Session 3530

Incorporating Student Assessment Skills into MET Outcomes and Courses

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Abstract

Assessments used to improve the quality of education have recently been stated by ABET in its EC2000 list of A-K outcomes with similar criteria proposed by TAC. A difficulty lies in quantifying and documenting the assessment of these outcomes. From another perspective, employers typically use performance reviews which depend on assessing an employee's performance in a similar manner. Students in MET curricula who do not commonly use these assessment techniques and may enter the work environment ill-prepared.

This paper reviews two examples of incorporating student assessment into MET/Manufacturing Option classes. In an Applications of Strength of Materials class, students prepare a report of mechanical characterization test results, and grade/rank each other's reports. Statistics are used to assess the effectiveness of their criteria and weighting system, and the feedback provides a means to improve their skills.

In a second example, a CAD/CAM class is organized into 'companies' which assign job descriptions, get RFP's, create proposals, and carry out a phase II contract. In this process learning environment both company and student performance is reviewed and includes the use of peer assessment. Periodic assessment of company reports and individual journals encourage the student to improve themselves.

Introduction

There are two issues concerning assessment that engineering educators should address: 1)using assessment as a process to improve Engineering Technology (ET) programs, and 2)developing technical assessment skills in students. The first issue is current and relevant to TAC-ABET program criteria. The second issue is less visible, but student assessment skills can also be related to TAC-ABET as well as industry criteria.

Assessment can be applied to both processes and products. Education, for example, is a process. As educators, one of our jobs is to assure and improve the quality of that process. As engineers, we have tools to do this. Historically Deming, Taguchi and Juran contributed methods which can be related to the Total Quality Management (TQM) concept[1] which addresses the quality of both process and product. Shewart[1] developed another tool called statistical process control (SPC). The ISO 9000 standard is another example of an engineering tool aimed at improving manufacturing processes, and only the process (not the product) is addressed[2]. These engineering tools are primarily aimed at process improvement and have contributed to the new TAC-ABET criteria.

It appears likely that some form of outcomes based criteria will be adopted for use in accreditation of engineering technology programs. Using TAC ABET criteria as a basis for discussion[3], the three objectives of the accreditation process are listed below:

> 1.C.1. To serve the public, industry, and the engineering profession generally by stimulating the development of improved engineering technology objectives.
>
> 1.C.2. To identify for prospective students, student counselors, parents, potential employers, public bodies, and officials, engineering technology programs which meet the minimum ABET criteria in engineering technology.
>
> 1.C.3. To provide stimulation leading to curricular improvement in existing programs and to assist in the development of educational models for establishing new engineering technology programs as increased service to the public interest.

All of these objectives support the assessment of a process, similar to ISO 9000. However, TAC ABET Policy II.A.8. states that "Although rigid quantitative standards are not considered sacrosanct, programs are expected to meet the minimum standards delineated in the criteria." This statement is 'product' oriented, and in particular refers to evaluation. So our apparent goal is to improve the education process as well as the 'product' of an educated student.

The difference between assessment and evaluation is also important. Assessment is a process of measuring performance and giving feedback to improve future performance. Evaluation is a process of making a judgment concerning the quality of a performance by comparing the performance to a standard[4]. As engineers, we are particular about the purpose and scope of ISO 9000 vs. SPC concepts, for example. As educators, we may wish to be equally discerning, and model assessment and evaluation concepts to our students so that they may use these tools appropriately.

Students in engineering technology (ET) programs are assessed and evaluated regularly (e.g. course exams and grading), but they do not perform these tasks themselves. Student assessment by teachers may traditionally be manifested in the form of comments on a lab report. Student evaluation by teachers is typically individual oriented (e.g. test scores) and does not foster 'team skills'. The culture of a team offers great opportunity for students to assess themselves and their peers. Team skills are also of significant interest in industry. The 1997 Boeing Educator's Workshop[5] had four morning topics: EC2000, collaborative research, faculty/industry relations and student teamwork skills. Students need to enhance both assessment and team skills, but there are few traditional opportunities.

In one example of a curricula effort, Schmidt reported use of TQM in the classroom[6]. This involved 1.)customer satisfaction, 2.)continuous improvement, 3.)empowerment, and 4.)teamwork. This was a singularly successful implementation which eventually involved an entire high school. However, as with typical applications of TQM, total buy-in by participants was required. And as the author stated, "Colleges and universities continue to reward individual achievements rather than team efforts."

