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Implementing Rubrics as Part of an Assessment Plan*

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Student assessment of technical skills in engineering and engineering technology is relatively straightforward. Problems typically have right or wrong answers, and assessing students' ability to effectively solve problems, design systems and evaluate designs can be quantitatively measured. Assessing non-technical skills (sometimes called 'soft skills') such as the ability to function in teams, communicate effectively or understand ethical responsibilities [1] can be a challenge for faculty in engineering or engineering technology as these more qualitative characteristics don't necessarily involve right and wrong answers. These characteristics have traditionally been measured by engineering technology faculty the same way they are evaluated in the workplace: 'I know it when I see it'. While this method may lead to a letter grade ('That presentation was pretty good—I'll give it a B'), this is not truly assessing the student, the presentation or the degree program. Meaningful assessment of the student or of the presentation should include constructive feedback, and assessment of the degree program should include qualitative measurement of the necessary characteristics of a good presentation. Good assessment practices also recommend that data be 'triangulated', or measured in more than one way. The assessment plan for the Electrical and Computer Engineering Technology programs at IUPUI include the development and use of rubrics for assessment of student performance and to supply meaningful and consistent feedback to students.

Keywords: ABET, assessment, assessment plan, engineering technology, rubrics.

INTRODUCTION

A RUBRIC is a scaled set of criteria that defines a range of what acceptable performance looks like. 'The criteria provide descriptions of each level of performance in terms of what students are able to do and values are assigned to these levels.' [2] According to Bresciani, rubrics can be used in assessment to evaluate the effectiveness of entire programs, or individual student assignments, presentations or papers [3]. Rubrics may be developed by individual departments or existing rubrics may be borrowed and/or modified to fit assessment criteria.

Care should be taken in the development of rubrics. There are a number of excellent online resources available [4, 5] to format rubrics or list characteristics of effective design [6]. Many of these are designed for K-12 teachers, where rubrics have been extensively used. Some characteristics of effective rubrics include:

- Language that is understandable to the learner and teacher.
- Terms which are clearly defined and measurable.
- Descriptors encourage a 'continuous improvement' mindset (indicate what can be done to improve).
- Avoiding double-barrel questions (questions that ask the rater to assess multiple characteristics at one time).
- Avoiding duplication of questions.

According to Simkins, 'good rubrics are neither too specific nor overly general. They should be devised in such a way as to highlight parts of the work that the teacher regards as especially important' [7].

The number of criteria was kept to a minimum to speed the assessment process. According to Rogers, it isn't necessary to assess everything possible all the time. 'There is generally an inverse relationship between the quality of measurement methods and their expediency' [8]. Yet the more expedient the process, the more likely it is to be adopted for long-term use. Thus, there should be a balance between ease of use and the precision of the data.

Rubrics, once developed, are easy to use and are well suited for long-term implementation in an assessment plan. Successful implementation requires attention to the specific program objectives rather than simply adopting rubrics designed as part of other programs [9]. Rubrics designed for programs whose objectives may vary slightly may require some modification. Their successful implementation includes those designed to design

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process knowledge [10], engineering soft skills such as the ability to engage in lifelong learning and understanding the impact of engineering in a global and societal context [11], and overall characteristics of student achievement in a capstone experience [12].

a. Students complete a "self-assessment" survey each semester to evaluate course objectives which are mapped to this outcome.
   Goal: 70% of students will agree or strongly agree (4/5).
b. The design rubric will be filled out by the faculty member assessing the senior design project.
   Goal: 70% of students score a 3 or above on all items.

Fig. 1. Design objective assessment plan.

EFFECTIVE ASSESSMENT

Indirect vs. direct measures

It is desirable to assess student learning through a variety of methods [13]. Surveys appear to be an 'easy' method to generate data, yet they have major drawbacks. Surveys are not only difficult to design well, they are an indirect measure of student performance. Student self-assessment surveys are used as one measure in this assessment plan; but only as an indirect measure to triangulate findings in specific areas. In a self-assessment, end-of-semester survey, students are asked to report on their own learning: the students report their perception of their mastery of course objectives. This is an indirect, subjective measure. Thus, these surveys do not measure student learning directly —they measure students' opinions of their learning.

