

The Use of Portfolios as Assessment Tools in an Engineering Program

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Abstract

Portfolios have long been the pride of other disciplines, including the Architecture and Interior Design Programs, at most universities and colleges. Students compile master portfolios throughout their education to demonstrate to prospective employers, and accreditors, the depth of their skills and the breadth of their experience. In the professional arenas in which those students and graduates ply their trades, portfolios to demonstrate competence have become a standard of practice.

The use of portfolios has become a habit in the world of engineering for the Engineer-in-Training to be able to demonstrate to licensing boards that the applicant has complied with the strict rules of responsible charge needed to procure professional licenses. It has not yet found its way into the universities and colleges to any significant degree, however. In most institutions of higher education, more “conventional” means of demonstrating knowledge - tests, papers, reports, etc., - have been the bulwark of the educational process. Being particularly conservative by nature, engineering educators have been slow to see the advantages of this tool to the assessment of their programs.

With the advent of ABET 2000 rules for the accreditation of engineering programs, a new emphasis has been placed on the demonstration of competence in the students and the graduate. This has prompted a look for new tools to better assess program outcomes. As is so often the case, old tools put to a new use can be superior to any new tool developed for a single purpose. In this case, portfolios, developed and maintained by the students, can help provide the evidence needed to demonstrate successful implementation of program learning and competency objectives on a broad scale.

This paper addresses the development of the portfolio concept as a tool for program assessment and provides an overview of the implementation mechanism used at Wentworth. Portfolios are required of every student in the program in one class each semester. Although the portfolio is a required part of one class, it covers the entire range of courses taken that semester. Through the use of this tool, the students can better understand what they are expected to learn and when they are expected to learn it; the program faculty can better assess the achievement of learning and competency expectations; and the assessment process for accreditation can be expedited in a powerful way.

Report

The concept of using student portfolios as an indicator of the accomplishments of the students is not new. Architects, interior designers, industrial designers, and others in the artistic and creative professions have long relied upon these tools to differentiate among students and to demonstrate professional competence throughout professional careers.

New program accreditation concepts taking hold across the engineering disciplines, specifically with respect to ABET accreditation, focus on outcome assessment rather than outcome identification. This shift in accreditation emphasis has created new opportunities for engineering programs, among others, to develop more creative ways to measure and assess program outcomes. One of the more promising tools recently adopted by the Environmental Engineering Program at Wentworth Institute of Technology in Boston is the use of student portfolios.

It is instructive to note that the traditional concept of portfolios needs to be modified when it is applied to engineering programs. To be sure, the value of creativity in engineering is certainly strong and the elegant design is most often preferred over the mundane. Nevertheless, it is also clear that artistry is not yet widely perceived as a controlling attribute in the environmental engineering profession.

The minimization of artistry as a controlling attribute does not itself diminish the value of the well-prepared engineering portfolio. Indeed, most state registration boards have long required the documentation of professional experience through the submittal of portfolios of professional accomplishment.

It is not, therefore, a significant leap of professional faith to extend the development of the portfolio to the assessment of educational processes. Whereas the conventional portfolio is used to document the progression of professional experience, so can the student portfolio be used to document the progress of the educational experience.

In order for program assessment to have meaning, the program objectives must be measurable. Program objectives, however, have historically been lofty and intellectual. Such objectives are impossible to measure objectively. Accordingly, it has been necessary to rewrite goals and objectives into more measurable formats, or to concede the assessment to subjective value judgements. Since stodgy engineers tend to abhor subjective assessment more than Nature abhors vacuums, the former course has proved the more pragmatic approach.

At Wentworth Institute of Technology there are twelve Learning and Competency Objectives defined for all students, regardless of their curriculum. While not, perhaps, quite as prone to objective assessment as the stodgy engineers would like, they are nevertheless measurable through comparative documentation analysis. In addition, the Environmental Engineering Program has been based on a set of nine specific Program Objectives. The faculty believe that the Program Objectives are fully amenable to objective evaluation and assessment.

