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Revising a Portfolio Initiative to Assess Student Progress in a Mechanical Engineering Program

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By Nancy B. Barr, PhD

Abstract

Background: This *work-in-progress* paper describes an effort to modify a pre-existing course portfolio initiative in a large mechanical engineering undergraduate program to be used for multiple forms of program assessment while maintaining its value as a student learning tool. **Purpose:** This paper aims to outline the process that an ad-hoc department committee used to define what it wanted to assess in a required four-course second and third-year problem-based learning sequence by reviewing various rubric options. **Design:** Deciding what to assess and what language to use in a rubric involved a series of facilitated discussions. **Results:** Following a mock assessment exercise, the resulting rubric and assessment worksheet will be tested in a full-scale assessment in spring 2021. **Conclusions:** The discussions led course coordinators to better articulate learning objectives for the course sequence and a continuous improvement plan.

Keywords: ABET, assessment, portfolios

1.0 Introduction

Engineering programs have been using portfolios for a range of purposes since the late 1980s when some state governments, e.g., Colorado, and the federal government expressed concern about higher education quality and advocated improved assessment practices. A decade later, ABET shifted from inputs-based assessment requirements to outcomes-based, resulting in more engineering degree programs adopting portfolios as an assessment tool. In the last twenty years, portfolios have also been used for purposes other than assessment, such as professional skill development and purposeful reflection. Some programs eventually dropped portfolios for assessment because they found the process too resource-intensive in terms of time and possible expense for specialized portfolio software platforms. However, the recently revised ABET student learning outcomes present another opportunity to experiment with assessment techniques. This *work-in-progress* paper describes an effort to modify a pre-existing course portfolio initiative in a large (1400+ enrollment in fall 2019) mechanical engineering undergraduate program. This program at Michigan Technological University will use the portfolios for program assessment while maintaining its value as a student learning tool.

The purpose of this paper is to outline the process that an ad-hoc department committee used to define what it wanted to assess in a four-course second and third-year sequence by reviewing a variety of rubric options. Once a rubric was drafted, the committee then tested that rubric to finalize wording. This team of five faculty members led the Mechanical Engineering Practice course development and are actively engaged with undergraduate curriculum development and pedagogical research. The process of further refining the learning outcomes for each course and then narrowing down those outcomes to a set of programmatic outcomes resulted in insightful discussions about what our students truly needed to know to succeed in their final year of undergraduate work. Those discussions resulted in a rubric designed to take the guesswork out of assessment. Engineering educators may find the description of this process helpful as a model

when developing more effective assessment tools and facilitating productive, action-oriented discussions amongst faculty.

2.0 Defining Portfolios and Their Uses

Paulson et al. define portfolios as a "purposeful collection of a student's efforts, progress, and achievements. The collection must include student participation in selecting contents, the criteria for selection, the criteria for judging merit, and evidence of student reflection" (1991, p. 60). However, other researchers argue that student-selected content is not a requirement for program assessment portfolios (Forrest, 1990). While portfolios have long been used in architecture, art, and finance programs for showcasing student work, they first achieved broad recognition as useful assessment tools in writing studies programs in the mid-1980s (Reynolds & Davis, 2014, p. 3). In addition to assessment, portfolios have three other uses in education:

1) As learning tools to encourage students to track their progress through unrevised artifacts;
2) To showcase "best work," with the artifacts revised, edited, and polished; and
3) To collect crucial components of one's professional efforts, e.g., teaching portfolios that include teaching materials, assignments, in-class activities, and self-reflection.

A variety of engineering programs have used portfolios as vehicles for student self-reflection and assessment. Table 1, although not meant to be all-inclusive, presents a sense of the range of institutions using portfolios at some point and their uses.

Forrest argued that one of the main advantages of using portfolios for assessment is that it "is more likely to lead to discussions about curriculum and instructional improvements" (1990). One disadvantage of portfolios is the time commitment required to develop an assessment rubric, collect materials, and conduct the assessment. New Jersey Institute of Technology abandoned its portfolio assessment effort after just one semester because of these issues (McGourty et al., 1998). However, starting with an existing framework and distributing the workload (student-collected work versus faculty-collected and limiting the scope of the portfolio) can alleviate some this time commitment. Williams argues that, regardless of the type of portfolio, "the work that is gathered will serve its best purpose if it is associated or mapped to one or more learning outcomes or--even better--to specific performance criteria" (2010). Finally, once those learning outcomes are determined, a portfolio designed to assess those outcomes should include work products demonstrating progress towards those outcomes (Nilson, 2013, 58).

