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How Accurate Is Students' Self Assessment Of Computer Skills?

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AC 2008-2439: HOW ACCURATE IS STUDENTS' SELF-ASSESSMENT OF COMPUTER SKILLS?

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How Accurate is Students' Self-Assessment of Computer Skills?

Abstract

Self-evaluation by students is commonly used as a key element in program and course assessment plans. Such instruments are intended to provide crucial feedback for program improvement and thus play a significant role in closing our assessment loop. For many of the program outcomes, self-assessment by current students and graduates augments other, more objective measures. However, for some outcomes there are no practical means of obtaining objective assessment and we must rely on self-assessment. The heavy reliance on this metric begs the question "How accurate is student self-assessment?" This paper provides data from a second-semester engineering course in which students develop proficiency using computer tools to solve typical engineering problems. Students' self-assessments in several areas are compared with the instructor's assessment of these students.

Some work reported in the literature addresses the accuracy of student self-assessment in specific academic areas. In the medical field, literature exists which addresses medical students' self-assessment of specific skills. Other comparisons have been published to compare students' expected grades with actual results. Little was found that is relevant to engineering student and in particular to their assessment of professional skills.

The work reported here relates to the assessment of ABET's program outcome k: "an ability to use the techniques, skills and modern engineering tools necessary for engineering practice. Methods of Engineering Analysis is a course taken by all engineering majors during their second semester at the University of New Haven. In this course, students are introduced to engineering topics and a variety of numerical methods for solving these problems. The current platform used is a spreadsheet with Visual Basic for Applications programming. Students complete a 30-question survey the first day of class in which they rate their expertise in three broad categories: basic spread-sheet usage, advanced spread-sheet usage and programming. The same survey is completed at the end of the class, thus providing a pre and post view from the students perspective. Quizzes given throughout the course and the final exam were structured to enable instructors to assess student performance in these same areas with composite measures. Data is presented to compare the instructor assessment of performance with students' self-assessment at the individual level.

Introduction

Engineering programs rely heavily on students perceptions in assessing courses and programs. It is common practice to use student input to assess the degree to which a course or a program has achieved its objectives. Examples include end-of-course student evaluations, senior exit surveys and surveys of recent alumni. In many cases students are asked to assess the degree to which a course or program has been useful in developing their knowledge or skill is specific areas.

This paper presents results of a study to compare student self-assessment of their skills in using computer tools in an engineering problem-solving context. In particular, they are asked to rate their expertise in 30 specific items, which can be grouped as basic spread sheet, advanced spread sheet and programming concepts. The survey was administered at the beginning and end of a particular course as a means of understanding the skill level of entering students and the degree to which the course was successful in helping students develop various skills. Student perceptions are compared to results from specific parts of the final exam, which are mapped to skill sets from the survey.

During their second semester, engineering students at the University of New Haven are required to take EAS112 Methods of Engineering Analysis. EAS112 is part of the Multidisciplinary Engineering Foundation Spiral Curriculum in the Tagliatela College of Engineering. Details of the course and the curriculum have been discussed in earlier publications.[1,2,3] To summarize briefly, the course uses a uses a problem-driven approach in which various case studies provide the unifying theme for a sequence of engineering problems. Students develop solutions to the problems using spreadsheets and Visual Basic for Applications programming. Most of the required equations are provided with some discussion of the engineering concepts involved; however, the primary emphasis is on developing the modeling and solution algorithms. Students are use various analytical and numerical methods as they develop the solutions. An active-learning approach is used in which most of the classroom time (nominally 4 hrs per week in 2 meetings) is devoted to problem-solving activities, generally using a computer.

EAS112 is designed to achieve the following Objectives:

- To develop proficiency in the design of spreadsheets and related programming tools, such as Visual Basic for Applications
- To provide an understanding of computer programming fundamentals
- To gain experience in solving engineering problems using spreadsheets & programming
- To enhance the understanding of basic engineering concepts in a variety of areas

Student outcomes define activities that students should be able to perform at the conclusion of this course:

- to use computer tools and programming to solve engineering problems which require analysis of systems of linear and non-linear equations and simple differential equations
- to represent and analyze data sets using appropriate graphical methods, descriptive statistics, linear and non-linear regression and interpolation techniques
- to demonstrate an understanding of common computer data types, such as

character, integer, floating point & boolean

- to write and use stand-alone functions which accept parameters and return data
- to develop and implement computer algorithms which include features such as arrays, mathematical and logical operators, built-in and user-defined functions, assignments and conditional statements

- to apply iterative methods to solve engineering problems, including the development of programs which use loops and other flow control features

While this level of input is useful, we were interested in obtaining a finer granularity of feedback in order to improve the course, and thus administered a detailed survey at the beginning and end of the course. After using the survey instrument for several years, we thought it would be useful to examine the validity and reliability of this approach, in accordance with the recommendations of Moskal, et al.[4] Selected items from the survey instrument were compared with instructor assessment of student performance on related exam questions. Since the purpose of the survey is to provide feedback for improving the course, student performance at the end, on the final exam, was the only measure used. Care was taken to link specific final exam questions to corresponding survey questions.