It is one thing, of course, for a faculty member who develops an objective to proclaim its amenability to objective assessment; it is quite another to suggest to a student that the student

should be equally as adept at assessing achievement. Moreover, the assessment tools available to the faculty will be significantly different from those available to the student.

Faculty tend to focus on test scores, comparative assessments of students within a class, and the expectations of the faculty teaching a class to assess achievement of objectives. There is a built-in bias in such an assessment which can lead the faculty to see achievement and success on a macro-scale, when no such achievement may be occurring on a micro-scale.

The challenge, then, was to devise an assessment tool which can more accurately reflect the micro-scale effectiveness of the program courses. At the same time, it was recognized that the expectations of the faculty were not being well-communicated to the students. Individual faculty can clearly state the objectives of specific courses - and even measure the achievement of those goals through selective testing and writing assignment assessments. There is no course, however, in which the Institute Learning and Competency Objectives or the Environmental Engineering Program Objectives are specifically taught. Consequently, there are no tests administered to generate measurable assessment data.

The solution adopted by the Wentworth Environmental Engineering Program was to adapt the basic portfolio concept to the engineering curriculum. In essence, the student self-assesses, and documents, the outcomes to minimize the subjectivity of the faculty. The student is provided a matrix outlining the expected level of achievement for each of the twelve Institute and nine Program Objectives at the beginning of each semester and must document achievement of each objective at the end of that semester. The portfolio thus developed is critiqued by the faculty and evaluated for adequacy. Corrections to the process can be developed from the faculty evaluations of the portfolios to optimize the self-assessment process.

In order for the portfolio process to be effective, the outcome measurements need to be comparable. Therefore, it is necessary to establish standards of achievement to which the student can work. It is clear that the students will not achieve complete competence in any of the Learning Objectives in the first semester or the first year. Competence achieved that easily would be of very limited educational value. Indeed, competency must be developed over time and can be expected only in the later years of an educational program.

If achievement of objectives can be optimized through the gradual infusion of knowledge, then documentation of the growth of that knowledge should also be demonstrable. By setting educational achievement standards at progressively higher levels throughout the full length of the programmatic experience, it is possible to create measurable interim standards and ask the student to document attainment of those interim standards each semester.

Inherent in the concept of interim standards, which are necessarily soft from a measurement perspective, is the need to define vague and subjective concepts in precise and measurable terms. While the term "oxymoron" may spring to the mind at such a suggestion, it is, in fact, a manageable task in the context of outcome assessment.

Attachment 1 shows the matrix of learning objectives and achievement expectations provided to all students in the Wentworth Environmental Engineering Program. It can be seen from the

matrix that the objectives are extraordinarily simplified, down to two or three key words, and that the uncontrolled student interpretation of those objectives would be anarchistic, at best. The three descriptors used to suggest the expected level of objective achievement are equally subject to interpretation. Consequently, it has been necessary to more carefully define both the objectives and the descriptors in common terms.

Attachment 2 provides a list of the Objective definitions provided to the students, while Attachment 3 provides the definition of the achievement descriptors. The matrix, the definitions of the objectives, and the definitions of the descriptors are packaged together with a cover memorandum, shown as Attachment 4, to complete the portfolio assignment. It will be seen that the student is required to complete the portfolio as an integral, graded, component of one class each semester, but that all classes taken that semester are expected to contribute to achievement of the educational objectives. Documentation of success can come from any class.

It is interesting to note, as a sideline, that the interim achievement objectives were developed by faculty based on the subject matter taught in the various courses each semester. The student is not told, however, what those expectations are. The reason for that is to force the student to consider the issue of where in the curriculum that semester each specific objective was addressed. That will allow the faculty to better assess the validity of their original assumptions in that area and to adjust the curriculum, as a whole or in a course, to better reflect the needs of the program.

Overall, then, the adaptation of the portfolio to the assessment of an engineering program has provided several benefits.