Against this current backdrop of limited use of assessment in the classroom, assessment is a skill that a student should have and use in their career. Even if it is unmanageable to convert entire university curricula to incorporate TQM and foster student assessment skills, there are methods of including the development of assessment skills into traditional ET curricula.

This paper offers two methods of incorporating student assessment skills into traditional MET curricula.

Student Assessment Skills

An MET program outcome might include a statement like 'the student will be able to select and use appropriate equipment and design systems for product testing or research experimentation'. Inherent in this outcome is the students' ability to evaluate choices and assess them regarding a purpose. We have supported this program outcome of the 'ability to select' through a course objective such as 'select reports and use assessment to improve their own reports by using decision matrices'. We use an activity in our "Applications in Strength of Materials" course for this purpose. This course is lab oriented and focuses on mechanical property testing techniques. One activity on Charpy Impact testing in which the class characterizes unknown specimens. The students are informed up front that they will assess each others reports. On a specific date, copies of the reports are made available in class, and the activity sheet (see Appendix A) is implemented.

In this two hour activity, attributes of a 'good' report are discussed, and the students take an hour to measure a half dozen reports and perform Step 1 (criteria, weighting and scoring). A discussion of statistics follows, with emphasis on the meaning and use of standard deviations while the students perform Steps 2 and 3 (determining if the current criteria and weightings are appropriate). An example of student work is presented in Appendix A which shows a decision matrix and statistical analysis. At the end of the activity a discussion is held concerning different purposes that the report could be used for (e.g. instead of an example of a 'good' report, perhaps it could be 'the best procedure' or 'the best for posting on your website'). This discussion should include a comparison of the statistics used by each student..

This process results in discussions about how to measure the selection process itself. For this report selection activity, a minimum standard deviation can be used to determine a good decision matrix. This can also offer a way for an employee to support his selection to a peer or superior. There are also four questions on the back of the activity sheet that the students fill out after class.

1) Validity: Using your data, which report did you select (for both defined uses) and why were they good choices?
2) Influence of Criterion: Rank your criteria for importance. Which was the least and most important; why?
3) Aspects of Representation: Was your criterion selection good enough (inclusive) to let you change the purpose of assessment and re-evaluate through changes in weighting factors? Explain.

4) Evaluation vs. Assessment: Would a change in the evaluation scaling range (e.g. poor is 0, best is 10) make a substantial difference in your results, or the usefulness of the assessment? Explain.

These questions are meant to cause the student to reflect on the critical aspects of this assessment process, and is an aid in further discussions of assessment as well as writing their next report. The importance of this activity is that it develops student assessment skills in a format which is easily incorporated into typical MET curricula with minor impact. It also generates documentation for program assessment.

Team Skills and Peer Assessment

Program and course outcomes directed at student abilities to work in teams are demanded by TAC-ABET Program Criteria 1.e stating that graduates should "function effectively on teams". Engineering project teams are common in industry and assessment can be used to improve performance. However, team skills are not easily incorporated into traditional curricula. One reason is that team dynamics must occur, and numbers such as a dozen[5] offer more dynamics than teams of two or three. Aspects of time are important with respect to team skills used in industry. For example, a performance review is typically done after months, as opposed to a single class period. And an employee performance review will typically include feedback from their peers regarding performance as a team member in various roles. With team skills and peer assessment as design drivers for a class curricula, a suitable class was found to restructure in our MET program.

Our CAD/CAM class is a senior level course with no subsequent classes to support. This allows a flexibility of subject matter determined by outcomes not encased in sequential courses. The schedule (shown in Appendix B) includes two concurrent themes: content material and team environment. The course content can be evaluated as suggested in TAC ABET II.A.8 regarding 'development in ET education', in that team skills are of singular interest to industry and society. Throughout the class specific assessment and team skills used in industry are employed. Teams (companies) are formed, and job descriptions written. A request for proposal is issued and proposals are written (methods, resources, budgets and schedules included). The proposal is limited in scope, but a project design review (PDR) occurs as well as student performance reviews. Performance reviews can be done following any local industry methods, and may be used as assessment tools to improve student and team performance.