Direct measures of student learning do not rely on student opinions of what they know. Direct measures observe and quantify student ability to reach an objective. A standardized test is a classic example of a direct measure of student learning,

Table 1. ECET Design project assessment rubric

To be completed by the instructor regarding each project; may be individual students or a team design
Used to evaluate ABET items d & k:

- Apply creativity in the design of systems, components or processes appropriate to program objectives.
- Have a commitment to quality, timeliness and continuous improvement.

May be used in student grading, but this is not required.

	Excellent	*Average*	*Poor*	*Ex . . . Avg . . . Poor*
Identification of Problem or Definition of Project	Clear & complete ID of design goals & objectives	Adequate ID of problem; any lack of specifics does not impair solution or design	Insufficient ID of problem; inadequately id's objectives	
Technical design	Exceeds specs if appropriate; meets specs with efficient design	Meets nearly all specs	Missing significant specs	
Complexity of project / design	Exceeds typical technical complexity for course level	Meets typical technical complexity for course level	Below typical technical complexity for course level	
Appropriate choice & use of resources (e.g. computer apps, internet sources, lab equipment)	Innovative selection of resources; expert use	Appropriate resources used (such as demonstrated in class); resources limited to faculty-provided materials/tools	Inadequate use of suggested resources.	
Time Management	Identified plan/ timeline & worked to it; consistently met deadlines	Goals accomplished; most milestones met; some schedule defined; inconsistent use of time; misses some deadlines despite reasonable effort	Missed significant milestones or project not completed	
Information management: Log book, status reports, documentation	Detailed, appropriate and timely entries; collected & distributed to appropriate parties	Adequate entries in journal or log book; only critical data/ information collected & distributed	Insufficient data collection / recording; existing documentation not shared/utilized	
Conclusions & result interpretation	Obtained & adequately interpreted meaningful results with appropriate, insightful conclusions	Produced some results, but struggled with interpretation or lacked sufficient support for their conclusions	Generated few results with little meaningful interpretation; conclusions are absent, wrong, trivial or unsubstantiated.	

and, if available, is an excellent assessment tool. Some student work, such as writing or team work, does not lend itself to quantification. Rubrics provide a method to assess student work objectively and repeatedly and yield quantifiable data, even when the student work can have more than one 'right' answer.

The ECET assessment plan uses rubrics to assess several program objectives that do not lend themselves to standardized test questions. These objectives are:

- Apply and design components, circuits, systems and software programs in their specialty area as demonstrated in a senior project.
- Function as a member of a 2–4 person team to complete a task in a timely manner. Demonstrate ability to organize work done by team members.

a. The following courses are to be used to assess teaming: ECET 209, 257, 307, 309, 360, 371 and 417. In each case, the teaming rubric will be filled out by the faculty member assessing the success of their teams.
   Goal: 70% of students score a 3 or above on all items.
b. A teaming rubric will be filled out by each student (self / peer evaluation) in ECET 234, 209 and 360.
   Goal: 70% of students score a 3 or above on all items.

Fig. 2. Teamwork objective assessment plan.

- Write technical reports; present data and results coherently in oral and graphic formats.
- Demonstrate ethical conduct as described in the university student code of conduct. Demonstrate knowledge of a professional code of ethics.
- Demonstrate a respect for diversity as described in the university civility statement.

Table 2. ECET Teaming assessment rubric

To be completed by the instructor regarding each team; not individual team members
(May also be used for each team member to evaluate the function of their team)
Used to evaluate ABET items e:

- Function effectively on teams.

May be used in student grading, but this is not required.

	Excellent	*Average*	*Poor*	*Ex . . . Avg . . . Poor*
Contributions (quality/ management of quality	All members routinely contribute quality & useful ideas and information; the team evaluates all ideas and uses only the best.	Most (but not all) members contribute useful ideas & information; or the team as a whole adequately integrates the ideas presented	Internal conflicts results in team failing to achieve projects goals	
Division of labor (equality/quantity)	All members make significant contributions & are accountable to complete assigned tasks	Progress is satisfactory, but unequal workload is observed	Serious problems due to unequal workload	
Communication (within the team)	Consistent communication throughout project; insightful use of real and virtual meetings: meetings are productive	Adequate number of meetings (real or virtual)	Inadequate meetings and communications	
Professional conduct	All team members consistently behave in a professional manner (show up for meetings prepared and on time, treat other team members with courtesy & respect) & seek outside advise if team is not productive	Team members usually behave in a professional manner; do not repeat the same error & accept outside advise if team is not productive	Team members frequently fail to behave in a professional manner: team does not seek outside help	
Group discipline	Stays focused on task; finds solutions as problems are encountered. Uses sound principles of inquiry when analyzing problems & seeking solutions.	Adequate focus to complete task; some problems are discounted until a later time	Totally lacks focus; problems are discounted; team does not take responsibility for failures of the group	
Group dynamics	Synergy	Majority of team members willingly participate; team functions adequately	Everyone going their own way	

