CRITERION 3. PROGRAM OUTCOMES

ABET definition: *Program outcomes are narrower statements that describe what students are expected to know and be able to do by the time of graduation. These relate to the skills, knowledge, and behaviors that students acquire in their matriculation through the program.*

ABET definition: *Assessment under this criterion is one or more processes that identify, collect, and prepare data to evaluate the achievement of program outcomes.*

ABET definition: *Evaluation under this criterion is one or more processes for interpreting the data and evidence accumulated through assessment practices. Evaluation determines the extent to which program outcomes are being achieved, and results in decisions and actions to improve the program.*

Process for Establishing and Revising Program Outcomes

The PSE faculty articulated the first set of formal expectations for student achievement in 1996. Using the UWSP Assessment Committee's terminology, these expectations were called "Behavioral Objectives", and included the following:

1. Fundamental knowledge of pulp and paper raw materials and processes
2. Excellent communication skills
3. A high level of computer literacy
4. The ability to work effectively as part of a team
5. A professional comportment
6. The ability to continue learning

These six statements were the basis for our initial assessment efforts that began in 1997. PSE faculty discussions that led to the PEOs (see previous section) included consideration of these six Behavioral Objectives and whether they were suitable for the ABET assessment requirements. PSE faculty decided that the ABET Criterion 3 outcomes a-k were more appropriate for use in our program as they were stated in ABET documents. The ABET outcomes included all of the objectives we were already assessing and provided an improved framework for assessment. The program is committed to the education of engineers for the pulp and paper industry, so the faculty added a twelfth outcome of industry-specific knowledge. These Program Outcomes have been in place since being officially adopted by the PSE faculty in 2007. The six Behavioral Objectives that were the original basis for assessment of student achievement may be mapped onto the current Program Outcomes as shown in Table 3-1 below.

Program Outcomes

The Program Outcomes are published on the department web site, and incorporated into the syllabi for courses in the program where appropriate. The outcomes map directly onto the ABET Criterion 3 outcomes, with the additional requirement of industry-specific knowledge for graduates of this program:

> Graduates of the PSE program at the University of Wisconsin - Stevens Point have the greatest potential for success in their professional lives if they possess the following attributes:
>
> (a) the ability to apply knowledge of mathematics, science, and engineering
> (b) the ability to design and conduct experiments, as well as to analyze and interpret

data

(c) the ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability
(d) the ability to function on multi-disciplinary teams
(e) the ability to identify, formulate, and solve engineering problems
(f) the understanding of professional and ethical responsibility
(g) the ability to communicate effectively
(h) the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context
(i) a recognition of the need for, and the ability to engage in life-long learning
(j) a knowledge of contemporary issues
(k) the ability to use the techniques, skills, and modern engineering tools necessary for engineering practice
(l) knowledge of the science and technology used in the paper industry

Table 3-1. Relationship of Behavioral Objectives to Program Outcomes

Behavioral Objective	Program Outcomes
Fundamental knowledge of pulp and paper raw materials and processes	(a) the ability to apply knowledge of mathematics, science, and engineering (b) the ability to design and conduct experiments, as well as to analyze and interpret data (e) the ability to identify, formulate, and solve engineering problems (l) knowledge of the science and technology used in the paper industry
Excellent communication skills	(g) the ability to communicate effectively
A high level of computer literacy	(k) the ability to use the techniques, skills, and modern engineering tools necessary for engineering practice
The ability to work effectively as part of a team	(d) the ability to function on multi-disciplinary teams
A professional comportment	(c) the ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability (d) the ability to function on multi-disciplinary teams (f) the understanding of professional and ethical responsibility (h) the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context (j) a knowledge of contemporary issues
The ability to continue learning	(i) a recognition of the need for, and the ability to engage in life-long learning

Relationship of Program Outcomes to Program Educational Objectives

Table 3-2 illustrates the supporting relationships among the PSE Program Outcomes and the PEOs. Each of the PEOs has at least one supporting Program Outcome. Many of the outcomes are intended to support more than one PEO, allowing the assessment of the Program Outcomes to connect directly to the achievement of the PEOs. For example, ensuring that our graduates have the ability to design and conduct experiments and analyze and interpret data (outcome b) is certainly a contributor to their background in science and engineering principles (PEO#1) and their professional problem solving ability (PEO#3).

Table 3-2. Mapping of PSE Program Outcomes to the PSE PEOs

Program Outcomes / Program Educational Objectives	a. Apply math & science	b. Design & conduct experiments	c. Design a system	d. Work on a team	e. Solve engr problems	f. Prof & ethical responsibility	g. Communicate effectively	h.Broad education	i. Life-long learning	j. Contemporary issues	k. Use modern engr tools	l. Knowledge of pulp and paper
1. Have a sound background in fundamental science and engineering principles as applied to paper science and engineering	X	X	X		X					X	X	X
2. Understand related societal issues such as environmental protection, occupational health and safety, resource management, and appropriate business skills.						X		X	X	X		X
3. Are well-rounded professionals in terms of teamwork, communication, and problem solving.	X	X	X	X	X		X				X	
4. Have developed life-long learning skills.	X								X			

Relationship of Courses in the Curriculum to the Program Outcomes

Table 3-3 maps the Program Outcomes to the courses in the PSE curriculum. The courses are listed in the table in the approximate order that PSE students take them.

Table 3-3. Program Outcome Curriculum Map

Outcomes / Courses	Term	a	b	c	d	e	f	g	h	i	j	k	l
CHEM 115	1-F	F	X										
MATH 120	1-F	F											
ENGL 101	1-F							F	F				
PAPR 103	1-F								F				F
PAPR 105	1-F			X	X	X	X				X	X	
CHEM 116	1-S	F	X										
MATH 121	1-S	F											
COMM 101	1-S							F					
ENGL 102	1-S							F	F				
PAPR 210	1-S	F	F		X			A				F	F
CHEM 325	2-F	F	F										
MATH 222	2-F	F											
PHYS 150	2-F	F	F										
PAPR 215	2-F	A		F	F	F	X				X	F	F
CHEM 326	2-S	F	F										
CHEM 248	2-S	F	F										
PHYS 250	2-S	F	F										
ECON 210	2-S								F		X		
PAPR 300	SUM	F	F		F	F	F						F
PAPR 320	3-F	A		F	F	A						A	F
PAPR 350	3-F	F				F		A		F	A		A
PAPR 385	3-F	A			F	F					F	A	A
CHEM 335	3-F	F											
MATH 320	3-F	F											
PAPR 314	3-S	A	A			F						A	
PAPR 326	3-S	A		A		A						A	F
PAPR 355	3-S		A		A			A		F	A		A
PAPR 365	3-S									F			A
PAPR 430	4-F	A		A		A				F			A
PAPR 440	4-F	A				A						A	
PAPR 460	4-F	A				A				F		A	
PAPR 475	4-F				A			A		F			A
PAPR 484	4-F	A	A	A	A	A	A	A		F	A	A	A
PAPR 410	4-S	F						F					F
PAPR 445	4-S									F			F
PAPR 486	4-S	A	A	A	A	A	A	A		F	A	A	A
WASTE 489	4-S								F	F			F
Gen Ed Req	Var								F		F		