An activity in which students study and perform team roles is used at the start of the course. The students find out quickly that the recorder has to produce a document at the end of a class period, and that the spokesman has to get up and report to the rest of the class. This also adds to the meaning of 'deliverables' in a proposal. These roles are rotated for small tasks like learning the CAM program. This helps the students understand job responsibilities at technical and administrative levels. This type of cooperative learning is also a very effective education method for conveying knowledge and skills like mastering new software. Role perspective also helps when the companies are formed and job descriptions are defined. A standard lab journal is kept and used to document activities and assess both individual and team progress.

The skill of peer assessment is largely ignored in traditional curricula, but incorporated in most current industrial performance assessment methods. The CAD/CAM course offers a suitable environment in which a student can exercise peer assessment skills using industry guidelines. In fact, the categories used for evaluation are taken directly from industry and can represent great motivation for the student to understand the process.

Peer assessment is performed by the CAD/CAM students three times over the life of the class project; at the time of the proposal, the PDR, and the final report. Each team evaluates both themselves and their teammates. This data is normalized and the peer evaluation results are shown to the individuals (see Appendix C). This knowledge of how their peers evaluate their performance is then used by the students to better themselves. The students have typically addressed issues of commitment, decision skills, and ‘people’ skills. The lab journals can be used to substantiate aspects commitment (e.g. hours worked), etc., and provides a framework for creating tactics to improve student performance.

There have been few examples of students not participating in the evaluations (either by evaluating all members the same, or not at all). But by explaining the intent of both the evaluation (grades, pay raises, etc.) and the assessment (documenting progress, identifying career objectives, etc.) and discussing specific cases in class, the students have generally bought into the system. To date we have not included statistics in the peer assessments, though this is an opportunity.

Conclusion

Students may use assessment skills to improve their performance, just as educators use them to improve their programs. Two examples of educational activities have been shown which develop assessment skills in students. The first is a decision matrix activity which can be included in a traditional curricula and can result in increased quality of student selection performance. The second example is a course curricula which incorporates team activities and peer assessment. The students are able to use their team and assessment skills to improve their performance.

Bibliography

1. Kalpakjian, S., “Manufacturing Engineering and Technology,” 3rd ed., Addison Wesley, 1995.
2. Schuler, C., “ISO 9000: Manufacturing, Software and Service,” Delmar Publishers, 1996.
3. Accreditation Board of Engineering and Technology, http://www.abet.org/tac/9899TACr.html, 1998.
4. Krumsieg and Baehr, “Foundations of Learning,” Pacific Crest Software, 1996.
5. Third Boeing/University Key Schools Workshop, 1997.
6. Schmidt, K., “Applying the Four Principles of TQM to the Classroom,” Tech Directions, 1998.

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Appendix A

MET326, Fall 1998 Impact Test Lab Report Selection Activity #5

General:

Our purpose in this activity is to develop the skills needed for you to form bias; to be used in selecting reports for specific purposes, or other engineering selections. In this session we will use our second lab report as a test article, and apply bias forming methods to evaluate them.

Safety:

This type of activity can be detrimental to egos. Please fasten your brain belt and be prepared to eat crow while pondering words like humility, clarity, and sanity. This activity can be considered ‘character building’.

Resources:

Our previous lab writing and lab grading guidelines, this handout, as well as examples in the library.

Instructions:

STEP 1

1. List all of the attributes of a ‘good’ report on a piece of paper (e.g. grammar, content, etc.). Now weight them (from 1-less to 3-most) important. Now generate a table with the left side composed of ‘attributes’ (with the weighting beside them), and across the top list each report identifier (allow two columns per report).

2. Assemble everyone’s report on the front table. Read them, assess them (list specifics), evaluate them (from 0-missing, to 10-perfect) and record your findings on the table you have. Use the same grading as before, but oriented toward each attribute. Label the defined Audience, and Purpose of the assessment.

3. After you have assessed everyone’s report, retire to a safe place and tally up the scores on the bottom row. Multiply the scores for each attribute by the weighting (creating a new column of numbers for each report). Now total the scores for each report on the bottom row. Normalize the scores to reflect a possible total of 100.

