AC 2007-186: ABET ASSESSMENT USING CALIBRATED PEER REVIEW

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Introduction

Most engineering programs have some type of capstone design experience. At Rose-Hulman Institute of Technology (Rose) the Electrical and Computer Engineering (ECE) Department also has a similar set of courses. Therefore, the ECE Department decided to use senior design to assess EC3(g) (ABET Engineering Criterion 3-g): “ability to communicate effectively”. However, we needed/wanted a tool to help us develop our assessment process for EC3(g).

The ECE Department was introduced to the Calibrated Peer Review™ (CPR) [1]. CPR is an online-tool with four structured workspaces that perform in tandem to create a series of activities that reflect modern pedagogical strategies for using writing in the learning process

- **Task**: Students are presented with a challenging writing task, with guiding questions to act as scaffolding for the demanding cognitive activities.
- **Calibration**: Students read through three “benchmark” samples and assign each a score based on a series of evaluative questions (a rubric). Students are then given a “Reviewer Competency Index – RCI” from 1 to 6, based on their demonstrated competency in these exercises. This segment mitigates the common objection to peer review in the undergraduate classroom: that the experience reduces itself to the-blind- leading-the-blind.
- **Peer Review**: After becoming a “trained-reader” – and being assigned a RCI – students read and provide written feedback on three anonymous peer essays using the same rubric as used in the calibrations. Students also assign each essay a holistic score from 1 to 10.
- **Self-Assessment**: As a final activity, students evaluate their own essay. As with calibration and peer review, students use the same “rubric” (set of performance standards for the task). Having “trained” on benchmark samples, and then applied their expertise in evaluating peer text, students now engage in a reflective, final activity by assessing their own submission. Students are encouraged at this time to make comments to themselves (and also available to the instructor) that capture the evolving insights they have gained in the previous two segments. They are also invited to reflect on whether they have gained a deeper level of understanding for the assignment and its outcomes.

How We Applied CPR

After some experimentation with CPR, it was very obvious that with proper design of exercises, CPR could be used to assess EC3(g). In fact, CPR could be used to make **writing a method of learning engineering design**. Therefore, the ECE Department has developed a complete course using CPR assignments to help our students develop proposals for their senior design projects. This course, ECE362 Principles of Design, is a junior level required course for all computer and electrical engineering students. ECE362 includes intellectual property, research methods, design specifications, conceptual design, scheduling, project management, business plan, market survey, and budgeting that culminates in a written proposal and oral presentation requesting funds for development of a product. The following CPR exercises’ are used in ECE362:

CPR 1: What Is Intellectual Property (IP): This CPR introduces IP in the form of patents, trademarks, industrial designs (trade secrets) and copyright to the students. Patent protection is the major focus of this CPR.

CPR 2: What Is An Annotated Bibliography: This CPR introduces students to research using the annotated bibliography. The reason the annotated bibliography is used, it adds descriptive and evaluative comments (i.e., an annotation), assessing the nature and value of the cited works.

CPR 3: Market Analysis: The students are introduced to two methods of market analysis coupled with project idea generation. These two methods are augment or bi-associate projects.

- **Augmented Projects** are existing products that are *added-to or supplemented*, to extend their functionality. These types of projects are the easiest to do since the base product is already developed. It is also easy to get market information on these types of products.
- **Bi-associated Projects** are projects that *combine two different* products and create a new product from the combination. These types of projects are more difficult to do since the combination of technologies or products may not be obvious. However, it is still easy to obtain market information for each product and then estimate a market if the two different products were combined into one product.

CPR 4, Product Design Specification: A Project Design Specification (PDS) is a document should reflect the common knowledge of the team about the project. The students make use of their preliminary research to develop environmental, performance, and technology specifications for their projects.

CPR 5, Social Impact Statement: This CPR requires the students to reflect on their proposed project and write a social impact document using the IEEE Code of Ethics as the rubric. For this assignment the students write one or two pages about the impact of their project on society.

CPR 6, Project Technical Description: The project technical description should provide a concise explanation, which is not overly technical, while frequently emphasizing the key benefits and incorporating appropriate visual elements. Therefore the three essential elements of the project technical description are:

1. Description: It is important to start the description with a very concise description in order to put the features and benefits in context.
2. Visual Element: A picture, a sketch, screen shot, or a diagram that shows either the components of the product or how the product fits in its environment is usually helpful for the reader.
3. Key Benefits: State the key benefits of the product early. The use of bullet points is ideal. Then conclude stating the key benefits again in a paragraph form.