Relevant Previous Work

The authors readily admit to being novices on the topic of student self-assessment. Having perused the literature, however, has sparked significant interest in the role of self-assessment in the learning process as well as appropriate its use in the teaching endeavor.

Literature on the use and analysis of self-assessment is voluminous and exists primarily in the educational research and educational psychology fields. Fortunately, there are a number of comprehensive articles which summarize much of the work and interpret composite results in a way that is accessible to engineering educators who are not formally trained in these fields. One of the very active researchers in this area, David Boud, has a wealth of information on his web site[5] , including references to publications relevant to this work. His publication with Nancy Falchikov[6] was found to be extremely useful. This article presents a meta-analysis of work on student self-assessment prior to 1989. Numerical results are summarize for many studies and several useful suggestions are made. The metrics used to compare student to instructor assessments were drawn from this article along with suggestions for interpretation. Readers may wish to investigate several of Boud's works, in particular "Avoiding the Traps: Seeking Good Practice in the Use of Self Assessment and Reflection in Professional Courses"[7], "Sustainable Assessment: Rethinking Assessment for the Learning Society"[8], and "Redesigning Assessment for Learning Beyond Higher Education"[9]. The first of these provides useful information for engineering faculty who wish to use student self-assessment either as an input for assigning grades or as a formative assessment tool to improve their courses. The latter articles are helpful in understanding the critical role of self-assessment and reflection in the learning process.

A few more recent articles were found with direct relevance to engineering education. Simon Cassidy published an interesting study relating students' ability to self-assess to their learning style[10]. He found that students with a preference for "deep" learning or "strategic" learning tend to match more closely with instructor's assessment, while "surface" and "apathetic" learners did not. Maskell[11] suggests that self-assessment needs to be introduced early in a student's career for it to be accepted by the students as a valid tool. Faulkenberry[12] provides a framework for broad use of student self-assessment and illustrates its use in a particular course. He presents some limited data to compare students to instructors assessment of professional skills. Sarin[13] presents a study comparing engineering students self-assessment to that of instructors for specific topics in a course. The focus in the work is student prediction of grade on a test of specific knowledge. His conclusion, consistent with much of the other literature, is that higher-performing students are more accurate in predicting their grades.

Based on the literature reviewed, several points stand out as relevant for our work. 1) The accuracy of student self-assessment appears to be linked to the length of time they have studied a particular area - depth in the field rather than time as a student. For example juniors in a discipline are better able to judge their performance in disciplinary course than are freshmen, but seniors taking a freshman level course outside their primary are of study are not particularly accurate; 2) Student involvement in developing the metric and the degree of specificity of the metric seem to correlate with accuracy of self-assessment; 3) There is a connection between learning style (level of investment in the educational process) and accuracy. Since our course is a first year course with a wide variety of student styles, there is little that can be done to avoid the associated inaccuracies. However, care can be taken in the design of the survey instrument used to elicit student input.

The use of self-assessment for our course is intended to be a tool for improving the course rather than as input for determining a student's grade. Furthermore, we are more interested in the students reporting on their skill development over a longer period than in short-term mastery. The question then is whether the aggregated input from the students about their mastery of specific skills can be of use as a formative course assessment tool.

Course Assessment

The data reported in this paper is based on students who took the course EAS112 Methods of Engineering Analysis during the spring 2006 and spring 2007 terms. This included fours sections of students taught by two instructors, as outlined in the table below:

Table 1 Course Section Demographics

Term	Spring 2006	Spring 2007	Spring 2007	Spring 2007
Section	2	3	1	50
Instructor	Instructor 1	Instructor 1	Instructor 2	Instructor 2
Enrollment	14	12	21	20
Time	Day	Day	Day	Eve