NOTES:
Term code: #-F = Year #-Fall semester, #-S = year #-Spring semester, SUM = summer, Var = various semesters
Codes in table represent the levels of outcome exposure
X = introductory exposure to this outcome
F = develop more familiarity and practice on this outcome
A = in-depth instruction and assessment of this outcome

Documentation

During the site visit, the team resource room will have course portfolios for each Paper Science and Engineering course in the curriculum. These portfolios will contain the syllabus for the course, examples of student work, and if indicated, the results of the assessments of the learning outcomes addressed in that course. For example, the PAPR 484/486 course portfolio will include the final report for the senior design project, the results of the evaluation of the project and student presentations by Academic Advisory Meeting attendees, and a statement by faculty members on the level of achievement of the program outcomes addressed in the course.

The team will also have access to the program's assessment plans and reports that were prepared as part of our campus assessment process. These documents span the years from 1997 through 2006. The team will have access to the reviews of these reports and plans from the UWSP Assessment Committee.

Achievement of Program Outcomes

The Paper Science and Engineering program at UWSP is a small, close-knit group of faculty and staff allowing a great deal of informal discussion of student achievement. Historically, this sharing of information was the primary method for monitoring the students' levels of subject mastery and how to improve their performance. In 1996-97, the PSE faculty began development of assessment plans and tools. Learning about ABET accreditation requirements has led to even more formal evaluation and assessment being gradually and deliberately introduced into the program. The following will first describe the department's historical approach to assuring the quality of its graduates. The additional elements and processes that have been introduced more recently will then be discussed.

ASSESSMENT ACTIVITY: PRE-ABET

Student achievement is a frequent topic of both formal and informal conversation for PSE faculty. It is common for lunchtime discussions to revolve around a faculty member's latest assignment or exam, the problems students were having with it, and brainstorming ideas to help the students perform at a higher level.

In 1997, the PSE faculty articulated the first set of formal expectations for student achievement. Using the UWSP Assessment Committee's terminology, these expectations were called "Behavioral Objectives", and were stated as follows:

> *Graduates of the Paper Science program at the University of Wisconsin - Stevens Point have the greatest potential for success in their professional lives if they possess the following attributes:*
> 1. *Fundamental knowledge of pulp and paper raw materials and processes*
> 2. *Excellent communication skills*
> 3. *A high level of computer literacy*
> 4. *The ability to work effectively as part of a team*
> 5. *A professional comportment*
> 6. *The ability to continue learning*

The assessment of the first three "Behavioral Objectives" was the initial focus of our effort. The faculty prepared a comprehensive multiple choice examination on pulp and

paper knowledge (christened the "Paper Knowledge Exam") and administered it to the senior class. The Academic Advisory meeting attendees assisted with the second Behavioral Objective by evaluating senior design presentations (as had been the practice since the PSE program's inception); this data was used to assess the seniors' oral communication skills. In addition, the UWSP English Department agreed to administer and evaluate a writing test for our seniors, similar to the placement exam for English 101/102. We were then able to determine the improvement in students' writing skills directly. To address the third Behavioral Objective, a faculty member developed a computer skills test to evaluate the computer literacy of PSE students. All of these assessments were carried out for many years, and the results are presented in the Assessment Reports prepared for the Assessment Committee. At the time, the department was at the forefront of assessment activity on campus, and received much praise for our work.

The Paper Knowledge Exam consisted of fifty questions: twenty-five based on engineering courses and twenty-five based on paper technology courses. This exam was created by the faculty members in the department in 1996-97, with each faculty member contributing questions that were supposed to reflect the important information that students were expected to remember. The results of five years of exams are shown in Figure 3-1. The graph shows the scores on the engineering questions and the technology questions, as well as the overall average scores.

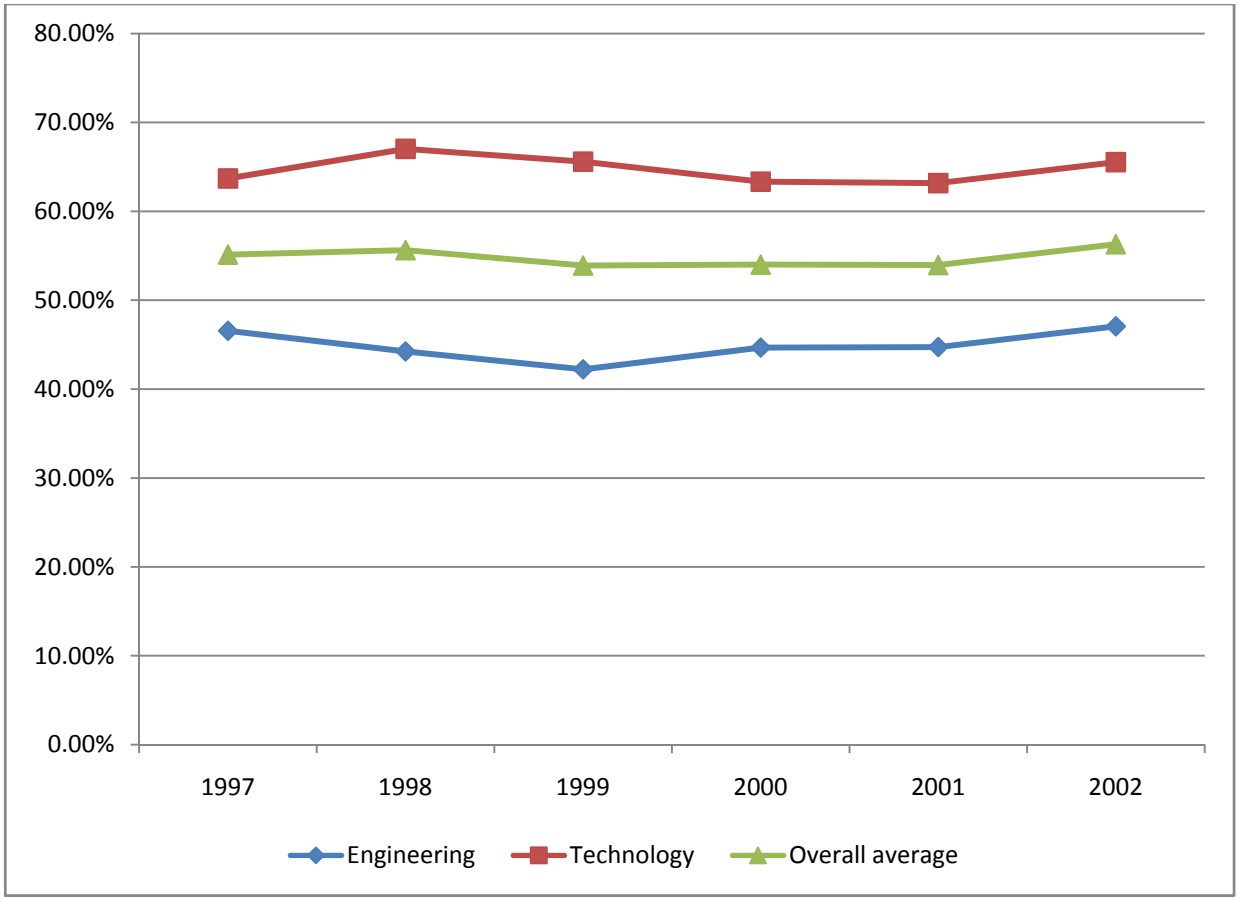

Figure 3-1. Results of Paper Knowledge Exam

Concerned about the utility of the exam as an assessment tool, we asked nine volunteers from our network of paper industry professionals to take the exam. Five of the volunteers were graduates of our program. The average score for this group of knowledgeable engineers was only 46%.