The students produce their first draft of the project technical description using the information from the previous CPRs.

CPR 7: Project Technical Description, Again: The students next take the feedback from CPRs 6-1 and rewrite their project technical description with these specific elements:

1. Does the project technical description tell the reader what the product does in the opening paragraph or sentence?
2. Does the project technical description use concise and precise sentences along with concrete words to explain the product?
3. Does the project technical description use visual elements to help explain the product?
4. Does the project technical description present the key benefits of the product early in the description?
5. Does the project technical description present an analysis of any competitors?
6. Does the project technical description include an explanation of how the parts fit and function together?
7. Does the project technical description conclude with the key benefits of the product in paragraph form near the end of the description?
8. Does the project technical description convince you this project can be done?

The students are also using the NCIIA E-Team RFP as a format guide for the project technical description.

CPR 8: Product Design Specification, Again: A PDS is a document that will change substantially over the length of the project. There are many factors that will cause a PDS to change. But the one factor that will have the greatest impact is the development of a deeper understanding of the project. As the student teams move forward developing their project proposal, they will always need to think more intensely about their project. The PDS should reflect the common knowledge of the team about the project. Therefore, the PDS needs to be regularly refined during the proposal phase to reflect a deeper understanding of the team's project. Therefore the PDS is reviewed again using the following questions:

1. Is a function list given with a short description for each project-function?
2. Are performance specification given for each function?
3. Is the operating environment for the project given?
4. Are specifications provided relating to the operating environment provided?
5. Are target technologies identified to meet all of above?

At this point, the PDS for each student team is very well structured.

CPR 9: Social Impact Statement, Again: This CPR requires the students to reexamine their proposed project and rewrite their social impact statement using the IEEE Code of Ethics as the rubric. Especially focusing on item 1 of the IEEE Code of Ethics:

1. to accept responsibility in making decisions consistent with the safety, health and welfare of the public, and to disclose promptly factors that might endanger the public or the environment;

For this assignment the students write one or two pages about the impact of their project on society.

Other CPRs: Additional CPRs done are: resume construction, memo writing, writing an executive summary, and how to do power point presentation.

CPR Provides Data

This project was started with the pragmatic emphasis to address EC3(g) (ABET Engineering Criterion 3-g): "ability to communicate effectively." Each CPR assignment requires students to complete three calibration essays. Each student is assigned a score based on their performance on these calibration essays. This score is reported as the Reviewer Competency Index – RCI. The "RCI" (Reviewer Competency Index) indicates how well the student "trained" during the calibration. RCI scores range from 1 (poor performance on the calibration essays) to 6 (excellent performance on the calibration essays). (The algorithms embedded in CPR™ are beyond the scope of this paper. Suffice it to say that the calculations are very robust and that the instructor can set the level of tolerance for many of the indicators.)

A total of 54 students in the Spring Quarter 2006 participated in the PDS exercises 1 and 2. PDS-exercise-1 was a preliminary PDS and PDS-exercise-2 was the final PDS.

- The rating rubric for PDS exercise 2 was increased in difficulty from PDS exercise 1; see CPR 4, Product Design Specification and CPR 8: Product Design Specification, Again.
- The text rating is based on calibration essays. The calibration essays all come from past projects that were successful and well written.
- The overall grade rubric was not changed from PDS exercises 1 to PDS exercises 2.

PDS	PDS 1 Overall Grade	PDS 1 Text Rating	PDS 1 Reviewer Competency Index	PDS 2 Overall Grade	PDS 2 Text Rating	PDS 2 Reviewer Competency Index
Class Averages	91.91/100	7.78/10	5.02/6	93.02/100	8.13/10	4.93/6
Total Students in Sample	54	54	54	54	54	54

This table shows the overall grade and RCI remained constant from PDS exercise 1 to PDS exercise 2. Also, this table shows a modest 4% increase in the text rating from PDS exercise 1 to PDS exercise 2. These results are significant, due to the increase in difficulty of the assignment from PDS exercise 1 to PDS exercise 2. This same trend is seen in the Product Technical Description exercises 1 and 2.