1. The student immediately learns the Learning Objectives of the Institute and the Program.
2. The student is forced to focus on the learning objectives and to objectively self-assess his or her own achievement of those objectives.
3. The faculty develop a running documented history of academic achievement by each student, which can then be used to document the faculty's self-assessment of overall student achievement.
4. The faculty can effectively test their initial expectations for each course in the curriculum against the perceptions of the students regarding the source and timing of objective achievement.

The development of portfolios at Wentworth was initiated in the Fall of 1999, with all five classes of students. Initial reactions from the students are positive and the results are expected to be constructive. It is also expected that two to three semesters of experience will generate significant improvement in the process.

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ATTACHMENT 1A			INSTITUTE	LEARNING	OBJECTIVES	
SEMESTER	LEADERSHIP QUALITIES	ANALYTICAL THINKING	INNOVATIVE PROBLEM SOLVING	TEAM BUILDING	COMMO. SKILLS	DECISION SKILLS
FR - FALL	A	A	A	A	A	A
FR - SPRING	A	A		A	A	A
SO - FALL	U	A		A	U	U
SO - SPRING		U		U	U	U
OPT. CO-OP				U	U	U
JR - FALL	U	U	U	U	U	U
JR - SPRING	U	U	U	U/C	C	C
CO-OP 1	U	U	U	U/C	C	C
SR - FALL		U/C	U	U/C	C	C
SR - SPRING	C	C	C	C	C	C
CO-OP 2	C	C	C	C	C	C
FY - FALL	C	C	C	C	C	C
FY - SPRING	C	C	C	C	C	C

SEMESTER	BUSINESS ACUMEN	APPLIC. TO CONTEMP'Y SOCIETY	THOROUGH KNOWL. OF DESIGN	COOPTIVE WORK EXPERIENCE	ABILITY TO WORK EFFICIENTLY	LIFE LONG LEARNING SKILLS
FR - FALL	A	A	A	A	A	A
FR - SPRING	A			C	A	A
SO - FALL	U		A		U	U
SO - SPRING		U	U			U
OPT. CO-OP	U			C	U	
JR - FALL		U	U		U	U
JR - SPRING	U/C		U/C	C	C	U
CO-OP 1	U/C		U/C	C	C	
SR - FALL			C	C		C
SR - SPRING	C	C	C	C	C	C
CO-OP 2	C		C	C	C	
FY - FALL		C	C	C	C	C
FY - SPRING	C	C	C	C	C	C

ATTACHMENT
1B

PROGRAM LEARNING OBJECTIVES

SEMESTER	ENGINEERING			MANAGEMENT			EMPLOYABILITY		
	SKILLED ENGINEER	SOUND FOUNDATION	COMPETENT WRITING	TEAMING SKILLS	KNOWLEDGE TRANSFER	PROJECT MANAGEM'T	IMMINENT EMPLOYAB.	PERFORM ENTRY LEV'L	COMFORT w/PEER REV
FR - FALL	A	A	A	A	A	A	A	A	A
FR - SPRING	A	A	A	A	A	A	A	A	A
SO - FALL	U	A/U	U	A	U	U	U	U	U
SO - SPRING	U	U	U	U	U				U
OPT. CO-OP	U			U			U	U	
JR - FALL	U	U/C	U	U	U		U	U	U
JR - SPRING	U/C	U/C	C	U/C		U	U	U	C
CO-OP 1	U/C			U/C		U	C	U/C	
SR - FALL	C	U/C	C	U/C	C		C	U/C	
SR - SPRING	C	U/C	C	C	C	C	C	C	C
CO-OP 2	C			C		C	C	C	
FY - FALL	C	C	C	C	C	C	C	C	C
FY - SPRING	C	C	C	C	C	C	C	C	C

ATTACHMENT 2

DETERMINATION OF LEARNING LEVEL FOR STUDENT PORTFOLIO DEVELOPMENT

In order to properly develop and maintain a portfolio to demonstrate achievement of learning objectives, it is first necessary to fully understand the nature of those objectives. This document defines the various learning objectives to be met and defines the level of achievement expected at the end of each semester.

Wentworth has defined twelve specific learning and competency objectives. They are the following. Note that at the end of each definition, in parentheses, is a short name for this specific learning objective. That name corresponds to the name on the chart showing the level of knowledge expected each semester with respect to that learning objective.