The faculty reviewed the results of student testing over this six-year period. Unlike standardized tests, there were no national norms for comparison. The average scores did not improve over the years. Based on informal conversations with employers, faculty members were confident that graduates of the program continued to perform well in industry. The faculty became convinced that this multiple choice exam wasn't measuring Behavioral Objective #1 as intended, and some other assessment approach was needed. These results were discussed with attendees at the Academic Advisory meeting in May 2002. Industry personnel agreed with the faculty, and the exam has not been administered since 2002.

We now assess the Program Outcomes related to engineering and technology using assignments, projects and exams that are a regular part of student course work (embedded assessments). These assessments are more "authentic", giving a better indication of what the student knows and can do with their knowledge. The embedded assessments are described for each Program Outcome in the section entitled "Assessment Activities: Current" below.

The development of communication skills has been a major focus of the PSE program for at least twenty years. The faculty has deliberately built in a sequence of activities in required courses that requires students to perform progressively more difficult writing and speaking assignments. These assignments, described more fully under outcome (g) below, culminate with the seniors' design project presentations to the Academic Advisory Meeting. The industry professionals attending this meeting rate the students' performance using the same form that is used for all other PSE course presentations, shown in the PSE ABET information web site.

PSE faculty who teach courses that require writing use the same evaluation rubric for writing in every course. This rubric is shown in Table 3-4. Students receive copies of this evaluation rubric with the assignments so that they know what is expected. Faculty provide detailed feedback on the students' work at each stage, and students may also evaluate each other's work.

Table 3-4. Writing evaluation rubric

Numerical Score	English Skills	Organization	Report Format	Scholarship	Technical Competence
96-100	Reserved for truly outstanding performance				
91-95	Superior use of grammar, no significant errors	All topics presented in logical sequence	No observed departure from required format	Well researched report	Excellent understanding of processes
81-90	Some lapses in grammar	Some noticeable topics out of sequence	A few formatting errors	Good use of library resources	Good, solid understanding of processes
71-80	Many lapses in grammar	Many topics out of sequence	Many lapses in format	Minimal library use evident	Adequate understanding of processes
<70	Poor use of language	Random sequence of topics	Does not comply with required format	No library work evident	Poor understanding of processes

For several years, the English Department assisted with the evaluation of improvement in PSE students' writing. They administered a writing evaluation that was very similar to the English placement exam given to entering freshmen. These writing samples were scored by the same English faculty who score the placement exams. We were then able to compare the scores of the students who started their studies here at UWSP with their scores in their senior year, giving a direct measure of their improvement. The results are shown in Figure 3-2 for all PSE students graduating during the academic years of 1997-98 through 2004-05. Scheduling difficulties prevented the assessment of the seniors graduating in 2006 and 2007. The scores assigned may range from 1 to 5 as illustrated in Table 3-5.The writing samples are evaluated based on the grading criteria rubric for Freshman English at UWSP (Table 3-6). The shift in the distribution of writing scores in Figure 3-2 clearly shows the improvement in writing ability in our graduates.

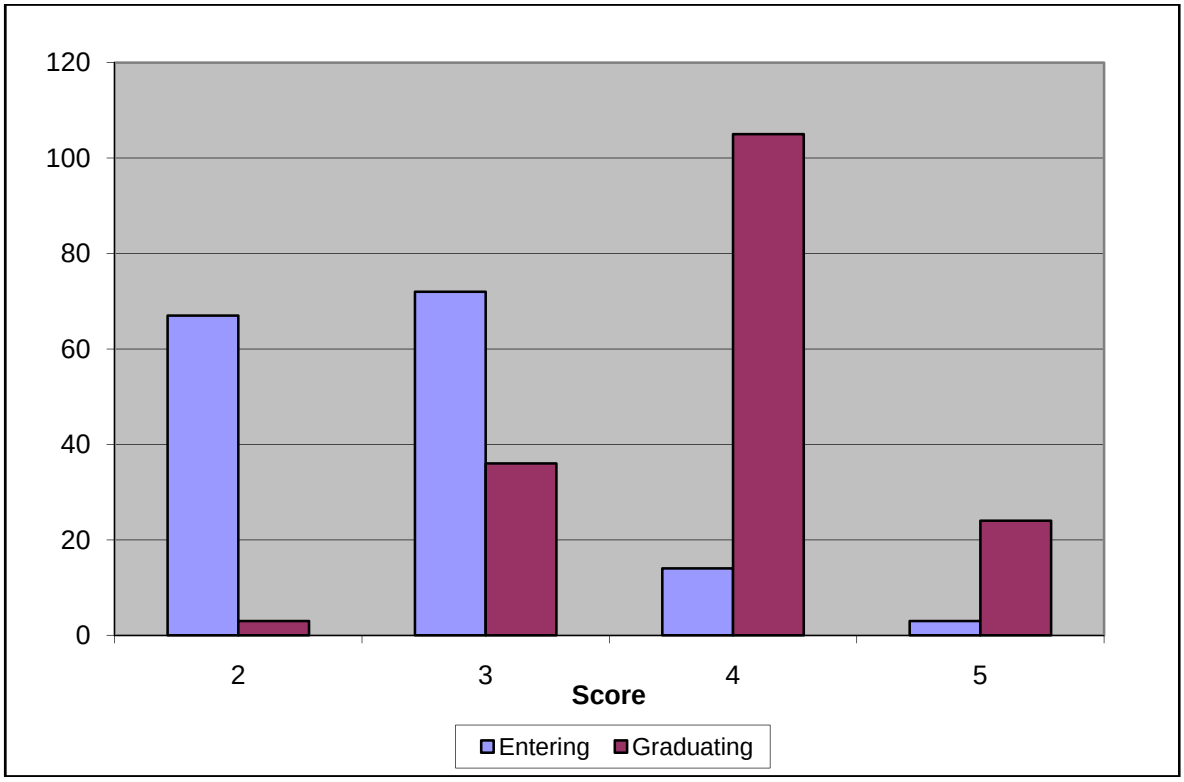

Figure 3-2. Writing assessment results, 1998-2005

Table 3-5. Holistic method for evaluating English placement exams

Score	Description
5	The student is clearly above average in writing proficiency and should be placed in English 150
4	The student has some elements of his/her writing that exceeds the usual 101 competency, but other elements are only at the 101 elements. The student might be successful in English 150.
3	The student's writing proficiency matches that of the usual incoming English 101 student.
2	The student's writing is somewhat below the usual level for incoming English 101 students.
1	The student's writing is far below the usual level for incoming English 101 students. This student might benefit from remedial work on writing skills.