Table 2 - Student Self-Assessment Survey Instrument

Self Assessment of Student's Skill in Excel and Programming Concepts - Post Version							
Spring 2007		Section					
name		date					
Excel and Programming Concepts 0 = Never Used 1 = Minimal Exposure 2 = Comfortable With 3 = Advanced User		0	1	2	3		
1	Formatting numbers in cells						B
2	Copying cell ranges						B
3	Entering formulas in Excel						B
4	Using absolute addresses (eg., C6)						B
5	Plotting Data on an xy graph with linear axes						B
6	Plotting Data on an xy graph with logarithmic axes						B
7	Using trend lines on plots						B
8	Using Excel mathematical Functions						B
9	Using Excel lookup Functions (eg., VLOOKUP..)						A
10	Using Excel logical Functions (IF, AND…)						B
11	Using Excel descriptive statistics functions (average, std deviation etc.)						B
12	Using Excel comparative statistics functions (eg., TTEST …)						A
13	Using Excel probability functions (NORMDIST …)						A
14	Using Excel Regression routines for a single independent variable						A
5	Using Excel Regression routines for multiple independent variables						A
16	Recording and executing a Macro in Excel						A
17	Using the Visual Basic for Applications window from Excel						A
18	Using Goal Seek in Excel						A
19	Using Solver in Excel						A
20	Using Matrix methods in Excel						A
21	Using controls in Excel (list box, button, …)						A
22	Writing a Visual Basic function						P
23	Programming in any language						P
24	Passing parameters to a function						P
25	Understanding of the scope of variables in a function						P
26	Working with different data types: integer, floating point, boolean, character, string						P
27	Using arrays or subscripted variables						P
28	Writing an iterative loop in a program (DO loop, For/Next loop, etc..)						P
29	Using logical test statements in a program (IF..Then..Else)						P
30	Writing a modular program						P

Students were asked to complete a self-assessment survey of computer skills the first day of class and again the last day of class. It was emphasized that the results would not be used for grading, but rather for improving the course. The survey, shown in table 1, includes 30 topics in three categories: basic spreadsheet skills, advance spreadsheet skills and computer programming. For each question students rated their level of understanding on the defined scale using the following descriptors: never used (0), Minimal exposure (1), Comfortable with (2) or Advanced user (3). Their responses were tabulated using the numerical range 0 to 3, with higher numbers indicating higher proficiency. The pre and post surveys were instituted as a means of obtaining information about the background of students entering the course as well as the degree to which the course is successful in meeting its objectives.
The column to the right is not part of the survey, but shows the collection of questions associated with the three categories Basic Spreadsheet, Advanced Spreadsheet and Programming.

A summary of results from the pre and post surveys is shown in table 3, including the mean and standard deviation of student self-assessment results, by section. Results are aggregated into the Basic Spreadsheet (B), Advanced Spreadsheet (A) and Programming (P) categories.

Table 3 - Comparison of Post to Pre Survey Results												
Spreadsheet Basics												
	Spr 06, Sect 2		Spr 07, Sect 3		Spr 07, Sect 1		Spr 07, Sect 50		All			
	mean	st dev	mean	st dev	mean	st dev	mean	st dev	mean	min	max	st dev
Pre	1.3	0.35	1.7	0.55	1.3	0.49	1.1	0.58	1.3	0.2	2.9	.53
Post	2.7	0.15	2.9	0.29	2.7	0.34	2.3	0.49	2.6	1.3	3.0	0.4
Advanced Spreadsheet												
	Spr 06, Sect 2		Spr 07, Sect 3		Spr 07, Sect 1		Spr 07, Sect 50		All			
	mean	st dev	mean	st dev	mean	st dev	mean	st dev	mean	min	max	st dev
	0.2	0.24	0.3	.44	0.3	0.30	0.2	0.37	0.3	0.0	1.7	0.31
Post	2.0	0.4	2.0	0.26	1.9	0.51	1.7	0.37	1.9	0.8	2.8	0.4
Programming												
	Spr 06, Sect 2		Spr 07, Sect 3		Spr 07, Sect 1		Spr 07, Sect 50		All			
	mean	st dev	mean	st dev	mean	st dev	mean	st dev	mean	min	max	st dev
Pre	0.9	0.82	0.6	.46	0.4	0.53	0.3	0.26	0.5	0.0	2.8	0.59
Post	2.0	0.6	2.1	0.34	2.0	0.30	1.5	0.43	1.9	0.8	3.0	0.5

From the pre survey, it is clear that the computer skills of the students vary greatly as they enter the course from those with minimal experience with spreadsheets to a few with a relatively high degree of programming experience.

Comparison of post to pre versions of the survey indicate that the students perceived that their skills improved significantly. In comparing the different sections, it is apparent that section 50, the evening section, has the lowest post survey scores for each area. This section included many part-time students, many of whom were older than the typical freshman in the other sections. They often were less comfortable with the computer than their younger peers.

The instructors also examined the more detailed results of individual survey questions to identify areas which need more attention in the course. For example, comparative statistics and probability functions were rated well below the mean, as was the "programming" item.

Comparison with Instructor Assessment

The final exam for EAS112 included a combination of conceptual questions and application problems. Although the exam questions were not designed for the purpose of comparing with the self-assessment survey questions, it was possible to map specific parts of the survey to final exam questions. A set of five metrics were defined as shown in table 4.