1. A Leader is a person with commanding authority or power. Leadership is the effective use of that authority or power in guiding or directing others towards the achievement of a common goal. It is a characteristic that is often considered to be an innate character trait rather than a learned skill. Nevertheless, it is possible to develop skills which help draw out the innate leadership abilities that everyone possesses and this criterion evaluates the degree to which the student has developed those skills at Wentworth. ("Leadership Qualities")
2. The art of analytical thinking encompasses the concept of being able to separate a problem into its component parts in such a way that each part can be independently solved in some creative manner and the sum of the partial solutions will yield an acceptable solution to the whole problem. Effective use of this skill requires an understanding of how to visualize a problem in different ways, an ability to recognize and apply the underlying theory, and an understanding of how to dissect a problem so as to understand its component parts. This criterion measures the ability of the student to think analytically and to apply that form of thinking to effectively solve engineering problems. ("Analytical Thinking")
3. An advantage to analytical thinking is that it leads to innovative problem solving by identifying potential solutions that are creative and new, or new applications of old solutions. This is the essence of innovative problem solving. Engineers must always be alert to the possibilities of innovation in their designs. This criterion measures the degree to which the student has mastered the art of innovative problem solving. ("Innovative Problem Solving")
4. Virtually all engineering projects of any significance are done by a team of engineers and professionals from other disciplines, rather than by a single engineer. The engineer who can not effectively participate in and/or lead a team of professionals in the development and completion of a project will quickly stagnate. This criterion evaluates the degree to which the student has mastered the complexities of team participation and leadership. ("Team Building")

5. Effective communication of ideas and concepts is a key ingredient of life, in general, and in participation in professional activities in particular. The professional who can effectively communicate ideas and thoughts verbally and in writing, to small groups and large audiences, to technically competent audiences and to non-technical audiences of all ages, will be the most successful. It has been said that a mediocre professional who communicates well will be perceived better than the brightest professional who communicates poorly. This criterion evaluates how well the student is learning effective communication skills and the variety of skills learned. (“Commo. Skills”)
6. Usually, after all the data have been collected and all the analyses have been made, a decision has to be made on what solution to use, what process to develop, what problem to solve next, etc. Decisions are seldom made on the basis of complete information and most have to be made at the least convenient moment. The ability to make the correct or best decision is an art that can be learned and developed. While effective decision making is often considered a part of leadership, it is also distinguished as an independent trait. This criterion measures the students ability to make rational decisions and to support those decisions with justifying data. (“Decision Skills”)
7. Business acumen implies a quickness and propriety of judgement and an effective insight into entrepreneurial matters. To the nascent entrepreneur graduating from Wentworth, the application of this skill is most likely going to be first in the area of project development and management, and later in the organization and management of a business enterprise. For those who do not wish to manage a business, it is still essential to understand the essence of business, how it functions, the effects of business decisions on design, the effects of design decisions on business, and how the individual fits into the operations of the business. This criterion evaluates how well the student has mastered the various characteristics of a business in his/her chosen profession. (“Business Acumen”)
8. The issues of importance to society change over the years, often dramatically even within the time frame of a single generation. It is essential that the practice of professional skills relate to the issue with which society is grappling at the time, rather than to issues of the past. It is relatively easy to re-solve old problems, but where society no longer sees the old ways as valid or acceptable, the professional has a duty and obligation to change the way he/she practices. The practice of a profession needs to be reflective of the societal issues of the day and the engineer needs to understand the social impacts of his/her designs. This criterion evaluates the degree to which the student understands how to determine the societal issues of importance and how to adapt the practice of his/her profession to best meet current societal standards. (“Applic. to Contem’y Society”)
9. All of the professional practices taught at Wentworth involve design. For example architects design buildings, interior designers design living and working areas, civil engineers design earthworks and other structures, environmental engineers design processes to treat and manage wastes, and computer scientists design computer programs and hardware. The design process is an intricate tapestry of technical skills, mathematical and scientific knowledge, and social sciences woven together to achieve a

desired end. The art of design is developed over time from practice. This criterion evaluates the degree to which the student has mastered the ability to apply this skill to his/her professional activities. ("Thorough Knowledge of Design")