This paper's remainder describes the portfolio program's evolution in light of the above research and the path towards using portfolios for assessment. This project is a work in progress, with various aspects having been adjusted based on faculty and student feedback and the department's changing needs.

Table 1 Universities Using Portfolios

University	Purpose of portfolio
Colorado School of Mines (Olds & Miller, 1997, and Olds, 2008	University-wide program in which a committee collected student work for inclusion in a portfolio for institutional and programmatic assessment.
Massachusetts Institute of Technology (Brodeur, 2002)	Assess student achievement in 16 program objectives in the Department of Aeronautics and Astronautics.
Messiah College (Underwood, 2013)	Portfolio program to evaluate student performance in integrating liberal arts concepts into their multi-year engineering projects.
Rose-Hulman Institute of Technology (Williams, 2002 and 2010)	Collection of faculty-determined student products that demonstrate performance on program and institutional learning objectives related to communication.
Stanford University (Eris, 2006)	Proposed portfolio program to evaluate students' divergent inquiry and conceptual thinking abilities
The Ohio State University (Christy & Lima, 1998)	ABET assessment of student-centered learning practices where students selected work they felt best represented select competencies in the Department of Food, Agricultural, and Biological Engineering.
University of Washington (Sattler & Turns, 2015)	Collection of student-selected work design to encourage self-reflection and self-authorship.
Virginia Polytechnic Institute and State University (McNair & Garrison, 2012)	ePortfolio program designed to help graduate students in engineering develop professional identities as future faculty and engineers.

3.0 Portfolio Structure

3.1 Portfolio Program 1.0

The portfolio program began when the department implemented a new BSME curriculum in fall 2014. The new curriculum's centerpiece is a sequence of four required courses called Mechanical Engineering Practice (MEP) I-IV, with problem-based learning as their foundation (2016 reference to be inserted here). This sequence creates a link between two introductory engineering courses in the first year and Senior Capstone Design in the final year. The classes incorporate active learning techniques such as teamwork and hands-on activities and are designed to

reinforce concepts in theory-based courses such as statics, mechanics of materials, dynamics, and thermodynamics. As these courses were unique, the department also wanted a unique way to assess the program and gauge their impact on how students viewed their progression through the curriculum. The result was a portfolio in which students would compile four assignments they felt best represented their learning progress. Students also wrote an essay in which they answered a series of questions and reflected on what they had learned in the class (2017 paper). These questions helped the students frame their experience in the course. Below is a list of the essay questions from the first iteration of MEP I in fall 2015:

- What assignments did you choose to include in your portfolio, and why? Explain why you selected these four assignments to include in your portfolio. Consider what you learned from these assignments and how you incorporated your instructor/GTA's feedback to improve the work.
- Which lesson or assignment in this course has been the hardest for you so far? What courses outside ME Practice helped you understand the concepts in this class?
- Finally, what aspects of the class helped you learn the material, and what aspects were not helpful? What could the instructors/GTAs do differently to help you learn the material and complete the assignments?

The portfolio served two purposes. First, it was designed as a vehicle for students to reflect on their progress through the program and present their best work to potential employers. The portfolios were graded based on whether the students included all components and followed the directions, not on the essays' quality. The artifacts included in the portfolios had already been graded. Second, the portfolios provided a rich source of information about students' perceptions of the courses. After the end of the semester, the portfolio coordinator (the author) reviewed the essays to determine the most common assignments included, areas where students indicated they had struggled in the course, and teaching techniques that helped them learn or were a hindrance. These results were then compiled into a report for the MEP course coordinators, the associate chair for undergraduate studies, and the department chair. These reports were valuable in assessing the effectiveness of the structure of each course initially and led to improvements in organization and, in some cases, instruction. For example, one GTA was repeatedly recognized by his students for the way he would begin the practice session by explaining the lesson objectives, quirks of the equipment, and common mistakes to avoid. This technique was incorporated into training for all of the MEP GTAs as a "best practice." These reports were included in the department's ABET review package in 2018 to demonstrate a culture of continuous improvement.