Note that these 'soft skill' objectives are observable, but students demonstrate them as part of a process within a technical course; they are not typically objectives that would be tested in an exam. Using rubrics to measure these objectives allows the focus of the student work to be on 'technical' material, but still yields quantitative data about the students' ability to meet the objectives. These rubrics also enable an instructor to provide feedback to the student, thus allowing the student to improve.

Rubrics give a quantitative evaluation for assessment, a trait that naturally leads to their use as a grading tool. The rubrics that are presented here were not designed to be used for grading, although this is certainly a common use.

a. Written reports will be evaluated in 155 or 157, 234, 304, 403, 417, 483, 490 & 491 using departmental written report rubric.
   Goal: 70% of students score a 3 or above on all items.
b. Oral reports will be evaluated in 155, 234, 360, 371, 483, 490 & 491 using departmental oral report rubric.
   Goal: 70% of students score a 3 or above on all items.

Fig. 3. Communications objective assessment plan.

Instructors may wish to assign weights to some items when used as part of a grade [14].

Each of these objectives and the associated rubric will be discussed here. All rubrics are available as Microsoft Word or .pdf format online [15].

Table 3. ECET writing assessment rubric

To be completed by the instructor regarding each presentation; may be individual students or a team design
Used to evaluate ABET items g:

- Communicate effectively.

May be used in student grading, but this is not required.

	Excellent	*Average*	*Poor*	*Ex . . . Avg . . . Poor*
Introduction	Introduction provides background and a forecast of the document. Problem or situation is defined clearly with orienting material for audience	Introduction is adequate.	Introduction is missing or confusing	
Organization	Points are clearly presented in a logical order. Easily followed. Page layout is effective & professional looking.	Most points are ordered well. No major problems with layout.	Confusing, disorganized. Layout is distracting or unprofessional.	
Language	Wording is concise, clear, and easy to follow. Style is consistent and appropriate in formality. Professional tone; consistently proper grammar, spelling and punctuation.	Author has most of the "Excellent" traits. Minor problems with grammar, spelling, punctuation.	Distracting word choice; style is not appropriate in formality. Unprofessional. Problems with grammar, spelling and punctuation inhibit reader understanding.	
Content	Consistently appropriate; Analysis is logical and sound—no gaps in topic coverage. Data / analysis clearly support the thesis.	Generally appropriate to audience and the author's role; appropriate length; Data / analysis are accurate & sufficient.	Major gaps in information or analysis; too long or too short	
Conclusions	Clear, insightful conclusions.	Most but not all points contained in the conclusion	Inadequate summary; No conclusion.	
Visuals	Easy to read; improves comprehension	Layout is satisfactory; meets standard requirements	Visuals inappropriate or distracting	
Sources	Credit is given for all work from other sources using standard format. Material from external sources is relevant and adds to the report.	Credit is given for main points. Sources are listed.	Sources are not listed. External material is not relevant.	

Table 4. ECET speaking assessment rubric

To be completed by the instructor regarding each presentation; may be individual students or a team design
Used to evaluate ABET items g:

- Communicate effectively.

May be used in student grading, but this is not required.

	Excellent	*Average*	*Poor*	*Ex . . . Avg . . . Poor*
Introduction	Clear, concise and complete	Introduction orients the audience adequately.	Introduction is missing or confusing	
Organization	Points are clearly presented in a logical order. Easily followed.	Most points are ordered well.	Confusing, disorganized; audience confusion because of organization	
Language	Wording is concise, clear, and easy to follow. Style is consistent and appropriate in formality. Professional tone; proper grammar.	Speaker has most of the "Excellent" traits	Distracting word choice; style is not appropriate in formality. Unprofessional	
Delivery	Extemporaneous, relaxed body language; excellent eye contact, pace and volume.	Notes used minimum distraction; appropriate eye contact, pace and volume.	Obviously read or memorized major portions; little or no eye contact; too slow or fast; too soft or loud	
Conclusions/Q&A	Clear, insightful conclusions; questions handled well	Most but not all points contained in the conclusion	Inadequate summary; No conclusion; questions & answers handled unprofessionally	
Visuals	Easy to read; improves comprehension	Layout is satisfactory; meets standard requirements	Does not use equipment smoothly; visuals inappropriate or distracting	
Content	Consistently appropriate; Analysis is logical and sound—no gaps in topic coverage.	Generally appropriate to audience and the speaker's role; appropriate length; Analysis is sufficient	Major gaps in information or analysis; too long or too short	