10. A hallmark of a Wentworth education is the opportunity to practice learned skills in the marketplace under well supervised conditions. This is the essence of effective cooperative education. In order to gain from a co-op assignment, the student must be capable of providing useful work to the co-op employer in exchange for being taught how the technical skills learned in school are applied to real situations. This criterion measures how well the student has been prepared for the co-op experiences he/she will undergo as a required part of the education process. ("Cooperative Work Experience")
11. To be effective, a professional must be able to work quickly and correctly. Wasting time means wasting dollars and professionals who consistently waste dollars are of limited value to an employer. The goal of this criterion is to measure how well the student has learned the skills needed to work efficiently, which means both quickly and correctly, and with minimal supervision. ("Ability to Work Efficiently")
12. Finally, it is important for all professionals to recognize that the world is an ever changing place and that the practicing professional must change with it. Change usually means the need to develop new skills and to understand how to use new tools to solve new problems or to rise to new opportunities. Learning is a life-long experience that can be enhanced with the proper motivation and skills. This criterion measures how well the student has developed the skills and motivation to continue his/her education beyond Wentworth and throughout his/her entire career. ("Lifelong Learning Skills")

In addition to the Institute Learning and Competency Objectives, the Environmental Engineering Program has its own objectives. Those parallel the Institute objectives in many ways, but they also add some additional concepts specifically related to the practice of environmental engineering. Those objectives are the following, along with the shortened name for each, in parentheses, that corresponds to the chart titles.

1. Wentworth expects its engineering graduates to possess those skills needed to be a skilled and competent engineer. It is not possible to learn all those skills at once, but it is possible to develop many of those skills over a period of several years of schooling. Others are necessarily developed over many years of practice after graduation. Nevertheless, it is expected that graduates will be competent engineers and that the skills to develop that competence will be learned during the five years spent at Wentworth. This criterion evaluates the degree to which the student has grown towards the level of confident competence expected in this area at graduation. ("Skilled Engineer")
2. In order to become a competent engineer, the student must necessarily develop a sound foundation in basic engineering tools and skills. This includes competence in areas such as mathematics, including algebra, trigonometry, calculus, differential equations, and statistical analysis techniques, chemistry, physics, mechanics, strength of materials, thermodynamics, and the design of environmental processes. This criterion evaluates the

degree to which the student has understood the basic mathematics and science courses upon which professional practice is founded. ("Sound Foundation")

3. One of the most important skills an engineer can develop is that of competent and effective communication, both verbal and written. Environmental engineering requires the preparation of a wide variety of technical documents, each with its own objective and its own form of presentation. The competent engineer must be skilled in the preparation of all the various forms of technical documents. This criterion, which is differentiated from the communication skills defined as an Institute Learning and Competency Objective, evaluates the degree to which the student has grown towards the level of confidence and competence expected in this area at graduation. ("Competent Writing")
4. Consistent with the Institute Learning and Competency Objective for the development of team building skills, the Engineering Program Objectives also require the development of team building skills. This criterion evaluates the degree to which the student has developed those skills. The achievement level in this criterion will generally be consistent with that for the Institute Learning Objective for the development of team building skills. ("Teaming Skills")
5. The Institute Learning and Competency Objectives include a requirement for the development of effective communication skills. This fifth Program Objective presumes the understanding that an effective engineer must be able to communicate technical concepts and ideas to a wide range of audiences with equal skill. Consistent with the Institute Learning and Competency Objective for development of communication skills, this criterion evaluates the degree to which the student has developed the ability to communicate effectively, both orally and in writing, to technical and non-technical audiences. ("Knowledge Transfer")
6. The management of engineering projects is a special skill different from other types of management. An engineer must be able to manage projects effectively and efficiently, within specific budget and time constraints. Those skills are learned over the course of an engineering program and through the practice of those skills during cooperative education stints. This criterion evaluates the degree to which the student has developed the level of competence expected in this area at graduation. ("Project Management")
7. The ultimate goal of all engineering programs is to provide graduates, who have the skills required, the opportunity to employ those skills in the field of expertise for which they are being trained. In this program, that field of expertise is Environmental Engineering. That field incorporates several specialty skills not necessarily required in other fields of engineering. It is the goal of this program to ensure that the Wentworth environmental engineering student is fully qualified for work in the environmental engineering field at each step of the cooperative education program and at graduation. The skill levels required and expected at the end of each semester are different and increasingly more complex. It is understood that a first or second year student will have just begun to develop those skills, while more advanced students will have developed them to a greater

