DEVELOPING SKILLS IN PROJECT DEVELOPMENT

ABSTRACT

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INTRODUCTION

Today's competitive need to develop high quality products has redefined the development role of engineers and engineering technologists. Historically, they have been hired to manage their own technical work activities and have not been expected to take on responsibilities required for overall project success. Today, engineers and engineering technologists assume much broader responsibilities. Responsibility for achieving specific technical performance requirements is now coupled with achieving requirements for project management, concurrent engineering, interdisciplinary problem solving, and teamwork. In effect, engineers and technologists assume two project development roles; project designer and project manager. As project designers they are responsible for completing assigned design tasks. As project managers they are responsible for defining a comprehensive and integrated plan which reflects overall development requirements and is aimed at achieving overall project success.

The New Jersey Institute of Technology (NJIT) Engineering Technology (ET) department has implemented a senior project course which is responsive to the changing role of engineering technologists. Specifically, the senior project course for NJIT's Electrical Engineering Technology (EET) program emphasizes two aspects of project development: 1. project design and 2. the development process associated with design and implementation. Although achieving a working model of a project is considered of prime importance, equal importance is given to the development process used to design and implement a project. Projects serve as a means (i.e. vehicle) for developing student technical skills as well skills in project management, concurrent engineering, interdisciplinary problem solving, teamwork, and communications. Instruction and training in these skill areas is an essential element of the EET senior project course described in this paper. Detailed descriptions of the skill areas as they apply to a senior project course have been provided in other companion papers (see references 7, 8, and 9). This paper is primarily concerned with the structure of the EET senior project course.

COURSE DESCRIPTION

The EET senior project course takes place over two semesters. Each semester consists of fourteen weeks. During each week of the first semester two hour lectures are given on the basic topics related to the project development process. The topics covered including the following:

- Projects and their .inter-dependencies .
- The project life cycle and its phases.
- Project life cycle deliverables.
- The development process as its relates to the project life cycle.
- Project management.
- The-concurrent engineering design process.
- Design review meetings.
- Project development evaluation and reporting.

The second semester consists of two hour, weekly laboratory classes. During this semester students build and test their projects. The semester ends with a final project report, presentation, and demonstration.

Course outlines for the first and second semester courses are given in Appendices I and II. A description of the development activity occurring during each semester is given below.

FIRST SEMESTER: In parallel with the first semester lectures students undertake the development of their senior projects in accordance to the topics covered and the initial phases of the project's life cycle. These initial phases are the concept phase, the definition phase, and the design phase. The build and test phase, and the closeout phase are left for the second semester.

Project development begins in the first semester with the concept phase. During this phase the student does research on possible projects and works with the instructor to define the basic concepts of a design project. Appendix III contains the guidelines and requirements provided to students for project selection and development. When the student and the instructor agree on the basic concepts of a project the student then prepares a formal project proposal. The proposal is graded by the instructor and submitted to an EET faculty committee for final approval.

The definition phase officially starts with final committee approval. During the definition phase of the project the student prepares a project requirements specification (PRS). The PRS specifies the detailed requirements on which the design will be based. It is a document that defines "what" must be done as opposed to "how" it must be done or implemented.

The definition phase continues with the preparation of a project development plan. During this phase and using information on project management provided during the lectures, the student prepares a work breakdown structure (WBS), dependency analysis, resource estimates, and schedule for the project. All work activities and tasks, dependencies, resources, dates, and deliverables are defined and documented as the official project plan for the project over its life cycle.

The proposal, PRS, and the project plan are submitted for grading. Students are required to correct the graded documents and resubmit them as part of a final report for the project.

The design phase officially begins with the completion of the definition phase. During this phase the student completes the paper design of the project. The phase is completed at the end of the semester with the submission of a documented design specification. The design specification represents the draft design of the project and includes the second level block diagram, the circuit diagrams, untested software coding, and the definition of how the project will be tested (i.e. the test strategy, tests, and expected test results) .

The draft design specification is graded by the instructor and returned to the student at the beginning of the second semester of the senior project course. It is the basis on which the second semester activities are defined. Detailed instructor comments are provided with the graded draft specification.