4. Wait for instructions: (students will determine standard deviations, providing feedback on bias level).

STEP 2

Instructor: Evaluate the results* of each students’ data; use their standard deviation as a ‘bias criteria’.

Note: If you don’t normalize the results, the weightings and scales will be unique.

* Criteria: Does the standard deviation reflect a reasonable bias? (generally, two digits are high bias)

YES: Go to STEP 4

NO: Choices: * students: change your criteria and weightings; you can also add parameters.
Try redefining your intent (the use of the document) to affect the weightings.

STEP 3

Re-assess each report and determine if your evaluation meets the bias criteria (this assures *validity*).

STEP 4

Verify that the criteria and weightings *represent* the intended application. This discussion should cover aspects of the content, medium, source and audience, with both historical and future uses in mind. Try using your existing measurements for another purpose (just by changing the weightings).

Deliverable: At the end of this lab, you should have selected a report for a particular use, and have supporting evidence to show validity and representation of the selection.

Note: You will have to assess and evaluate many works/reports/products in your lifetime. Good Luck!

Appendix A (continued)

C's second decision matrix		B		E		D		A		
Criteria (0-10pts):	Weighting	Score	Total	Score	Total	Score	Total	Score	Total	
Easy to follow	3	8	24	8	24	8	24	8	24	
Good english	2	10	20	10	20	10	20	10	20	
Good procedure	3	7	21	5	15	5	15	9	27	
Basic content	2	8	16	8	16	9	18	9	18	
Clear conclusion	1	10	10	10	10	10	10	10	10	
Total:	11		91		85		87		99	C's Std. Deviation
Total Poss	110	%	82.73		77.27		79.09		90	5.61

Purpose 1: Use report for students to reproduce experiment						Average	Std. Dev
	A	B	C	D	E		
A		96.7	85	90.8	85	89.375	5.596651
B	88		85	95	90	89.5	4.203173
C	91	86.4		87.3	84.5	87.3	2.728858
D	77.5	94.2	65		97.5	83.55	15.15179
E	83	94.6	86.9	96.2		90.175	6.273954
Average:	84.875	92.975	80.475	92.325	89.25	87.98	5.277499
		B is chosen!					

Purpose 2: Post report on Dept. Website as a 'good example'							
	A	B	C	D	E		
A		97	87	93.5	84.5	90.5	5.759051
B	90		76	92	90	87	7.393691
C	90	82.7		79.1	77.3	82.275	5.618051
D	73.3	92	66		99.3	82.65	15.59156
E	85	94.3	85	95.7		90	5.801724
Average:	84.575	91.5	78.5	90.075	87.775	86.485	5.174716
		B is chosen!					

Appendix B

MET 423 -CAD/CAM; Class Schedule for Winter of 1999

1/4	Register (Class Meetings: MWF at 3PM in HT 210)	TO DO:	DUE:
1/6	Introduction and Text tour (FL: Activity 2.3, Reading Skills)	Read Ch. 1, FL Ch. 1,	1/8
1/8	Review of AUTOCAD and NC systems (Use Teams & Journals)	Read Ch. 2	
1/11	CAM: Websites; Info Tech., data acq. (Activity: Team Roles)	Read Ch. 3	Now!
1/13	Numerical Control	Read Ch. 9 & 10	
1/15	G-Code and the CNC mill: Box with name (P1)		
1/18	**Martin Luther King Holiday**		
1/20	Safety: Shop, Mills, and other equipment (Activity: 5.1, 5.2 - due 1/22)		
1/22	Product Engineering: SolidWorks	**Exam #1**	
1/25	Company and Employee Definitions (Ind. vs. Co. reports, RFP's, Job Descriptions, Preliminary Design Reviews) Activity: 2.4 - due 1/27	Form Companies, job descriptions	
1/27	Assessment: Performance Reviews, **individual and peer assessment,** (Act. 5.3 - due 1/29)		
1/29	Intellectual Property, Lab Journals, Legal Issues (FL: Personal Development)	Week #1 Progress Reports	
2/1	Process Engineering (FL: Information Processing)	Read Ch 4	
2/3	Tooling	Read Ch. 5 & 6	
2/5	Automation (FL: Management: Activity 10.7- due 2/8)	Week #2 Progress Reports	
2/8	Programmable Logic Controllers	Read Ch. 7 & 8	
2/10	Local Area Networks (FL: Communication)		
2/12	ISO 9000 Accreditation	Week #3 Progress Reports	
2/15	**President's Holiday**		
2/17	Preliminary Design Review (outcome: action items, revised schedule) (FL: Problem Solving)		
2/19	Performance Reviews (**individual and peer assessment**)	Week #4 Progress Reports	
2/22	Robotics	Read Ch. 11 & 12	
2/24	Group Technology		
2/26	Field Evaluation **Exam #2**	Week #5 Progress Reports	
3/1	Databases (Activity: use of databases - due 3/5)	Read Ch. 13, 14 & 15	3/5
3/3	Concurrent Engineering		
3/5	Computer Integrated Manufacturing	Week #6 Progress Reports	
3/8	Material Resource Planning (Activity: Shop Layout - due 3/12)	Read Ch. 16	
3/10	Manufacturing Plant/Cell Layouts		
3/12	Preparing reports and prototypes (**individual and peer assessment**)	Presentation, reports, & prototype due on day of final!	
3/18	Final: Thursday March 18, at NOON!		