Table 3-6. Grading Criteria for English 101

Grade	Sentence Level Skills	Essay Construction	Audience & Style	Prewriting & Drafting	Critical Reading
A	rhetorically effective sentences; consistently accurate use of standard conventions of spelling & punctuation; almost no grammatical errors	rhetorically powerful strategy; firmly established thesis/purpose; effective use of meta-textual devices to indicate structure; individual paragraphs fully develop a single, pertinent idea; easy to read & convincing	written in the idiom and with the tone the audience expects; variety and precision in vocabulary; a unique and natural voice emerges	discovers original topics; has strategies for generating ideas; critically assesses and improves own draft; welcomes and responds to criticisms from others	full comprehension of literal and inferential meaning; recognizes themes, & motivations of author/character; aware of cultural & historical context ; synthesizes main points; understands tone
B	varied sentence structure and length with only occasional awkwardness; general adherence to standard conventions; only a few grammatical errors	appropriate rhetorical approach; identifiable thesis/purpose; evident structure with some signaling devices; all paragraphs relate to the thesis/purpose; coherent	largely successful utilization of the idiom and tone of the audience; appropriate vocabulary; an effective, but somewhat imitative voice	(same as above, but has greater need of teacher direction)	comprehension of literal meaning; accurate if limited interpretation of themes and motivations; some knowledge of context; identifies main points; recognizes tone
C	Communicatively adequate but repetitive sentence structure; awareness of, but inconsistent use of standard conventions; grammatical errors on every page	weak and/or inconsistent rhetorical approach; thesis/purpose present, but obscure; the rhetorical function of individual passages not always evident; occasional lack of distinction between major points and supporting points; hard to read	some attempt to utilize the relevant idiom and tone; sometimes inaccurate or confusing use of vocabulary; weak approximation of an appropriate written voice	slow to discover and develop original topics; needs assistance generating ideas; needs much guidance to improve drafts; trouble weighing and utilizing student criticism; perhaps indifferent effort	basic understanding of ideas/events; may not understand themes and motivations; minimum of background contextual knowledge; difficulty distinguishing major & minor points/issues; unaware of sarcastic or ironic tones
D	Command of only basic, SVO sentence pattern and consequent obscurity; many violations of standard conventions; grammatical errors throughout, some affecting comprehension	no rhetorical plan; thesis/purpose must be inferred with difficulty; paragraphs are short and general statements are often followed with little or nor support; subsequent readings do not clarify the meaning	idiom and tone are barely differentiated from casual speech; sporadic and/or ineffective use of crucial vocabulary; not immediately recognizable as belonging to a particular written genre	reluctance/inability to participate in the process; has few or no drafts to share with students and teacher; subsequent drafts evolve very little	holes in basic comprehension; only vague notions of themes and motivations; owns very few tools for interpreting texts

ASSESSMENT ACTIVITY: CURRENT

The current instruments for assessing the Program Outcomes use tasks that are embedded in student course work. Assessment of each Program Outcome is described below, including information from each course that includes direct assessment of the outcome as indicated in Table 3-2. All course syllabi may be found in Appendix A.

(a) the ability to apply knowledge of mathematics, science, and engineering

Evidence for the achievement of this outcome is included in the course portfolios for ten PSE courses: PAPR 215, 314, 320, 326, 385, 430, 440, 460 and 484/486.

PAPR 215: This course, Introduction to Process Engineering Calculations, introduces sophomore level students to the techniques of material and energy balances, a fundamental requirement for all internship and entry-level engineering positions for our students. PAPR 215 is sometimes called the "stoichiometry course" in a chemical engineering curriculum. Students learn to apply the basics of mathematics, chemistry and physics to problems concerning "real" processes. Students learn to draw process flow charts and perform balances on the material flowing through a system, often including chemical reactions. If time permits, students are introduced to energy balance procedures. If there is not sufficient time for energy balances during the semester, that topic is covered completely in PAPR 385. The evidence of student achievement is the final mass balance project. This project involves a case study on a large industrial system. The case study may be taken from a textbook or created by the instructor from industry data. All of these projects are based on pulp and paper industry technology. The course portfolio will contain the results of these projects from the last two offerings of this course. The project from 2006 is a case study taken from Felder and Rousseau's first edition of Elementary Principles of Chemical Processes, and includes a mass and energy balance on a Kraft pulp mill. The project from 2007 is a mass balance on our department paper machine using data that the students themselves collected during a machine run conducted by the senior class of PSE majors. In each case, every student in the course was able to create an accurate process flow chart and perform most of the calculations correctly. The average on the Kraft mill was 85% of the calculations performed correctly; the paper machine balance average was 80%.

PAPR 314: This course, Engineering Statistics and Experimental Design, teaches junior level students how to apply statistics to pulp and paper manufacturing. Like all manufacturing processes, the pulp and paper industry relies heavily on statistics to track system performance. Students are required to analyze data provided through course instruction and data generated by laboratory projects. Examples of student work will be located in the course portfolio. Grading of these projects has focused on the correct statistical calculations based on the type of data. The average grade for these projects is over 90% correct.

PAPR 320: This course, Fluid Mechanics and Hydraulics, teaches junior level students concepts in fluid mechanics and their direct application to the pulp and paper industry. Students learn how to determine if flow is laminar or turbulent and why industrial equipment is designed for a specific flow regime. The pulp and paper industry relies heavily on equipment grounded in fluid mechanics to run its various processes. Students are taught how to calculate friction losses when selecting pipe sizes and

pumping equipment. As a final project, students must build a spreadsheet which calculates friction losses for piping systems using water or paper stock. The course portfolio will contain friction loss spreadsheets built by the last two classes. All students must succeed on this project through submission of spreadsheets for analysis of the instructor. If the student spreadsheets do not work, they are given back to the students to produce a revised spreadsheet until correct.

PAPR 326: The main focus of Heat Transfer Operations is teaching concepts of heat transfer to junior level students. The pulp and paper industry relies on heat transfer to dry paper during production, dry waste materials prior to burning, drying coatings applied to the sheet, and reducing heat losses through the use of heat exchangers. Students are taught how to calculate heat transfer coefficients for heat exchangers and drying systems used in the pulp and paper industry. Every semester, the students run the paper machine to generate data for the calculation of heat transfer coefficients on individual dryer cans in the system. In addition, the students build and use a simple heat exchanger to demonstrate the loss in heat transfer efficiency during fouled conditions. Examples of these projects will be located in the course portfolio. The average grade for these two projects is 92% correct which is based on having the correct calculations and coming up with the appropriate conclusion based on the calculations.