degree. This criterion evaluates the degree to which the student has developed the level of competence in this area expected of a graduate. ("Imminent Employab.")

8. Upon graduation, the Wentworth Environmental Engineering student is expected to be able to work at an entry level, or higher, position immediately. It is expected that the marketplace definition of the skills required for "entry level" work will change as the student progresses through the program and looks to the workplace for employment in optional or mandatory co-op positions. The further along in the program a student has progressed, the greater the skill levels expected of that student by a prospective employer. It is a goal of the program to ensure that students are imminently employable at each stage of their Wentworth career. This criterion evaluates the degree to which the student has developed the appropriate level of competence in this area expected of a graduate performing entry level engineering tasks. ("Perform Entry Lev'l")
9. The final defined program objective is to prepare students for peer review of their work. It is one thing to have a professor evaluate student work and critique it. It is a much different thing to have another engineer critique one's work or for one engineer to critique the work of another engineer. It is a goal of the program that graduates will have experienced the role of a peer reviewer and to have had their work peer reviewed and critiqued. This criterion evaluates the degree to which the student has grown towards the level of confidence in doing and receiving peer reviews expected at graduation. ("Comfort w/Peer Rev.")

ATTACHMENT 3

DEFINITIONS OF ACHIEVEMENT LEVELS

The chart attached hereto indicates the expected level of competency to be achieved for each of the various learning objectives defined above at the end of each semester. The expected levels are defined in terms of "Awareness", "Understanding", or "Competency", designated on the chart as "A", "U", or "C".

A level of **Awareness** is defined as having been introduced to and being familiar with the meaning of the basic concepts and applications for an objective. At this level a student will have heard about, or been introduced to, the concepts and their applications, but may not be comfortable using them yet.

A level of **Understanding** is defined as having a knowledgeable comprehension of the concepts and the applications of the objective, beyond mere awareness. At this level, the student should be able to use or apply the concepts correctly in at least limited situations.

A level of **Competency** is defined as the successful application of the concepts in the classroom and/or during a cooperative work assignment.

Students should prepare their portfolios with the above definitions in mind and demonstrate by example that they have achieved the various levels of learning required. Students are highly encouraged to discuss their portfolios with their academic advisor and/or the professor in charge of the class in which it is to be submitted, if and when questions arise. Students are very strongly encouraged to develop the portfolio on a continuous basis. Waiting for the last couple of weeks to try to re-find all the supporting documents to make the case will not be effective.

ATTACHMENT 4

DEVELOPMENT OF STUDENT PORTFOLIOS

IN THE

ENVIRONMENTAL ENGINEERING PROGRAM

There are many objectives to be met in any educational program. Those objectives are variously described in numerous documents and they may be developed at any level within a university structure. At Wentworth, there are twelve defined Learning and Competency Objectives which the Institute has defined for all its graduating students. In the Environmental Engineering Program, there are nine Program Objectives, which build off the twelve Institute Objectives, which the Program faculty expect program graduates to achieve. Finally, in each course offered at the Institute, there is a set of specific course objectives which need to be met.

It is useful for both the student and the faculty of Wentworth to be able to determine whether the educational objectives are being achieved. Students need to be able to know how well they are doing, academically, and they also find that more and more often prospective employers are looking to the student to provide evidence of skill level attainment as a prerequisite to hiring. Faculty need to know how well the lessons they are trying to teach are being received and it is necessary at the time of re-accreditation visits that the Institute be able to demonstrate achievement of the objectives in a positive fashion. Portfolios can serve all those ends well.