APPENDIX C - PEER ASSESSMENT		A	B	C	D	A	B	C	D	Peer
Teamwork	Norm Factor	0.66 7	0.667	1	1	Normalized:				Ave:
Deficient=1	A	3	1	2	2	2	0.667	2	2	51.85
KEY: Meets=2	B	3	3	2	2	2	2	2	2	66.67
Exceeds=3	C	3	3	2	2	2	2	2	2	66.67
	D	3	3	2	2	2	2	2	2	66.67
Safety & Env. Awareness	Norm Factor	0.667	2	1	1					
	A	3	1	2	2	2	2	2	2	66.67
	B	3	1	2	2	2	2	2	2	66.67
	C	3	1	2	2	2	2	2	2	66.67
	D	3	1	2	2	2	2	2	2	66.67
People Skills	Norm Factor	0.667	1	1	1					
	A	3	2	2	2	2	2	2	2	66.67
	B	3	2	2	2	2	2	2	2	66.67
	C	3	3	2	2	2	3	2	2	77.78
	D	3	2	3	2	2	2	3	2	77.78
Customer Focus	Norm Factor	1	0.667	1	1					
	A	2	3	2	2	2	2	2	2	66.67
	B	2	3	2	2	2	2	2	2	66.67
	C	2	3	2	2	2	2	2	2	66.67
	D	2	3	2	2	2	2	2	2	66.67
Integrity	A	2	2	2	2	2	2	2	2	66.67
	B	2	2	2	2	2	2	2	2	66.67
	C	2	2	2	2	2	2	2	2	66.67
	D	2	2	2	2	2	2	2	2	66.67
Result Focus	A	2	2	2	1	2	2	2	1	55.56
	B	2	2	2	2	2	2	2	2	66.67
	C	2	2	2	2	2	2	2	2	66.67
	D	2	2	2	2	2	2	2	2	66.67
Commitment	Norm Factor	1	0.667	1	1					
	A	2	2	2	2	2	1.333	2	2	59.26
	B	2	3	2	2	2	2	2	2	66.67
	C	2	3	2	2	2	2	2	2	66.67
	D	2	3	2	2	2	2	2	2	66.67
Knowledge	Norm Factor	1	0.667	2	2					
	A	2	2	1	1	2	1.333	2	2	59.26
	B	2	3	1	2	2	2	2	4	88.89
	C	2	3	1	1	2	2	2	2	66.67
	D	2	3	1	1	2	2	2	2	66.67
Decision Skills	A	2	1	2	2	2	1	2	2	55.56
	B	2	2	3	2	2	2	3	2	77.78
	C	2	3	2	2	2	3	2	2	77.78
	D	2	3	3	2	2	3	3	2	88.89
Strategy Focus	Norm Factor	2	0.667	1	1					
	A	1	3	2	1	2	2	2	1	55.56
	B	1	3	2	2	2	2	2	2	66.67
	C	1	3	2	2	2	2	2	2	66.67
	D	1	3	3	2	2	2	3	2	77.78
Gross Evaluation %:						60.37	70	68.89	71.11	