PAPR 385: Students in this Systems Engineering and Simulation course study larger material and energy balance problems that are of specific interest to the paper industry, including the use of spreadsheets and other modeling software to study the steady-state response of systems to changes in operating conditions. Results of computer simulations must be described in written reports that discuss the implications of the system responses. For example, in a problem that models a waste heat boiler, changes in the excess air supplied may result in operating conditions and flow rates that are impractical in one or more ways. Students must recognize these problems and state what their results mean in practical terms. The course portfolio for PAPR 385 will contain the reports, spreadsheets and model examples from several simulation problems. Students' initial performance on these problems is highly variable, but if their first submission is inadequate the report is returned for revision and/or rework until the solution is correct. Students therefore have achieved 100% of the expected results on these assignments.

PAPR 430: Mass Transfer Operations is a course in which students apply many science and engineering principles to the analysis and design of mass transfer equipment. Students study several unit operations of importance to the pulp and paper industry. These processes require that they learn and use the principles of diffusion to solve the problems, which may also require mass and energy balances, phase equilibria and some fluid mechanics. Students prepare projects for this course, including an analysis of an operating gas absorption system, a study of the dryer section on the department paper machine and calculations for an industrial filtration process. The course portfolio for PAPR 430 will contain all of the course assignments and examples of student work on these assignments. Students tend to have the most difficulty with the gas absorption assignment, receiving an average of 70% on their work. This assignment is conceptually challenging for them, and is usually the first major assignment in the course. This is their first exposure to the concept of "transfer units" and operating/equilibrium lines. In subsequent assignments, such as the filtration work, the application of these concepts

seems to be more clear to them, with an average of 85% on their work.

PAPR 440: In Industrial Thermodynamics and Kinetics, students learn that difficult engineering problems can be approached in a logical manner through the use of a defined problem solving method given to them at the beginning of the semester. Furthermore, all examples given in lecture follow this method explicitly. Students learn to define known parameters as symbolic variables and to record the magnitude and units of each variable including the unknowns. In this course, students are required to express their final result as an equation rather than just a numerical answer. The course portfolio for PAPR 440 includes numerous samples of solved problems using this structured method. Problems are evaluated using the following criteria: format, use of MathCad, Excel and/or TEST (The Expert System for Thermodynamics), use of a symbolic approach, correct thermodynamic theory, proper units, and finally the correct answer. The percent score for each criteria is presented in the syllabus. A homework or test problem is always scored with a preference for the correct equation and not just the correct answer. By the end of the semester this approach produces typical scores above 85%.

PAPR 460: Process Dynamics and Control requires students to apply what they have learned in math courses and in PAPR 215/385 to the analysis of time-dependent systems. Students must construct unsteady-state material and/or energy balance equations and solve them. The course portolio contains examples of student solutions to these problems. Students generally have little difficulty with the solution of single differential equations, and their solutions are 90% correct.

PAPR 484/486: These courses house the capstone design project, described fully under Criterion 5.

(b) the ability to design and conduct experiments, as well as to analyze and interpret data

This outcome is assessed in four PSE courses: PAPR 314, 355 and 484/486.

PAPR 314: Both PAPR 314 and 355 are taught to junior level students. Over the past few years, students have been required to design experiments and analyze data as part of a two course project. Students must use concepts learned in PAPR 355 to develop a hypothesis to test and concepts from PAPR 314 to design and conduct experiments to test their hypothesis. Examples of student work from previous courses will be located in the course portfolio. Students were 100% successful on these projects through submitting drafts for analysis by the instructors until complete.

PAPR 355: Paper and Fiber Physics is a junior level course designed to teach students the scientific principles underlying the performance of paper and paper products. Although, there is a strong emphasis on teaching TAPPI testing procedures, the laboratory exercises are designed to explore key scientific principles and are essentially exploratory research projects. The projects are semester long and usually involve considerable planning and coordination by the students to produce analyzable results. Important experimental concepts such as accuracy and precision are emphasized to make students aware that correct procedures must be followed and sufficient sampling must be performed to obtain good results. This method of working with students has sometimes led to publishable results. Within recent years, the goal has been to have

students present a joint poster at the CNR Student Research Symposium. The portfolio for this course contains example student laboratory reports describing the assigned projects and the student's final results. One illustrating example is the construction of a model of a fiber network using paper strips and comparing those results with theoretical predictions. Another example is a more difficult experiment involving the collection of several paper sheet variables to determine veracity of the theoretical "Page" equation. This equation required the manipulation of a complex hyperbolic equation to determine regression parameters to enable data fitting. Student project reports generally earn "B" or better grades.

PAPR 484/486: These courses house the capstone design project, described fully under Criterion 5.

(c) The ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability

This outcome is assessed in four PSE courses: PAPR 326, 430 and 484/486

PAPR 326: Students in Heat Transfer Operations are required to design a simple heat exchanger and then analyze its performance under normal operating conditions and fouled conditions. This exercise demonstrates how easily a device of this sort can be severely compromised and become uneconomical to run when fouled. Examples of student work from this project will be located in the course portfolio. The average grade for these two projects is 92% correct which is based on having the correct calculations and coming up with the appropriate conclusion based on the calculations.

PAPR 430: Students in Mass Transfer Operations study several processes of importance to the paper industry. The textbook used for the course is Unit Operations of Chemical Engineering by McCabe, Smith and Harriott. The course includes a unit on Humidification Operations based on the corresponding chapter from the text, but including in-depth study of cooling towers used in the paper industry. As part of this unit, students improve their understanding of the psychrometric chart and wet-bulb temperature measurement. They use a sling psychrometer to measure the wet- and dry-bulb temperature in a variety of locations, plotting the response of the thermometers as a function of time. Based on the theory of wet-bulb temperature and their observations during the use of the psychrometer, they are asked to design a wet-bulb temperature measurement device that addresses the limitations of the sling psychrometer (e.g. space required for use, time to equilibrium, etc.). The course portfolio for PAPR 430 will contain examples of student designs and reports. Students are encouraged to be creative, but some will resort to looking for laboratory devices that are readily available from many suppliers and attempting to copy the design of those devices. Over the years, only about 10% of students have taken this path. About 60% of the students will see what the design requires and make a good attempt at addressing the requirements, but will fall short in the considerations of the practicality of their device. The remaining 30% will design a good instrument that addresses all deficiencies and wet-bulb temperature measurement needs. This level of achievement is unsatisfactory, and must be addressed. Plans are described under Criterion 4.

PAPR 484/486: These courses house the capstone design project, described fully under

Criterion 5.

(d) The ability to function on multi-disciplinary teams

This outcome is assessed in four PSE courses: PAPR 355, 475 and 484/486.