DESIGN

The assessment plan for the design objective uses a rubric as a direct measure in conjunction with an indirect method (student survey). (see Fig. 1.)

The rubric used in this assessment can be found in Table 1. This rubric was developed as a committee of faculty: criteria for effective designs were listed and categorized, then the rubric went through multiple iterations and refinements. As the final list of assessable criteria was developed, descriptions for excellent, average, and poor performance were defined. Faculty using the rubric are to assess each topic on a scale of 5 (excellent) to 1 (poor).

The design assessment rubric can collect assessment data for more than one TAC-ABET criterion:

- TAC-ABET Criteria 1.a., 'an appropriate mastery of the knowledge, techniques, skills and modern tools of their disciplines' may be assessed using the 'Appropriate choice & use of resources' category.
- TAC-ABET Criteria 1.d., 'an ability to apply creativity in the design of systems, components or processes appropriate to program objectives' may be assessed using the first three categories: 'Identification of problem,' 'Complexity of design,' and 'Technical design'.
- TAC-ABET Criteria 1.f., 'an ability to identify, analyze and solve technical problems' may also be assessed using the 'Identification of problem' category.
- TAC-ABET Criteria 1.k., 'a commitment to quality, timeliness, and continuous improvement' may be assessed using the 'Time management' category.

In addition to the skill mapping listed above, the 'Information management' category can give information to assess TAC-ABET Criteria 1.g., 'an ability to communicate effectively' and TAC-ABET Criteria 1.e., 'an ability to function effectively on teams' if the project is a team project. However, it would be better to split the category and specify communication and team dynamics in

Table 5. ECET professionalism and civility rubric

To be completed by the instructor regarding an entire class for one semester (not individual students).
Used to evaluate ABET items i & j:

- Understand professional, ethical and societal responsibilities.
- Recognize contemporary professional, societal and global issues and be aware of and respect diversity.

Does not have to be used in student grading

	Excellent	*Average*	*Poor*	*Ex . . . Avg . . . Poor*
Civility (demonstration of respect / politeness)	Individuals nurtured and supported within the team. All students treated with respect even if behavior is objectionable. All disagreements are handled with civility.	Groups are able to succeed with no failures due to non-acceptance or lack of respect or nurturing. Objectionable individuals are tolerated.	Individuals cannot succeed because of lack of respect & civility. Arguments, fighting, team members fired for reasons other than nonacceptable performance.	
Tolerance	Heterogeneous groups form naturally w/o regard to race, gender, nationality, etc.	Homogeneous groups naturally form, although no observable tension is observed.	Tension observed based on race, gender, etc. Harassment, discrimination observed	
Professionalism	Individuals accept responsibility and consequences for their work. Excuses not given.	Excuses, when offered, are reasonable and factual.	Excuses made are not factual or exaggerated; excuses not appropriate to the situation. Level of effort is misrepresented.	
Social ethics	Each individual in a group presents his/her own work / results. Evaluations are honest.	Minor collaboration in small matters when not appropriate.	Misrepresent data / results, level of effort. Present work of other students as their own.	
Technical ethics	Work presented as done; accurate, precise.	Data misrepresented slightly, edited	False data presented, large misrepresentations	
Plagiarism	None.- all sources properly credited.	Some references / contributions mislabeled. Isolated incidents (1–2) of major offenses.	Extensive blatant plagiarism (>10% of the class).	

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IUPUI student handbook: www.life.**iupui**.edu/help/docs/**student_code**_full.doc
IEEE Code of Ethics

the criteria if those data are desirable, rather than use one data point for two criteria.