3.2 Portfolio Program 2.0

Initially, each student prepared a separate portfolio for each class, with no carryover, and submitted it as a PDF to Canvas, the university's learning management system.
However, the plan was to make the portfolios cumulative once the courses were established, and the department had gone through one ABET review under the new curriculum. In reviewing the recently revised ABET criteria, the department's curriculum committee questioned whether the tools used to assess the old a-k criteria would be effective when applied to the new 1-7 outcomes. Specifically, the committee was concerned about criterion one's focus on problem-solving, which

was not captured well in the multiple-choice concepts exams, co-operative employer surveys, exit surveys, or Fundamental of Engineering exam results previously used. Thus, the committee suggested using the MEP portfolio program for assessment, which required a cumulative portfolio rather than the former standalone setup. This change was implemented in fall 2018 with MEP I.

In determining the structure of the new portfolio format, the department had two goals. One was to maintain the reflective aspect and continue to enable students to present their best work. The second was to have a format that could be quantitatively assessed. To achieve this last goal, the department formed an ad hoc committee consisting of the four MEP course coordinators led by the portfolio program director. The committee recognized that consistency was needed to effectively assess students' skill development at the end of the MEP sequence. Thus, each course coordinator selected one assignment that best represented the purpose of their course. See Table 2 for the required assignments. These assignments would be the focus of the quantitative assessment portion. The students would also choose two additional assignments they felt best represented their work, although these would not be assessed. They also continued to prepare a reflective essay as part of the portfolio, which the portfolio program director would continue to review.

In spring 2019, students in ME Practice II developed a similar portfolio but tacked on their MEP I portfolio, and so on. Thus, at the end of MEP IV in spring 2020, students had a cumulative portfolio that included a reflective essay, three assignments from that course, and the three similarly structured portfolios from their previous MEP courses. Once the portfolios' new format was implemented, the next step was to develop a rubric to assess the portfolios.

Table 2 Assignments required in the portfolio

Course	Assignment Title	Assignment Content
ME Practice I	Bridge Truss Distributed Load	Describe procedures of developing a Finite Element Analysis model of a bridge truss, and results from changing loads on an actual 3D printed model, provide hand calculations of loads deflections, and stresses as well as Matlab results (applies statics and introductory material science concepts in a technical memo and report).
ME Practice II	Measurement of Flow Rate	Determine what flow rate is most effective for a fan in a NICU incubator and report the results (applies introductory thermodynamic concepts in a technical memo and report).
ME Practice III	Design Project Concepts Summary	Describe a primary method of controlling motion of a trolley-type car, a secondary method of controlling motion of the car, and a method for guiding car along a path (applies multibody dynamics concepts in a technical memo and report).
ME Practice IV	Thrust Stand Dynamics Lab Results	Measure and report the natural frequencies of a thrust stand. Record acceleration and strain on the thrust stand during a speed sweep of the motor/propeller with output in the form of colormaps. Identify the dominant orders of excitation and system resonances. Explain results (applies vibrations and controls concepts in an archival slide deck).

4.0 Developing the Assessment Rubric

When the subject of a cumulative portfolio assessment program was first broached to the four ME Practice course coordinators, their two main concerns were who would be doing the assessment and whether it was possible to use the portfolios to assess students learning. Thus, the first step was to inform the group of the literature and then provide some possible models for assessment rubrics. The committee explored three different rubric options:

1) Using the learning objectives from each ME Practice course as a starting point for a rubric,

2) Using the ABET student learning outcomes as the foundation, or
3) Using the relevant AAC&U VALUE rubrics as the foundation because the university had already adapted eight of the rubrics for its own learning goal assessment program.

The first option was rejected because of the high number of learning objectives once all four courses were considered together. A brief attempt at possibly combining similar learning objectives revealed too many differences between the courses. At the same time, the group wanted to assess the entire course sequence using broader criteria. The second option was rejected as too nebulous as the university is still interpreting the new learning outcomes, and the process of developing a rubric would have been too time-consuming. Thus, option three was adopted.

The portfolio program director compiled four VALUE rubrics for consideration:

1) Two criteria from Teamwork - Contributes to Team Meetings and Fosters Constructive Team Climate
2) Four criteria from Written Communication - Content and Purpose for Writing, Content Development, Genre and Disciplinary Conventions, and Control of Syntax and Mechanics
3) All six criteria from Problem-Solving
4) All six criteria from Quantitative Literacy

The group decided to eliminate the Teamwork criteria because there was no way to evaluate them via the portfolios. Alternative methods such as adding to the portfolios the peer evaluations conducted multiple times in each class were rejected as too cumbersome. The Content Development criterion from Written Communication was also jettisoned as the group felt the criteria in Problem-Solving and Quantitative Literacy more effectively captured the spirit of the writing assignments. Finally, the phrase Open-Ended was added to the Problem-Solving (hereafter referred to as OEPS) rubric, and Quantitative Literacy was changed to Modern Engineering Tools (hereafter referred to MET).