PAPR 355: Paper and Fiber Physics has been described previously under PSE program outcome "b. design and conduct experiments". Because the assigned laboratory exercise was complex and generally entailed coordinated planning and execution, teams of approximately five students were formed to accomplish the assigned laboratory task. For this reason, this course was identified by its instructor as a good candidate to assess this program outcome. When the faculty attended the 2007 ABET Faculty Workshop on Assessing Program Outcomes, Gloria Rogers presented a rubric to assess this program outcome. As a result, the instructor of PAPR 355 chose to use this rubric in this course during the second semester of 2007-08. The following table was presented to the eight juniors taking this course. They were requested to rate their classmates in each criteria using the descriptors given in the table after the laboratory exercise has been completed that semester. The results of this peer review for the course are given below in Table 3-8.

Table 3-7. Team performance: Rubric for PAPR 355

	Performance Scale			
Performance criteria	***Unsatisfactory 1***	***Developing 2***	***Satisfactory 3***	***Exemplary 4***
Researched and gather information	Does not collect any information that relates to the topic.	Collects very little information—some relates to the topic.	Collects some basic information to the topic.	Collects a great deal of information—all relates to the topic.
Fulfill team role's duties	Does not perform any duties of assigned team role.	Performs very little duties.	Performs nearly all duties.	Performs all duties of assigned team role.
Share equally	Always relies on others to do the work.	Rarely does the assigned work—often needs reminding.	Usually does the assigned work—rarely needs reminding.	Always does the assigned work without having to be reminded.
Listen to other teammates	Is always talking—never allows anyone else to speak.	Usually doing most of the talking—rarely allows others to speak.	Listens, but sometimes talks too much.	Listens and speaks a fair amount.

Since this was the first year using this rubric, there is no other data to compare these results with. These results will be used in future years to benchmark other team's performances. This technique is encouraging. Although the results are narrowly distributed the average rankings did correspond to the instructor's evaluation of most involved student (#5) and least involved student ((#3). Overall, the instructor observed good team work among all the team members.

Table 3-8. Team performance: Peer ratings for PAPR 355

Team Member	Attribute 1	Attribute 2	Attribute 3	Attribute 4	Average
#1	2.9	3.1	3.0	3.1	3.0
#2	3.5	3.5	3.2	3.0	3.3
#3	2.8	3.0	2.9	3.0	2.9
#4	2.8	3.0	3.0	3.1	3.0
#5	3.5	3.5	3.4	3.4	3.5
#6	2.9	3.0	3.0	2.9	3.0
#7	3.4	3.5	3.4	3.0	3.3
#8	2.9	3.1	2.9	3.1	3.0

PAPR 475: Paper Machine Operations is a senior level course, where students learn about the design and operation of various types of modern paper machines. Because this department has a unique paper machine that is designed to be operated safely by students, this course's laboratory section takes the opportunity to use the machine at its intended potential. Students in this course are divided into teams with the intention of producing a pre-defined grade of paper. Five practice lab sessions are scheduled followed by a final production run. Each team has five members and uses the practice lab sessions to learn the defined operational roles on the machine. One student team member serves as the leader or coordinator. All students rotate through the operational roles. Each practice run increases the number of process parameters that must be controlled until five parameters are controlled during the fifth run. The production run is the sixth and last machine run where the production of at least one roll of paper to specifications is required. Before the production run the team must select one team member who will be their leader and also select all other roles. A final report on the production run is required. This report asks the following questions: 1) How personal leadership skills were developed during the machine exercises. 2) Discuss the development of communication skills. 3) Discuss your acquisition of knowledge and skills about paper making. And 4) Discuss particular problem solving events that occurred. These reports are included in the portfolio for this course. A final oral report is given at the end of the semester where all team members discuss their successes and failures. However, this assessment technique did not demonstrate that the team was striving to work together rather it invoked statements of personal leadership. Therefore, the assessment technique described for PAPR 355 above will be used for this upcoming year.

PAPR 484/486: These courses house the capstone design project, described fully under Criterion 5.

(e) The ability to identify, formulate and solve engineering problems

This outcome is assessed in seven PSE courses: PAPR 320, 326, 430, 440, 460 and 484/486.

PAPR 320: Student ability to solve engineering problems is evaluated through solving problems on exams and homework. Examples of graded student work are included in the course portfolio. Average student grades for assignments and exams in this course are 91% based on correct problem solutions.

PAPR 326: Student ability to solve engineering problems is evaluated through solving problems on exams and homework. Examples of graded student work are included in the course portfolio. Average student grades for assignments and exams in this course are 91% based on correct problem solutions.

PAPR 430: Students solve a variety of mass transfer problems in the final course in the transport phenomena sequence. Examples of student work will be presented in the course portfolio. Students achieve 70-85% proficiency on these problems, lower earlier in the semester, higher on the later assignments.

PAPR 440: Engineering Thermodynamics concentrates on traditional problems obtained from numerous thermodynamic textbooks. The problems range from simple change-of-state problems to more complex process problems. Student's ability to formulate and solve these problems is assessed using a structured problem-solving method. This format requires stating the givens, the unknowns, the thermodynamic theory or principle used to solve the problem, and the final solution to the problem stated with correct units in engineering notation. The course portfolio for PAPR 440 includes numerous examples of this formatted problem solutions. At the end of the semester, all students are able to achieve 85% or better for assigned problems

PAPR 460: Students in Process Dynamics and Control extend their knowledge of industrial processes to include non-steady state material and energy balances and automatic control systems. During this course, students work many problems from the textbook, Principles and Practice of Automatic Process Control by Smith and Corripio. The course portfolio for PAPR 460 will contain several examples of solved problem assignments and exams. Students have little difficulty with the early mathematical content of the course (LaPlace Transforms for simple differential equations, 100% of students solve problems correctly). The subsequent application of LaPlace transforms to transient material and energy balance problems causes more difficulties (60% performed problem development correctly). Creation of block diagrams to represent processes is done well by students (100% correct). The solutions to problems in which a controller is introduced are handled with spreadsheets, and these problems are handled well by students (80% correct).

PAPR 484/486: These courses house the capstone design project, described fully under Criterion 5.

(f) The understanding of professional and ethical responsibility

This outcome is assessed in PAPR 475 and 484/486.

PAPR 475: Paper Machine Operations is a course that enables students to acquire sound professional and ethical responsibilities of working safely on potentially dangerous equipment. This course since 1997 has required that all students read and understand the safety and operations manual before being allowed to work on the paper machine. To ensure that students meet this high requirement, all students must first pass the safety exam with at least a 85% on a multiple-choice/fill-in-the-blanks exam. Each team assigned to work on the paper machine must have all its members pass the exam before being allowed to begin their assignments.

For the last four years, each team has been asked to produce a video "safety" film

teaching their fellow classmates the required safety procedures on and around the machine. Examples of these videos will be incorporated in the PAPR 475 portfolio.