Accordingly, it has been decided that beginning with the Class of 2004 (plus all currently registered students in all classes) each student registered in the Environmental Engineering Program at Wentworth will be required to develop and maintain a portfolio of work demonstrating achievement of the various learning objectives. The portfolio will be an integral part of one course each semester, but will cover the work in all classes undertaken that semester. Students will be provided with a list of learning objectives for that semester and the courses in which those objectives are expected to be attained. It will be the responsibility of the student to accumulate evidence, in the form of lab reports, papers, exams, etc., and to submit that evidence, supported by a short analysis of the work presented, to demonstrate his/her achievement of those objectives. The portfolio will generally constitute up to 15% of the final grade for the course in which it is prepared and submitted. Failure to submit an adequate portfolio will result in a failing grade for the course, regardless of the quality of the rest of the work completed.

STUDENT PORTFOLIO DEVELOPMENT CRITERIA

ENVIRONMENTAL ENGINEERING PROGRAM WENTWORTH INSTITUTE OF TECHNOLOGY

It is a requirement of the Environmental Engineering Program that each student prepare a portfolio of work each semester demonstrating that he/she has achieved certain levels of knowledge or competency in specific areas. Each area is defined by a Learning or Competency Objective. In the early years of the program, a student is generally expected to become aware of the various objectives and their meaning. In the mid-years, the student is expected to gain an understanding of how and when to use the theories and concepts learned. In the last years of the program the student is expected to become competent in applying the theories and concepts to the solution of engineering problems.

Achievement of learning objectives will focus on whether a student has gained the intended level of ability with each objective in each semester. Not all of the learning objectives will necessarily be addressed in each semester. Students will develop a portfolio of work examples, including tests, papers, reports, laboratory reports, projects, etc., which, by the grades and or comments provided by the Professors, demonstrate achievement at the required level.

There are two sets of Learning Objectives which need to be addressed. The first is the set of Institute Learning and Competency Objectives, of which there are twelve. The second is the set of Program Learning Objectives, of which there are nine. Two charts are appended hereto which define the expected level of achievement in each Objective in each set, by semester. The expected achievements were developed from a review of the various course work offered during each semester. The student does not need to achieve the various educational objective levels in specific courses; only in specific semesters. It is the intent of the program that the student will identify the courses in which the expected achievement has occurred. This will help the faculty do a better job of curriculum planning for the future and provide the student an opportunity to identify areas of technical skill development in which he/she may need to place more effort in the future.

The Portfolio will be a requirement in only one course each semester, but will address the learning which has occurred in all courses taken that semester. The portfolio will be graded and will count as part of the final grade in the courses for which it is required.

Students will prepare two separate, but identical, portfolios. One will be turned in at the end of the semester and will be placed in the student's permanent portfolio file in the Department. The second copy is one that the student will maintain as a continuous file throughout his/her stay at Wentworth.

The copy retained by the student is intended to serve several purposes. First, in the event of damage to or loss of the official file, the student will have a back-up copy with which to demonstrate compliance with the requirement to date. Second, the student will be able to see the

growth of learning as he/she progresses through the program at Wentworth. Third, it provides an opportunity for the student to demonstrate to potential co-op or permanent employers that the student has, in fact, acquired specific knowledge and skills at the time of the interview. This can be very helpful to a prospective employer in finding the right niche for the individual and should help with the procurement of employment by the student.

The copy retained by the Department will be used during accreditation visits to demonstrate that students have achieved the learning objectives intended by the faculty.

In order to properly prepare a suitable portfolio, students are very strongly encouraged to maintain copies of suitable documents as the semester develops. It is not necessary to include every test, every report, every paper or every project. Only a sufficient number needs to be included to properly and adequately demonstrate achievement of the various objectives for that semester. Each student is also strongly encouraged to discuss portfolio development with his/her advisor whenever a question of suitability of a document or the intent of the project arises.

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