After using this rubric to evaluate a variety of projects, the authors have determined that the rubric as it stands is effective for gathering information about larger (approximately four week or longer) projects that require teams to submit periodic status reports. For smaller projects it might not be possible to assess appropriate choice of resources and time management. Information management can only be assessed if students are required to submit documentation, such as log books, to the instructor for evaluation. Conclusions and results may also be assessed using the 'Written Report Assessment Rubric' or the 'Oral Report Assessment Rubric.'

Teamwork

The assessment plan for the teamwork objective uses a rubric in two ways: as evaluated by the instructor, and as evaluated by student peers (See Fig. 2). Notice that since students are evaluating other students, it is a direct measure as opposed to an indirect self assessment.

The rubric used in this assessment can be found in Table 2. This rubric was developed specifically to assess teamwork within a technical student project. Faculty teaching the courses are required to complete the rubric for each team, but they are not required to use it for grading purposes. Notice that each of the criteria is observable by the faculty, as well as student peers. Students can receive summary results of their team's performance as feedback.

Written and oral communications

The assessment plan for the communication objective uses two rubrics: one for written work and one for oral presentations (See Fig. 3). These rubrics are used to evaluate student assignments on technical topics relevant to the course.

The rubrics used in this assessment can be found in Tables 3 and 4. These rubrics were developed in conjunction with Technical Communication

a. ECET 234 assignment to evaluate student work using turnitin.com to check for plagiarism.
   Goal: 90% of students show 10% or less plagiarism as measured by turnitin.com.
b. Survey all full time faculty and any part time faculty teaching ECET 155, 231 and upper division courses regarding student ethics and civility (Professionalism, Social ethics, Technical ethics, Plagiarism criteria).
   Goal: 90% of courses report 4/5 or better on each item.
c. Students will state the IEEE code of ethics on a quiz in ECET 499. Scores should be reported to the assessment committee each semester.
   Goal: 90% of students will score 70% or better.

Fig. 4. Ethics objective assessment plan.

a. Survey faculty regarding student ethics and civility (items 1, 2, & 5 on rubric).
   'Goal: 90% of courses report 3 or better on each item.
b. Students will complete a quiz over sexual harassment and diversity in ECET 499. The instructors should use the same/similar questions semester-to-semester. Scores should be reported to the assessment committee each semester.
   Goal: 90% of students will score 70% or better.
c. Students will complete a case study including global perspective in ECET 499.
   Goal: 90% of students will identify at least one globally significant aspect of the scenario.

Fig. 5. Diversity objective assessment plan.

faculty to assess communications specifically as they might occur in the workplace as opposed to formal presentations in an academic environment (i.e. speech class). The criteria may be very similar for both situations; for example, spelling and grammar. The organization of material may be quite different for communications in the workplace as opposed to a literature or communications course.

ETHICS AND DIVERSITY

The authors created a rubric to evaluate ethics and diversity. This rubric was validated by a faculty member in Organization, Leadership and Supervision. The rubric is presented in Table 5.

This rubric is meant to assess two related areas: civility and ethics. Some of the ethics elements are used in the ethics objective assessment plan (See Fig. 4).

Other elements of the rubric are used to evaluate the civility and diversity objectives (See Fig. 5).

Since all the elements deal with similar topics, and the evaluation for both objectives is done by the same constituency (faculty, one rubric for each class), it is convenient to include all the elements on one sheet. In both the ethics and diversity objectives assessment plans, the rubric is only one out of three direct measures.

CONCLUSIONS

Rubrics, such as those presented in this article, have been used successfully within the department assessment plan to collect data on non-technical skills. Specific rubrics were developed to assess design, teaming skills, oral and written communication, and ethics and civility. The rubrics meet criteria as specified for effective rubric design, including ease of use, clarity of criterion, and effective definition of levels of success in each criterion. Five point scales allow for quantitative data to be collected and analyzed. Results from the rubrics can be returned to students (individual or summarized) for effective feedback.

The use of these rubrics alone cannot be a complete assessment plan: effective assessment requires additional direct measures to allow for triangulation of data.

Data collection is a necessary step in an assessment plan, but actions taken based on data analysis are more important than collection of raw data. The data collected from these rubrics must be evaluated. Faculty should review the analysis and determine if changes in the curriculum should be made; once changes are implemented, they should be evaluated with a continual assessment plan. This is an effective model, using assessment results (including results of data collected by these rubrics) to feed changes into the curriculum and program, allowing for continual improvement.

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