PAPR 484/486: In the senior design sequence, students participate in class discussions of the responsibilities of engineers and engineering codes of ethics. The students then complete an online quiz on the code of ethics. They must repeat the quiz until they score 100%. Last year's senior class (five students) required a total of 47 attempts for all of them to achieve 100%. This exercise will be repeated with future classes. The course portfolio for PAPR 484/486 will contain the ethics quiz and results, showing which of the questions caused students the most difficulty.

(g) The ability to communicate effectively

This outcome is assessed in six PSE courses: PAPR 210, 350, 355, 475, 484 and 486. The development of writing skills is emphasized in the PAPR 210→ 350→ 355→ 484/486 course sequence, although many other courses include some form of writing in their assignments. Oral presentations are required and assessed in PAPR 350, 355, 475 and 484/486.

PAPR 210: This course is the first of two writing emphasis courses within the Paper Science & Engineering major. The main focus of this course is to develop student writing skills. The type of written communication this course emphasizes is brief technical reports. Engineers when working in industry must be able to provide technical reports summarizing current development projects within the organization. These reports must contain the vital information without including unnecessary information. This course is taught to freshmen students in the major. During their sophomore year, students will begin their cooperative learning experience in industry. The writing style taught in this course will be needed by students during their co-op. Students are graded in this course using the standard department rubric. In addition, students are provided a writing manual to guide report style in the course. The writing manual will be included in the course portfolio. Students are required to reflect on their weekly reports after they have received their grade online. This exercise has been a great way to get feedback from students who may be reluctant to ask specific questions during class time. Examples of student papers and online reflections are included in the course portfolio. Technical writing is a skill that students do not generally learn in high school which typically translates into poor grades at the start of the semester which gradually transition better grades as the students improve. The average grade for the first paper in the course is 67% which is at a D average. The average grade of the final paper is 93% which is at an A- average.

PAPR 350: This is the second writing emphasis course. The focus of this course is for students to write research papers similar to the type that would be submitted for publication in a scientific journal. Paper style and evaluation requirements are included as part of the department writing guide which is included in the course portfolio. In addition to written papers, the students present their information orally in the course to students and faculty in the department. Oral presentations are graded following a standard department speaker evaluation form which is included in the course portfolio. Examples of student papers will also be included in the portfolio. The average grade for the research papers has been 90% correct based on the department writing rubric. The

average grade for the oral presentations has been 92% based on the department presentation evaluation form.

PAPR 355: In PAPR 355, a 3000 to 5000 word research paper is assigned to improve writing skills with a complex multi-page report that is more challenging than the writing tasks assigned during sophomore year. In addition, the objective is to have students search the published literature and use these sources as citations in their report. Usually eight to ten refereed citations are required. At the end of the semester, these reports are summarized in an oral presentation in class using PowerPoint software. The written reports are evaluated using the PSE grading criteria matrix developed in conjunction with the English department and paper industry members twenty years ago. The oral presentations are evaluated using the PSE standard speaker evaluation form. Examples of these reports are presented in the PAPR 355 course portfolio. In addition, several examples of the research reports, collected since the early 1990s, are included in a CD in the course portfolio. These reports are being compiled in order to provide a mechanism in which the work of students can benefit other students in their class and others. The expectation is that all students in this course is that all students will receive a B- or better grade in both the research report and oral presentation, and roughly 10% of the students will merit an A. Over the last five years involving 48 students, the grades ranged from B to A.

PAPR 475: In PAPR 475, students learn effective communication by assuming the role of leader during the practice runs and the final production run. The student team leader is called the "Machine Tender" to correlate with functional roles on actual paper machine crews. During each operation the machine tender is responsible for planning the run prior to the operation, communicating with the other team members to coordinate their actions and solving any immediate problems that occur. They are usually given an hour or more to achieve the objectives of the operation. There are usually five students on each team. During the run the instructor is observing the operation and scoring performance criteria for preparation, communication, problem solving and participation. At the end of the operation a sample sheet of paper must be handed in to prove that their objectives have been met. During these exercises, students are very much aware of their performance. When the fifth exercise, the production run, takes place the team members have learned to work well with each other and run the paper machine correctly to make a useable sheet of paper. In the portfolio for this course you will find evaluations of team performance and how communication related to their success. The minimal expectation for this course is that a "B" level of performance is achieved. However, this course generates a level of enthusiasm that usually has to be graded as a B+ or greater. Few teams fail to make good paper.

PAPR 484/486: These courses house the capstone design project, described fully under Criterion 5.

(h) The broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context

This outcome is studied in several courses throughout the curriculum, primarily through the general education component. Although there are ample opportunities for assessment in these courses, UWSP as a campus does not assess general education

outcomes at all. The campus recognizes this as a significant problem, and must address this issue as a condition of its latest accreditation recommendation from the Higher Learning Commission.

(i) A recognition of the need for, and the ability to engage in life-long learning

This outcome is assessed by extension of the Industry Survey results for PEO #4. In this survey from 2002, 44 out of 49 supervisors of PSE graduates rated these employees either "Excellent" or "Very Good" on their "Ability to continue learning".

The results of the 2008 survey of PSE alumni show that alumni take an average of 6.8 continuing education opportunities, only 3.5 of which are required by their employer. This illustrates that PSE alumni recognize the need to continue upgrading their skills and knowledge. Results of these surveys will be available to the team during the visit.

(j) A knowledge of contemporary issues

This outcome is assessed in PAPR 350, 365 and 484/486.

PAPR 350: Research topics for this course focus on contemporary issues in the pulping manufacturing sector. Current hot topics focus on biofuel production and energy efficiency. Each student is assigned a topic for a research paper. After finishing the research paper, all students are required to present their paper to the class. The oral presentations allow the students in the class exposure to all of the assigned contemporary issues. Paper style and evaluation requirements are included as part of the department writing guide which is included in the course portfolio. Oral presentations are graded following a standard department speaker evaluation form which is included in the course portfolio. Examples of student papers will also be included in the portfolio. The average grade for the research papers has been 90% correct based on the department writing rubric. The average grade for the oral presentations has been 92% based on the department presentation evaluation form.

PAPR 365: PAPR 365 addresses the knowledge of contemporary issues in the paper industry through the chosen topics of the assigned research paper. The most recent assignment involved "Nanotechnology" in papermaking, a topic that is considered the next important technology for the future of the industry. These reports were required to be 5000 words long with eight literature citations. An oral presentation was also required. The standard PSE tools were used to measure this program outcome. These reports are found in the portfolio for this course. This year's average score for the term paper was 84%, which was worth 35% of the course evaluation. The average score for the oral presentation was 60%, which was worth 10% of the course evaluation.

PAPR 484/486: These courses house the capstone design project, described fully under Criterion 5.