Table 4 - Definition of Computer Skill Metrics

Metric	Measured Skills	Survey Questions	Final Exam Questions
S1	Spreadsheet: basic operations	1, 3, 10, 16, 19, 21	4 - iterative solution of a non-linear eqn, IF function, macro
S2	Spreadsheet: graphing and regression	1, 3, 4, 5, 8	5 - plotting and data analysis
P1	Programming: basic concepts	22, 23, 24, 26, 28, 29	1 - set of 6 conceptual questions
P2	Programming: application	22, 23, 24, 27, 28,29	3 - writing a VBA function to process an input array of cells
P3	Programming: more advanced concepts	24, 25, 27, 30	1 - set of 4 conceptual questions

Student self-assessment values for the five metrics were computed as normalized means of the post-survey ratings:

$$M = \frac{\sum_{i=1}^{n} x_i}{3n}$$

where M = metric (S1, S2, P1, P2, P3)
x_i = value of student response (0 to 3)

Instructor values for the metrics were calculated by normalizing the appropriate parts of the final exam to 1.0 by dividing the student's score on the question by the maximum value possible.

Table 5 shows the results for the students' self-assessment and instructor metrics for each section and for the entire set of students:

Table 5 - Metrics from Student Self-Assessment and Instructor's Assessments

	S1		S2		P1		P2		P3	
Metric	St	In	St	In	St	In	St	In	St	In
Section 2 Mean	0.88	0.80	0.98	0.81	0.70	0.79	0.68	0.63	0.71	0.71
Section 3 Mean	0.89	0.80	0.96	0.75	0.70	0.74	0.68	0.66	0.69	0.60
Section 1 Mean	0.85	0.74	0.93	0.64	0.66	0.67	0.64	0.65	0.64	0.51
Section 50 Mean	0.71	0.66	0.80	0.62	0.51	0.53	0.50	0.37	0.50	0.47
All Students: Mean	0.82	0.74	0.90	0.69	0.63	0.66	0.61	0.56	0.62	0.56
All Students: min	0.44	0.00	0.40	0.00	0.28	0.17	0.28	0.00	0.25	0.00
All Students: max	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
All Students: std dev	0.14	0.26	0.15	0.24	0.18	0.18	0.17	0.32	0.19	0.3

In order to compare the student to instructor, we use methods suggested by Boud in a comprehensive study of student self-assessment. Three techniques were suggested for this comparison: Effect Size, Correlation Coefficient and Percent Agreement. The Effect Size is calculated as the difference in means divided by the standard deviation of the instructor's assessment.

$$E = \frac{M_{student} - M_{instructor}}{s_{instructor}}$$

Where E = Effect Size,
M = metric (S1, S2, P1, P2, P3)
s = standard deviation

Effect size is generally used in studies which employ a well-defined control group for comparison with the experimental group. In such cases, the standard deviation of the control group is used. Boud's recommendation for studies which compare student to instructor assessment is to use the standard deviation of the instructors assessment.

This statistic is useful in determining how well the students' self-assessment reflects the performance of the class as a whole. A value of zero indicates perfect agreement, while a positive value indicates that the students overestimate their proficiency. Boud suggests that values of 0.2 are considered small, values of 0.8 are considered large.

A correlation coefficient can be used to determine the strength of correlation between student and instructor values. In this context, a value of 0.5 is considered to imply a strong correlation between the variables, 0.3 is medium and 0.1 is considered low.

Table 6 - Correlation Between Instructor and Student Assessments										
Effect Size (E) and Pearson Correlation Coefficient (C)										
	S1		S2		P1		P2		P3	
	E	C	E	C	E	C	E	C	E	C
Section 2	0.7	0.4	1.2	0.0	-0.5	0.4	0.1	0.5	0.0	0.5
Section 3	0.6	0.9	1.1	0.4	-0.2	0.4	0.1	0.3	0.3	0.1
Section 1	0.4	0.6	1.0	0.2	0.0	0.4	0.0	0.5	0.4	0.4
Section 50	0.2	0.3	0.8	0.4	-0.1	0.2	0.4	0.3	0.1	0.3
All Students	0.6	0.7	1.1	0.3	-0.3	0.4	0.1	0.4	0.2	0.3

The number of students in each section is too small to allow interpretation of differences among the sections. For the most part, there is fairly close agreement across the sections. The remainder of the discussion will focus on the combined results for all students.

The magnitude of the correlations coefficients would be interpreted as indicating a medium to high correlation between the instructor and student assessments. Clearly there are other important variables at work as well. It would be unwise to use the students input as a major component in assigning grades.

Effect size is a comparison of means, and thus more useful in answering the question about using student input for course improvement. The effect size appears to be small (indicating close agreement) for the metrics related to programming but not for the metrics related to spread sheet usage. The difference between instructor and student assessment is a full standard deviation unit off for the S2 metric. It is interesting to note that S2 relates to graphing data in the spreadsheet, a skill on which the students rated themselves relatively highly at the start of class. The type of errors encountered on the exam question were often related to the students not following the instructions closely, for example not scaling the axes to fully utilize the plot area, not allowing the default in Excel of showing only horizontal gridlines, etc.. In many cases it appeared that they were content with what they brought into the course and felt that they did not need to learn some new techniques.
Programming, on the other hand, was new for the vast majority of the students. It is interesting that their self-assessment was in closer agreement with the instructor.