The next step was to refine further the language in the resulting combined rubric (Appendix A). The ensuing discussion was robust in that much of the discussion revolved around what exactly the committee wanted to be assessed and whether to combine the OEPS and MET categories under one label because students use modern engineering tools such as simulation software in the process of solving problems in the courses. One member was also concerned that the criteria in MET needed to be reordered while another wondered if students in the MEP courses used all six steps in the OEPS section. The group decided the best way to proceed was to test this iteration of the rubric on a sample portfolio. Thus the program director generated a sample cumulative portfolio by pulling the required assignment from four different students across the four courses as well as the instructions for each assignment. The course coordinator for MEP III then generated a worksheet (Appendix B) that the group could use in their assessment. The four course coordinators then individually completed a mock evaluation of the sample portfolio using the rubric and worksheet. The results were then discussed as a committee.

5.0 Mock Assessment Results

The mock assessment revealed that both the rubric and worksheet could be effective tools for evaluating the MEP program's learning outcomes, and both tools were adopted with minor edits. The committee decided that the best way to approach the assessment was to use one worksheet per assignment instead of one worksheet for the entire portfolio. This would enable the assessor to see trends across a student's portfolio, e.g., improvement in analytical skills from MEP I to MEP IV. The discussion also showed consensus on where the artifacts should score on the rubric depending on the course, i.e., the MEP I artifacts would be expected to score a 1 or 2 in most categories while the more advanced coursework should demonstrate a higher level of competency. One important caveat is that the assignments assessed in MEP I, II, and III are completed as a team, while the MEP IV assignment is completed individually. Although not ideal, if the goal is to evaluate an individual student's performance, the committee noted the heavy emphasis on teamwork in MEP I-III is an integral part of the learning experience. Also, since students work with different people in teams in each course, their progress (or lack thereof) should still be evident in their portfolio as it is unlikely a student would be able to mask incompetency in all three courses. This assumption will be tested when the full-scale assessment is implemented. Finally, the committee decided that the assessment should be completed by a permanent ad hoc committee with membership relatively static from year to year to add stability to the assessment process.

Next Steps

An ad-hoc committee will be formed with four members, one from each research area in the department (Design and Dynamic Systems, Energy and Thermo Fluids, Manufacturing, and Solid Mechanics) and led by the portfolio program director. The assessment was originally planned for fall 2020. However, the pandemic placed an extra load on faculty as they redesigned their fall classes to accommodate the hybrid format (mix of in-person and remote learning). The committee will be convened in the spring 2021 semester and conduct the first full-scale assessment of the fall 2020 cumulative portfolios. The intent is to continue the assessment annually to establish trends and continuously improve the MEP course sequence. Future iterations of the portfolio program could include artifacts from the first-year Engineering Fundamentals I and II courses and Senior Capstone Design for an even more holistic portrait of student learning.

Conclusions

The department's portfolio program evolution demonstrates the value of reflective portfolios as tools for programmatic assessment and continuous improvement. This program evolved over six years, allowing for revision of instructions to students and refinement of essay questions. It also allowed time for the course coordinators to understand better the efficacy of the courses in meeting their original goals for effective problem-based learning. Furthermore, developing a rubric to assess cumulative portfolios pushed the course coordinators to more clearly articulate their learning objectives for the Mechanical Engineering Practice course sequence. In short, the process may prove as valuable as the actual assessment as a tool for continuous improvement.