(k) The ability to use the techniques, skills, and modern engineering tools necessary for engineering practice

This outcome is assessed in eight PSE courses: PAPR 314, 320, 326, 385, 440, 460 and 484/486. Students have access to the Microsoft Office suite of software through the campus computer labs (or they may purchase the software at a greatly reduced cost through a UW System contract with Microsoft). The WinGEMS software package is

also accessible through the campus network. WinGEMS was written specifically for the pulp and paper industry, and contains many industry-specific process blocks for use in simulation.

PAPR 314: This course teaches junior level students how to apply statistics to pulp and paper manufacturing. Like all manufacturing processes, the pulp and paper industry relies heavily on statistics to track system performance. Students are required to analyze data provided through course instruction and data generated by laboratory projects. To analyze the data, students are required to use Minitab and the statistical calculations in Microsoft Excel. This is the same software they will use during their careers in industry. Examples of student work will be located in the course portfolio. Grading of these projects has focused on the correct statistical calculations based on the type of data. The average grade for these projects is over 90% correct.

PAPR 320: Students develop skills to properly design flow systems necessary to run any pulp and paper facility. Students must build a spreadsheet to calculate friction losses in piping systems for water and pulp suspensions. These spreadsheets are tools that they can use in industry. Course exams require students to do these calculations without the aid of spreadsheets. Examples of student exams and spreadsheets will be included in the course portfolio. All students must succeed on this project through submission of spreadsheets for analysis of the instructor. If the student spreadsheets do not work, they are given back to the students to produce a revised spreadsheet until correct. Average exam grades based on completing the calculations correctly are 91%.

PAPR 326: Drying paper and pulp represents a very large cost in their manufacturing process. Every semester, the students run the paper machine to generate data for the calculation of heat transfer coefficients on individual dryer cans in the system. This assignment provides students a methodology to evaluate dryer cans when they work in industry. Examples of these projects will be located in the course portfolio. The average grade for these projects is 92% correct which is based on having the correct calculations and coming up with the appropriate conclusion based on the calculations.

PAPR 385: The simulation problems described under outcome (a) require the use of spreadsheets and higher level simulation software developed for the pulp and paper industry. Students use the Excel spreadsheet to solve many problems in this course. The course portfolio for PAPR 385 will show examples of student-created spreadsheets for material and energy balances for lime kilns, boilers and other commonly-used unit operations. The portfolio will also include examples of more complicated systems modeled with WinGEMS, including models of the department paper machine. This modeling task is the final assignment in the course. The students gather data for this simulation in groups, but each must prepare their own computer model of the system. Student performance on this assignment is excellent (100% produce a model that accurately reflects the operation of the paper machine), primarily due to the course policy of allowing students to correct and resubmit their work.

PAPR 440: PAPR 440 uses the web-based “The Expert System for Thermodynamics” (TEST) by Prof. S. Bhattacharjee (www.thermofluids.net). This software calculates all thermodynamic property values for virtually all materials in every phase. It calculates values for perfect, ideal and real materials. It calculates properties for several states and

graphs them in traditional diagrams such as PV, PH and TS. All calculations and graphs can be exported to Excel. It is also available to students after they graduate so that it is "carry forward" learning. Examples of the use of TEST with PAPR 440 homework problems and exams are included in the portfolio for this course. This web site is used frequently during lectures. Students enjoy using this site and it is a great improvement over steam tables and other more traditional property charts and tables.

PAPR 460: Students in Process Dynamics and Control use the Excel spreadsheet to model the time-dependent response of a system to process disturbances and setpoint changes. The course portfolio will contain examples of student-created spreadsheets that model the control of tank level and outlet solids concentration from a tank with dilution. Students perform well (100% achievement) on these assignments due to the ability to correct and resubmit their work. Future offerings of this course will incorporate the use of MATLAB/Simulink to model dynamic systems.

PAPR 484/486: These courses house the capstone design project, described fully under Criterion 5.

(l) Knowledge of the science and technology used in the paper industry

This outcome is assessed in eight PSE courses: PAPR 350, 385, 355, 365, 430, 475 and 484/486.

PAPR 350: Students are assigned papers in vital areas in pulp manufacturing in this course. Through written papers and oral presentations, each student in this course learns key concepts in pulp production. In addition, as part of this course students take 4 in-depth tours of pulp mills in the Central Wisconsin area where they witness firsthand the technology necessary to produce chemical and mechanical pulp. Students build an Excel spreadsheet to calculate H-factor and G-factor. Chemical pulp mills use one of these numbers to control their pulping process. Exams in this course cover much of the science and technology to manufacture pulp. Examples of student work and exams will be included in the course portfolio. Average student grades on the exams and spreadsheets are 91% based on performing the calculations correctly.

PAPR 385: The simulation problems described under outcome (a) require that students interpret their results using their knowledge of pulp and paper science and technology. The course portfolio contains examples of student reports for these problems. Although students willingly resubmit their spreadsheets and WinGEMS files to improve their achievement, they do not do as well with the interpretation of their results. None of last year's student reports showed high levels of thought about their simulation results. Many (75%) suggested process modifications that were highly impractical. These results are clearly unacceptable.

PAPR 355: Paper and Fiber Physics is the course where PSE students learn about paper as a product and the measurements of its properties. Information is presented to students via lecture, reading, and laboratory exercises. Acquisition of this knowledge is assessed using written exams. Exams are generally essay exams that explore student's deeper understanding of the material by posing complex problems that need analysis and understanding in order to answer them completely. Classroom material is supplemented by a research paper and laboratory exercises. In the course the expectation is that 85% will

score above a “B-” grade, and that 25 % will score above a “B+” grade. Since 2002, 48 students have taken this course and the average grade was 3.56 or between B+ and A-.

PAPR 365: Colloid and Surface Phenomena is the course where PSE students learn about the process chemistry and the numerous papermaking additives. Information is presented to students via lecture, and reading. Acquisition of this knowledge is assessed using written exams. Exams are generally essay exams that explore student’s deeper understanding of the material by posing complex problems that need analysis and understanding in order to answer them completely. Classroom material is supplemented by a research paper. In the course the expectation is that 85% will score above a “B-” grade, and that 25 % will score above a “B+” grade. Since 2002, 48 students have taken this course and the average grade was 3.43 or between B+ and A-.

PAPR 430: Mass Transfer Operations concentrates on processes of importance to the paper industry, such as gas absorption, humidification, drying and filtration. Students work on projects based on operating equipment in a mill for this course. The average scores on these projects range from 70% on early assignments to 85% on later assignments.

PAPR 475: Paper Machine Operations is the course where PSE students learn about the equipment and process of papermaking. Information is presented to students via lecture, reading and through hands-on operation of a paper machine. Acquisition of this knowledge is assessed using written exams. Exams are generally essay exams that explore student’s deeper understanding of the material by posing complex problems that need analysis and understanding in order to answer them completely. In the course the expectation is that 85% will score above a “B-” grade, and that 25 % will score above a “B+” grade.. Since 2002, 80 students have taken this course and the average grade was 3.86 or between A- and A.

PAPR 484/486: These courses house the capstone design project, described fully under Criterion 5.