Another interesting result is that students underestimated their ability on P1, which related to basic programming concepts, but overestimated their proficiency on the application of these same principles (P2). At this point, the authors have not clear explanation for this effect, other than that the effect sizes are quite small in both cases, so the differences may not be outside the noise.

Figures 1 through 10 show scatter plots and frequency histograms for the combined group of all students. The scatter plots include a linear regression relationship along with the coefficient of determination (R^2). The histograms show instructor and student assessments grouped in 4 bins.

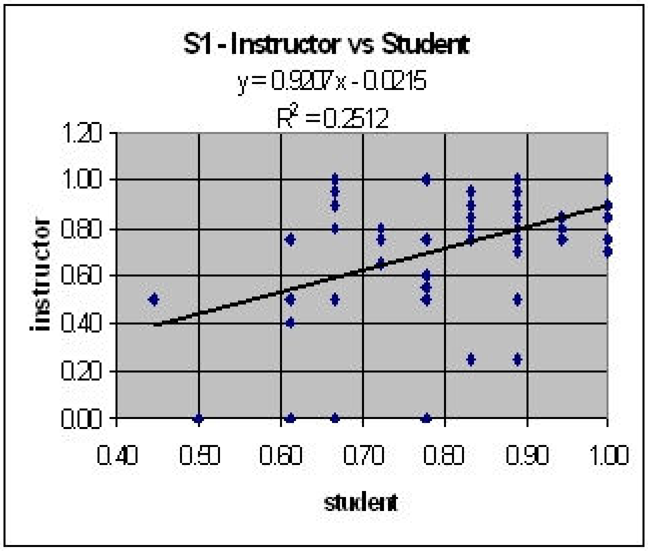

Figure 1

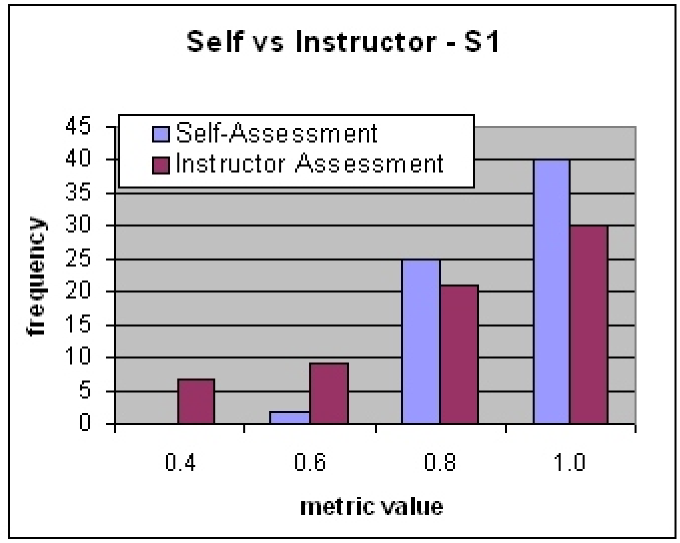

Figure 2

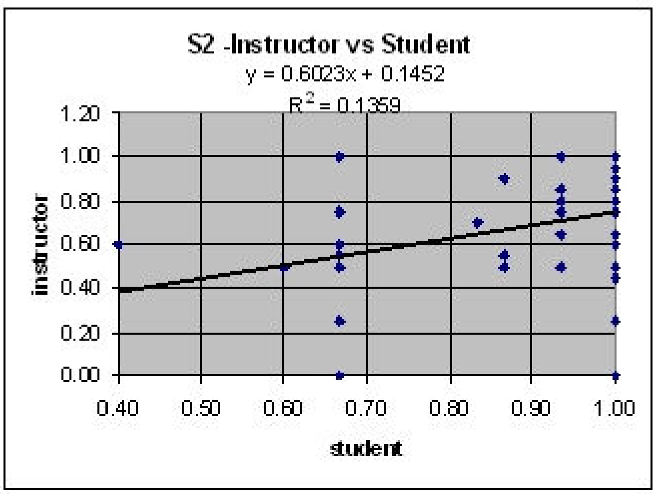

Figure 3

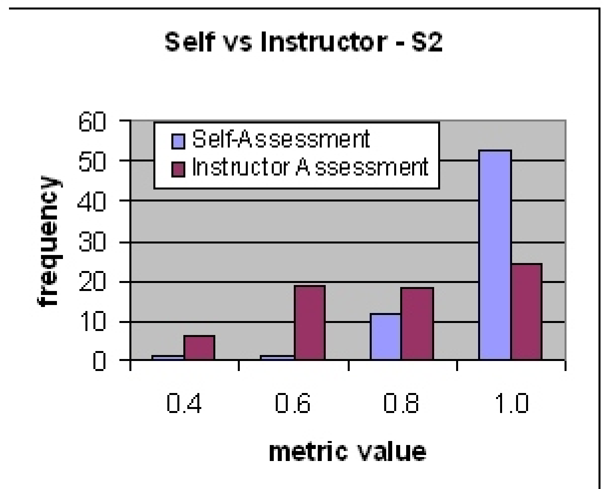

Figure 4

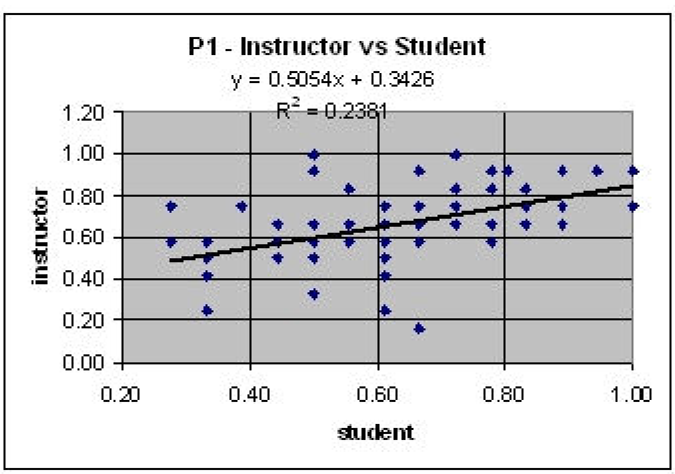

Figure 5

