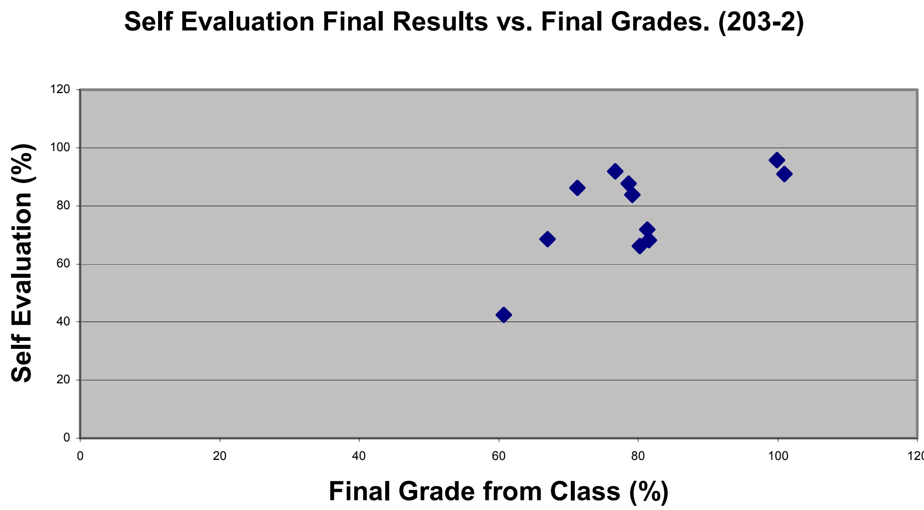

Fig 3. Correlation of Average Values Resulting from Student Self Evaluations for "Finish" Surveys for Each Student vs. Final Grade Earned in the Class.

The average student scores for all items related to the course key issues for the start and finish points are shown in Fig. 2, where all values demonstrate significant improvement for all members of this class of eleven students. Relative change (decrease or increase) of knowledge content ranged from -9% to +53%. This type of histogram provides a quick overview of learning intensity over the measurement timeframe for each individual student, and it gives instructors immediate feedback on the overall learning intensity of individual students at the end of the semester. One important question, which must be addressed in evaluating the effectiveness of this process as a teaching and learning tool, is how well the average student scores or class scores correspond to final grades assigned in a particular class. The correlation coefficient of Table 1 (0.664) may shed some light on this question. It can be seen from Figure 3 that there is a high correlation between the final grades earned by students and the average final results for all the survey items related to the course key issues at the finish point. This provides instructors with immediate feedback, plus checkpoints for their final grading in the class at the end of the semester.

In spite of the fact that this survey is limited due to the small class size of its initial application, these limited results are remarkably positive, and they serve to encourage the authors to continue their work by expanding the application of this process to increased student populations and additional, varied courses, and over longer periods. Should these positive outcomes continue over a larger sample space of students and courses and an expanded timeframe, further and more general conclusions may be forthcoming.

Conclusions and Recommendations

Based on this first use of a student self-evaluation survey process to asses the learning intensity of students in a particular selected class, the following conclusions are reached:

1. The proposed student self-evaluation questionnaire measures the outcomes of the learning process for individual students, as well as for the course involved, and it identifies key issues and control questions in which respondents/class participants are asked to rate their knowledge content with respect to various aspects of their course learning experience at the beginning and at the conclusion of the semester.

2. Despite the limited sample population (class size) and the fact that only one particular class was tested, the overall results are positive, and they encourage continuing work to expand the testing process over increased student populations, additional courses, and longer periods of time to establish trends in the learning indices.

3. The survey provides useful information for both individual students and for the class as a whole, through a correlation between the key issues coverage for specific courses and student learning intensity.

4. The results obtained in this initial study clearly indicate that expanded applicability of the proposed procedure for assessing individual student learning progress will result in an increase of acquired knowledge in the key course parameters.

References

1. Beaufait, Fred W., "Engineering Education Needs Surgery," Proceedings of the *Frontiers in Education Conference*, September 1991, pp. 519-522.
2. Astin, Alexander W., "Engineering Outcomes," *ASEE Prism*, September 1993, pp. 27-30.
3. Besterfield-Sacre, M., Atman J. C., and Shuman, J. L., "Characteristics of Freshman Engineering Students: Models for Determining Student Attrition in Engineering," *Journal of Engineering Education*, Vol. 86, No. 2, pp 139-148, April 1997.
4. Board of Engineering Education – National Research Council, "Improving Retention in Undergraduate Engineering Education*," Issues in Engineering Education: A Bulletin Addressing Culture Change in Engineering Education*, Vol. 1, No. 1, April 1992.
5. Keska, Jerry K., "Integration of teaching-by-Inquiry methods into Undergraduate Classrooms," IIA1, *Proceedings of the 2003 ASEE Gulf-Southwest Section Annual Conference,* University of Texas at Arlington, March 19 – 21, 2003. http://www.aseegsw.org/
6. Karimi, A., "Implementing a New Mechanical Engineering Curriculum to Improve Student Retention," *ASEE, 2001-1566*, *Proceedings of the 2001 ASEE Annual Conference*, Albuquerque, New Mexico, June 24-27, 2001.

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Appendix

STUDENT SELF-ASSESSMENT FORM

Name……………………………….. Date………….. Class…………………………

Assign a grade of 1 to 5 to each factor or principle in the matrix below. A "5" should be assigned if you feel you have achieved the highest level of competency, with a "1" for the lowest level. Enter your rating value in the third column, with any comments you may care to make in the last column.

	STATEMENT AND PRINCIPLES	Assign a grade of 1 to 5 (1 = Lowest and 5 = Highest)	Comments
1.	I learned and received hands-on experience in the following principles/systems:		
	1.1 Hooke's Law		
	1.2 Mechanical Energy		
	1.3 Principles of a Tachometer		
	1.4 My Personal Computer Toolbox includes: Word Processor, Spreadsheet, CAD, Browser, PowerPoint (Please circle the components you are now using.)		
	1.5 Measurement Errors		
	1.6 Experimental Data Analysis		
	1.7 Strain Measurement		
	1.8 Proposal Writing		
	1.9 Stress Analysis		
	1.10 Scalar Analysis and Computation		
	1.11 Pump Characteristics		
	1.12 Mechanical Efficiency		
	1.13 Bolt Grades		
	1.14 Vernier Calibration		
	1.15 Simple Machines		
	1.16 Measurement of:		
	Mechanical Parameters		
	Pressure		

	STATEMENT AND PRINCIPLES	Assign a grade of 1 to 5 (1 = Lowest and 5 = Highest)	Comments
	RPM		
	1.17 Metric System (SI)		
	1.18 Belt Deflection		
	1.19 Idler Gears		
	1.20 Chain Drive Mechanisms		
	1.21 Film Lubrication		
	1.22 Laboratory Report Writing		
	1.23 Bearings		
	1.24 V-Belts		
	1.25 Couplings		
	1.26 Pitch Circle		
	1.27 Pinion Gears		
	1.28 Levers		
	1.29 Dial Indicators		
	1.30 Use of a Tachometer		
	1.31 Friction Clutches		
	1.32 Theory of Micrometers		
	1.33 Internet Search Techniques		
	1.34 Vectors		
	1.35 Mechanical Clutches		
	1.36 Helical Gears		
	1.37 Use of a Micrometer		
2.	I am familiar with *refereed journal papers*.		
3.	I have some knowledge of *patents and patent searches.*		
	I have experience in *project presentations.*		