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Appendix A

MEP Portfolio Rubric Based on AACU VALUE Language					
Outcome	**Exemplary**	**Proficient**	**Developing**	**Beginning**	**Not Applicable**
Written Communication					
Context of and Purpose for Writing Includes considerations of audience, purpose, and the circumstances surrounding the writing task(s).	Demonstrates a thorough understanding of context, audience, and purpose that is responsive to the assigned task(s) and focuses all elements of the work.	Demonstrates adequate consideration of context, audience, and purpose and a clear focus on the assigned task(s) (e.g., the task aligns with audience, purpose, and context).	Demonstrates awareness of context, audience, purpose, and to the assigned tasks(s) (e.g., begins to show awareness of audience's perceptions and assumptions).	Demonstrates minimal attention to context, audience, purpose, and to the assigned tasks(s) (e.g., expectation of instructor or self as audience).	Category is not assessable for this student's portfolio
Genre and Disciplinary Conventions Formal and informal rules inherent in the expectations for writing in particular forms and/or academic fields (please see glossary).	Demonstrates detailed attention to and successful execution of a wide range of conventions particular to a specific discipline and/or writing task (s) including organization, content, presentation, formatting, and stylistic choices	Demonstrates consistent use of important conventions particular to a specific discipline and/or writing task(s), including organization, content, presentation, and stylistic choices	Follows expectations appropriate to a specific discipline and/or writing task(s) for basic organization, content, and presentation	Attempts to use a consistent system for basic organization and presentation.	Category is not assessable for this student's portfolio
Control of Syntax and Mechanics	Uses graceful language that skillfully communicates meaning to readers with clarity and fluency and is virtually error-free.	Uses straightforward language that generally conveys meaning to readers. The language in the portfolio has few errors.	Uses language that generally conveys meaning to readers with clarity, although writing may include some errors.	Uses language that sometimes impedes meaning because of errors in usage.	Category is not assessable for this student's portfolio

Open-ended Problem Solving					
Define Problem	Demonstrates the ability to construct a clear and insightful problem statement with evidence of all relevant contextual factors.	Demonstrates the ability to construct a problem statement with evidence of most relevant contextual factors, and problem statement is adequately detailed.	Begins to demonstrate the ability to construct a problem statement with evidence of most relevant contextual factors, but problem statement is superficial.	Demonstrates a limited ability in identifying a problem statement or related contextual factors.	Category is not assessable for this student's portfolio
Identify Strategies	Identifies multiple approaches for solving the problem that apply within a specific context.	Identifies multiple approaches for solving the problem, only some of which apply within a specific context.	Identifies only a single approach for solving the problem that does apply within a specific context.	Identifies one or more approaches for solving the problem that do not apply within a specific context.	Category is not assessable for this student's portfolio
Propose Solutions/Hypotheses	Proposes one or more solutions/hypotheses that indicates a deep comprehension of the problem. Solution/hypotheses are sensitive to contextual factors as well as all of the following: ethical, logical, and cultural dimensions of the problem.	Proposes one or more solutions/hypotheses that indicates comprehension of the problem. Solutions/hypotheses are sensitive to contextual factors as well as the one of the following: ethical, logical, or cultural dimensions of the problem.	Proposes one solution/hypothesis that is "off the shelf" rather than individually designed to address the specific contextual factors of the problem.	Proposes a solution/hypothesis that is difficult to evaluate because it is vague or only indirectly addresses the problem statement.	Category is not assessable for this student's portfolio

Evaluate Potential Solutions	Evaluation of solutions is deep and elegant (for example, contains thorough and insightful explanation) and includes, deeply and thoroughly, all of the following: considers history of problem, reviews logic/reasoning, examines feasibility of solution, and weighs impacts of solution.	Evaluation of solutions is adequate (for example, contains thorough explanation) and includes the following: considers history of problem, reviews logic/reasoning, examines feasibility of solution, and weighs impacts of solution.	Evaluation of solutions is brief (for example, explanation lacks depth) and includes the following: considers history of problem, reviews logic/reasoning, examines feasibility of solution, and weighs impacts of solution.	Evaluation of solutions is superficial (for example, contains cursory, surface level explanation) and includes the following: considers history of problem, reviews logic/reasoning, examines feasibility of solution, and weighs impacts of solution.	Category is not assessable for this student's portfolio
Implement Solution	Implements the solution in a manner that addresses thoroughly and deeply multiple contextual factors of the problem.	Implements the solution in a manner that addresses multiple contextual factors of the problem in a surface manner.	Implements the solution in a manner that addresses the problem statement but ignores relevant contextual factors.	Implements the solution in a manner that does not directly address the problem statement.	Category is not assessable for this student's portfolio
Evaluate Outcomes	Reviews results relative to the problem defined with thorough, specific considerations of need for further work.	Reviews results relative to the problem defined with some consideration of need for further work.	Reviews results in terms of the problem defined with little, if any, consideration of need for further work.	Reviews results superficially in terms of the problem defined with no consideration of need for further work	Category is not assessable for this student's portfolio