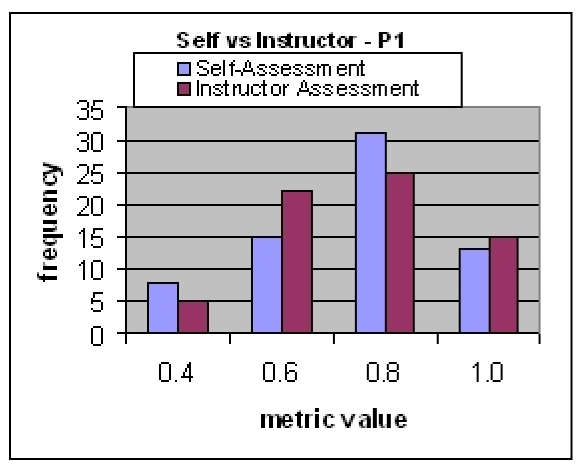

Figure 6

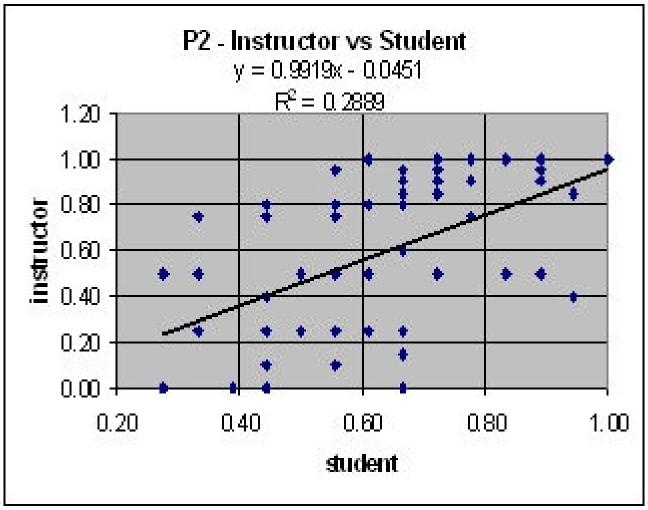

Figure 7

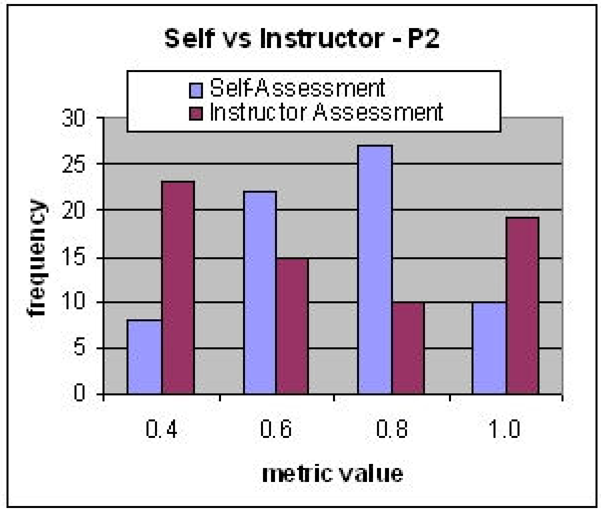

Figure 8

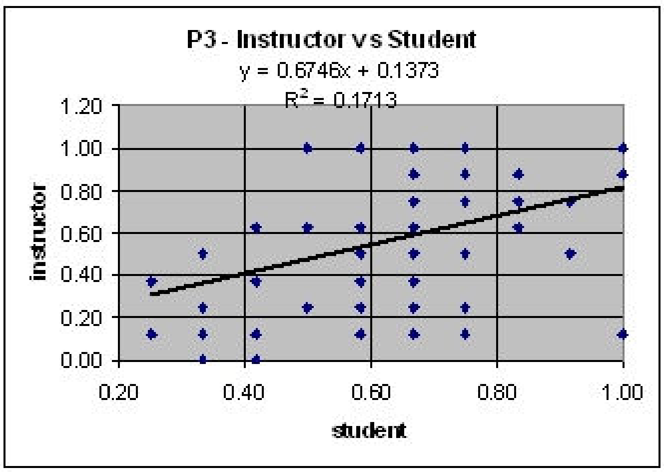

Figure 9

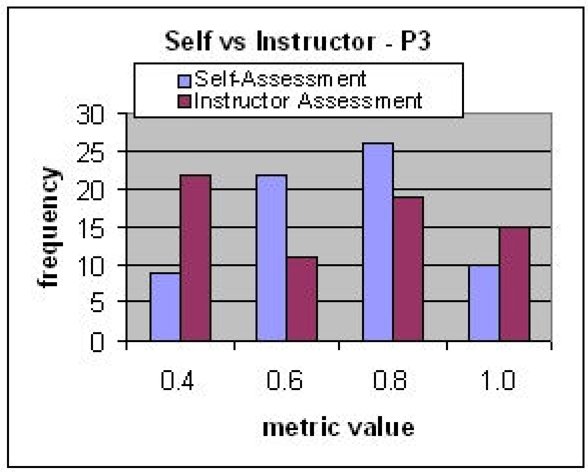

Figure 10

The scatter in the xy plots shows rather vividly that use of student self-assessment in grading would not be appropriate for this group, consistent with the literature for first-year students. The P2 data shows a slope that is very close to 1.0 and a relatively small intercept, indicating a reasonable relationship between instructor and student assessments. However, the coefficient of determination (R^2) indicates that less than 1/3 of the variation in instructor assessment is predictable from the student self assessment. The situation is much less promising on the S2 metric, with a flatter slope and an R^2 of only 0.14. The frequency distributions for S1 and S2 show students tending to assess themselves higher