Satisfying ABET (g): Driskill [2], in examining how ABET (g) is addressed in available ABET accreditation plans, noted little evidence in the literature that assessment plans incorporate modern rhetoric pedagogy, contemporary discourse analysis, or the fundamentals of communication theory in their expectations for writing in an engineering education. Thus, the development of a rich definition of "communication" and measuring "effectiveness" by a set of carefully thought out exercises would be needed to assess EC3(g) (ABET Engineering Criterion 3-g): "ability to communicate effectively".

From our preliminary research on the PDS and PTD exercises we feel that these exercises do demonstrate our compliance with EC3(g). Also, we believe the RCI data indicates the richness of implementation associated with the "writing as thinking" approach to teaching [4]. In other words the student learned. The following description, performance criterion and analysis are included from our ABET report.

ABET g: an ability to communicate effectively.

- Description: graduates will demonstrate an ability to communicate effectively with written reports.
- Performance Criterion: 70% of student written reports have a low percentage of mistakes and normally contain an executive summary, social impact statement, project technical description, and project design specification.
- Analysis: This performance criterion is being satisfied.

ECE362	AY 03-04	ECE	AY 04-05	ECE	AY 05-06	ECE
ABET g	Yes	N	Yes	N	Yes	N
Annotation	NA	NA	87%	70	87%	78
Project Design Specification Initial	79%	56	81%	48	92%	78
Project Design Specification Final	73%	56	84%	70	72%	78
Project Technical Description Initial	NA	NA	77%	70	91%	78
Project Technical Description Final	80%	56	74%	70	84%	78

Can We Write to Learn: Our second premise, essentially that writing within the educational process should be treated as crystallized thought – falls naturally out of the call for a more sophisticated definition of EC3(g). Based on the ideas of noted learning theorists, the "writing as a way of learning" approach to pedagogy holds that placing ideas into language mediates higher-order intellectual activities that are essential to mature thinking [3]. Indeed, practitioners who have pursued the notion that writing is a heuristic for cognition report their students to be more actively engaged in learning and also find improvements in critical meta-cognitive abilities (or thinking about one's own thinking).

Therefore, we believe that with proper exercise design addition ABET criterion can be satisfied. The following description, performance criterion and analysis are included from our ABET report.

ABET j: a knowledge of contemporary issues.

- Description: demonstrate an awareness of how the problem is affected by social concerns and trends
- Performance Criterion: 70% of student projects in ECE362 define the technical problem and demonstrate the link between it and social concerns/trends.
- Analysis: This performance criterion is being practically satisfied. However, all students do a Social Impact Statement using the IEEE Code of Ethics for their proposals. We will add an additional assignment earlier in the term to amplify the importance of this topic.

ECE362	AY 03-04	ECE	AY 04-05	ECE	AY 05-06	ECE
ABET j	Yes	N	Yes	N	Yes	N
Social Impact Statement using IEEE Code of Ethics	63%	56	71%	70	80%	78

ABET i: a recognition of the need for, and an ability to engage in life-long learning.

- Description: perform a literature search/gather information via library/internet
- Performance Criterion: 70% of student work has 3 independent references provided with analysis of each to support design recommendations.
- Analysis: This performance criterion is being satisfied.

ECE362	AY 03-04	ECE	AY 04-05	ECE	AY 05-06	ECE
ABET i	Yes	N	Yes	N	Yes	N
Annotated Bibliography of sources and references	NA	NA	87%	70	84%	78

- Description: ability to obtain and use technical data on components and subsystems
- Performance Criterion: 70% of students reported they used at least 1 source of information.
- Analysis: This performance criterion is being satisfied at present. However, all CPE students do perform patent research but many failed to use the patent research in their proposals. We will add an additional assignment to assess the value of the patents found relative to the proposal topic.

ECE362	AY 03-04	ECE	AY 04-05	ECE	AY 05-06	ECE
ABET i	Yes	N	Yes	N	Yes	N
Intellectual Property, patent research	77%	56	81%	70	71%	78

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Conclusion

From our preliminary work, CPR is proving a very effective tool for presenting an engineering design process, teaching multi-staged writing, encouraging students to develop higher-order reasoning processes, and capturing student outcome data. Additional research and data analysis is underway which better frame the effectiveness of CPR as a tool for ABET.

References

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