Modern Engineering Tools (Quantitative Literacy)					
Interpretation Ability to explain information presented in mathematical forms (e.g., equations, graphs, diagrams, tables, words)	Provides accurate explanations of information presented in mathematical forms. Makes appropriate inferences based on that information. For example, accurately explains the trend data shown in a graph and make reasonable predictions regarding what the data suggest about future events.	Provides accurate explanations of information presented in mathematical forms.For instance, accurately explains the trend data shown in a graph.	Provides somewhat accurate explanations of information presented in mathematical forms, but occasionally makes minor errors related to computations or units.	Attempts to explain information presented in mathematical forms, but draws incorrect conclusions about what the information means.For example, attempts to explain the trend data shown in a graph, but will frequently misinterpret the nature of that trend.	Category is not assessable for this student's portfolio
Representation Ability to convert relevant information into various mathematical forms (e.g., equations, graphs, diagrams, tables, words)	Skillfully converts relevant information into an insightful mathematical portrayal in a way that contributes to a further or deeper understanding.	Competently converts relevant information into an appropriate and desired mathematical portrayal.	Completes conversion of information but resulting mathematical portrayal is only partially appropriate or accurate.	Completes conversion of information but resulting mathematical portrayal is inappropriate or inaccurate.	Category is not assessable for this student's portfolio
Calculation	Calculations attempted are essentially all successful and sufficiently comprehensive to solve the problem. Calculations are also presented elegantly (clearly, concisely, etc.)	Calculations attempted are essentially all successful and sufficiently comprehensive to solve the problem.	Calculations attempted are either unsuccessful or represent only a portion of the calculations required to comprehensively solve the problem.	Calculations are attempted but are both unsuccessful and are not comprehensive.	Category is not assessable for this student's portfolio

Application / Analysis Ability to make judgments and draw appropriate conclusions based on the quantitative analysis of data, while recognizing the limits of this analysis	Uses the quantitative analysis of data as the basis for deep and thoughtful judgments, drawing insightful, carefully qualified conclusions from this work.	Uses the quantitative analysis of data as the basis for competent judgments, drawing reasonable and appropriately qualified conclusions from this work.	Uses the quantitative analysis of data as the basis for workmanlike (without inspiration or nuance, ordinary) judgments, drawing plausible conclusions from this work.	Uses the quantitative analysis of data as the basis for tentative, basic judgments, although is hesitant or uncertain about drawing conclusions from this work.	Category is not assessable for this student's portfolio
Assumptions Ability to make and evaluate important assumptions in estimation, modeling, and data analysis	Explicitly describes assumptions and provides compelling rationale for why each assumption is appropriate. Shows awareness that confidence in final conclusions is limited by the accuracy of the assumptions.	Explicitly describes assumptions and provides compelling rationale for why assumptions are appropriate.	Explicitly describes assumptions.	Attempts to describe assumptions.	Category is not assessable for this student's portfolio
Communication Expressing quantitative evidence in support of the argument or purpose of the work (in terms of what evidence is used and how it is formatted, presented, and contextualized)	Uses quantitative information in connection with the argument or purpose of the work, presents it in an effective format, and explicates it with consistently high quality.	Uses quantitative information in connection with the argument or purpose of the work, though data may be presented in a less than completely effective format or some parts of the explication may be uneven.	Uses quantitative information, but does not effectively connect it to the argument or purpose of the work.	Presents an argument for which quantitative evidence is pertinent, but does not provide adequate explicit numerical support.(May use quasi-quantitative words such as "many," "few," "increasing," "small," and the like in place of actual quantities.)	Category is not assessable for this student's portfolio

Appendix B

MEP Portfolio Rubric Based on AACU VALUE Language			Assignment #				
	4	**3**	**2**	**1**	**0**	**NA**	
Outcome	Exemplary	Proficient	Developing	Beginning	Not Demonstrated	Not Applicable	Notes
Written Communication							
Context of and Purpose for Writing							
Genre and Disciplinary Conventions							
Control of Syntax and Mechanics							
Open-ended Problem Solving							
Define Problem							
Identify Strategies							
Propose Solutions/Hypotheses							
Evaluate Potential Solutions							
Implement Solution							
Evaluate Outcomes							
Modern Engineering Tools (Quantitative Literacy)							
Interpretation							
Representation							
Calculation							
Application / Analysis							
Assumptions							
Communication							