than the instructor, and with significant skewing to the higher mastery levels. The P1 histogram shows reasonable good agreement, but this is not repeated in the P2 and P3 metrics. Choice of bin size and frequency scales can drastically alter the appearance of the histograms, so it is best to not overanalyze these results.

One last plot is presented in figure 11: student self-assessment index vs grade on the final exam. In this case, the index is a composite of the differences between student and instructor assessments, normalized to 1, and can be viewed as an accuracy index. Avalue of zero indicates perfect agreement between student and instructor, while a negative value implies that the student underestimates his/her ability.

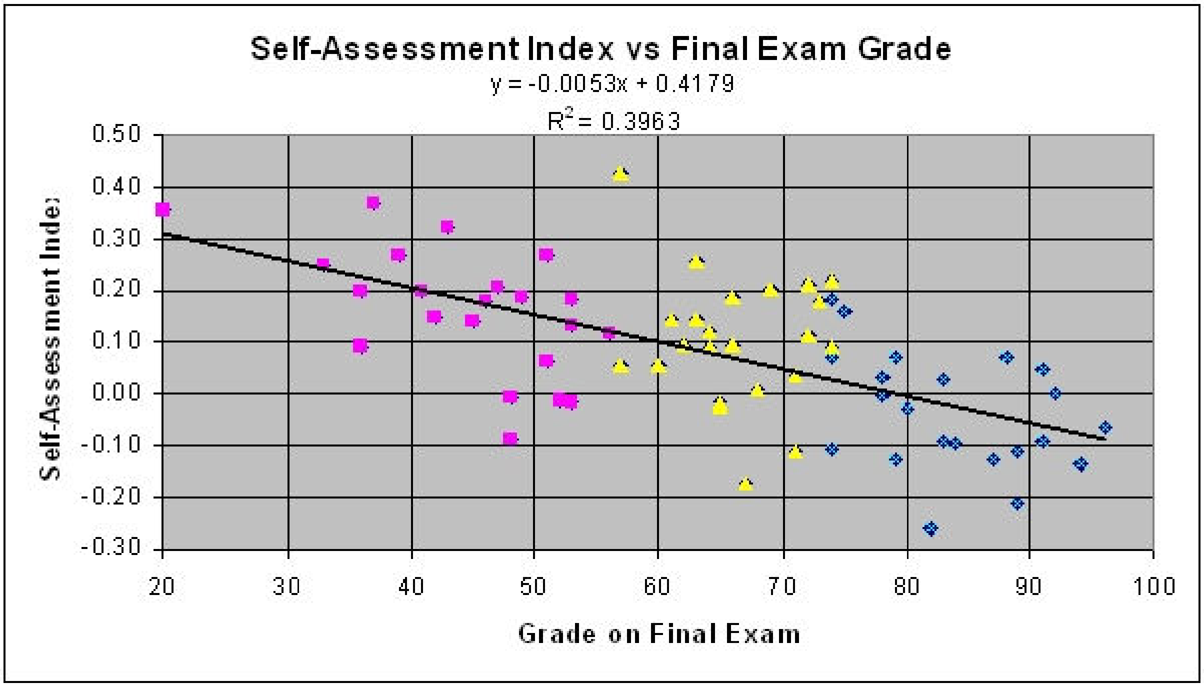

Figure 11

There appears to be a correlation between accuracy and final exam grade. The table below shows the average value of this index for students grouped by final exam grade:

Table 7 - Self-Assessment Accuracy Index Averages		
Student group	Index	Interpretation
Lowest 1/3 of students	0.15	(student assesses 15% higher than instructor)
Middle 1/3 of students	0.09	(student assesses 9% higher than instructor)
Highest 1/3 of students	-0.04	(student assesses 4% lower than instructor)

Students in the lowest 1/3, with final exam grades below 55, have an average value of 0.15 on this index, meaning that they overestimate their ability. Perhaps this leads them to prepare less for exams resulting in poorer performance. The middle 1/3 has a lower, but still positive index. Their assessments are closer to the instructor. The highest performers actually under estimate their ability, slightly, although they are fairly accurate in their judgement.

In using the results of this work, it is important to maintain perspective on the nature of the comparisons. This was not a case in which students and instructors were using the same metrics to perform evaluations. Many of the studies reported in the literature involve a comparison of students' prediction of how they will perform on a test with the instructors' grade on that test. The comparison here was the student's estimate of ability in specific areas with test questions which were intended to assess their mastery of related topics. Thus the resolution of the data suffers from the weaknesses inherent in creating test questions as well as the matching of test questions to specific questions on the student self-assessment survey. If the metrics are compared with this in mind, an appropriate view might be the following table, which limits the reporting of the metrics to a single digit:

Table 8 - Comparison of Student to Instructor Assessment (0.1 unit resolution)

	S1		S2		P1		P2		P3	
group	St	In	St	In	St	In	St	In	St	In
2	0.9	0.8	1.0	0.8	0.7	0.8	0.7	0.6	0.7	0.7
3	0.9	0.8	1.0	0.8	0.7	0.7	0.7	0.7	0.7	0.6
1	0.9	0.7	0.9	0.6	0.7	0.7	0.6	0.6	0.6	0.5
50	0.7	0.7	0.8	0.6	0.5	0.5	0.5	0.4	0.5	0.5
all	0.8	0.7	0.9	0.7	0.6	0.7	0.6	0.6	0.6	0.6

It is readily seen that the differences are about 0.1 for S1 (basic spreadsheet) and even less for the various programming metrics (P1, P2, P3). The metric S2 stands out as having the largest discrepancy. S2 is related to basic spreadsheet operations, including plotting and data analysis.

Table 9 Differences in Metrics (stud - Instr)

group	S1	S2	P1	P2	P3
2	0.1	0.2	-0.1	0.0	0.0
3	0.1	0.2	0.0	0.0	0.1
1	0.1	0.3	0.0	0.0	0.1
50	0.1	0.2	0.0	0.1	0.0
all	0.1	0.2	0.0	0.1	0.1

It appears that student in this class overestimate their ability, particularly in areas that they are most familiar. Further work needs to be done to determine if the test questions and survey questions used to create S2 are not as compatible as would be desired. If the larger differences for S2 are real, the instructors may need to do more to educate the students about the level of expectation in the areas related to this metric.

Another issue that is raised by the data in this table is the possibility of differences across sections. The small number of students in each section imposes some constraints on the interpretation, but it is clear that the students in group 50 have lower scores as determined by both the instructors and them selves. Further work would be needed to parse out the reasons for this difference. As was stated earlier, this group was dominated by older, part-time students. Most likely they have a lower comfort level with the computer than the typical full-time freshman engineering student. A different classroom approach may be needed for this group.

Conclusions:

A rather detailed survey was administered to students as a formative assessment tool. The comparison of student self-assessment with instructor assessment suggests that use of overall averages can provide useful feedback for course improvement. It would be unwise to use the self-assessment as part of the grade computation, as there is significant disagreement between instructor and student assessments at the individual level.

In aggregate, the agreement between instructor and student is close enough to provide some comfort level in using the student assessment averages to assess aspects of the course. There is relative agreement on which topics are best understood and which are least understood. There was also some indication by both instructor and student of a difference in mastery in one section, which may indicate a need for further investigation.

Since the students completed a pre and post version of the survey instrument, it will be possible to investigate gains made in specific areas. The results of the work reported in this paper provides some confidence that the student data should be useful for assessing specific aspects of the course, including those for which only student assessment information is available.

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