During the first semester students are grouped into three person teams. The purpose of a team is to perform design reviews on the project of each team member. Each student takes a turn in presenting his or her project to the other team members. These other team members review the project technically and from a manufacturability, testability, and serviceability perspective.

Each student is responsible for calling the meeting, running it, and for writing the meeting minutes of their respective project review meeting. Lectures are given on these meeting topics.

SECOND SEMESTER: During the second semester students complete the final phases of their project 's life cycle;

- Build
- Test
- Closeout

The instructor who taught the first semester of the course is also the instructor for the second semester. Students meet weekly with the instructor as a group, and individually as required. The design specifications completed in the first semester are returned to the students with detailed instructor comments. These comments focus on the following:

Technical content.
Adherence to guidelines and requirements provided in the first semester.
Modularity of the design.
Test plan definition
Size of the project.

A primary emphasis in the second semester is student commitment. After the first semester students begin to understand the realities of the development process and methodology being taught. As a result, they often realize that what they initially defined as a deliverable project cannot be achieved by the end of the semester. This. realization is used by the instructor to again highlight important aspects of the project development process. Specifically with regard to project planning and the time it takes to reflect concurrent engineering aspects of a project in its overall development schedule.

At the beginning of the semester, students are asked to reconsider their project objectives and deliverables to insure that a meaningful and working project will be delivered at the end of the semester. This is done during the first two to three weeks of the semester. With the instructor's approval, students often reduce the scope of their projects. Priority is given to achieving the schedule at the expense of reduced technical content and/or increased project cost, but not at the expense of delivering a project which is meaningful. Final instructor approval is required and involves discussions similar to that which might occur in industry involving project plan changes. When changes are made students revisetheir project plans and design specifications, accordingly.

During the second semester, the project plan must also be revised to reflect a phased delivery of project modules. Experience has shown that letting students deliver the whole project at end of the semester often leads to incomplete projects. At least three modules must be defined and integrated to complete the project. Integration of the last module takes place at the end of the semester and completes the total project development. The requirement for phased deliveries also supports earlier lectures promoting modular project design.

During the semester students are required to prepare at least two progress reports indicating progress on their projects. Lectures are given on how to write progress reports and on topics related to evaluating and measuring project progress.

CONCLUDING COMMENTS

A primary objective Of NJIT's EET senior project course is to introduce and train students in the fundamental concepts and skills associated with successful project development. The course emphasizes the development process required to take a project from its concept phase to its defined closeout phase. Project management and concurrent engineering are key methodologies used in this process and primary topics of the course. At the conclusion of the course, students not only complete a meaningful technical project, but also have developed a portfolio of documentation illustrating the development process used to develop their projects. These portfolios has proved to be very useful in student interviews with prospective employers.

APPENDIX I

EET 401 SENIOR PROJECT COURSE OUTLINE
FIRST SEMESTER

LECTURE	TOPICS	ASSIGNMENT	DUE LECTURE
1	Course Description & "Requirements. Project Proposal Outline	Read Sections 1 2 & 3 EET 401 Manual	2
	Project & Project Dependencies, Multi-Level Project Perspective, Project Teams Project Life Cycle	Identification/ Library Research & Selection of Project	2
		Project Proposal	3
2	Preliminary Student Description of Projects	PRS	4
	PRS Outline Project Development Process -	Read EET 401 Manual Section 4	3
3	Concurrent Engineering	Read EET 401 Manual Section 5	4
	PROJECT PROPOSAL DUE		
4	Design Specifications - 2nd. HW Level Block Diagrams - Operational Flowcharts	Read EET 401 Manua 1 Section 7 pgs . 68-72: 2nd. Level Bk. & Flowcharts	5
	PRS DUE		
5	2nd. Level Block Diagram & Operational Flowchart Presentations		
	2ND. LEVEL BLOCK DIAGRAMS & OPERATIONAL FLOWCHARTS DUE		

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	PRS DUE		
	2nd. Level Block Diagram & Operational Flowchart Presentations		
	2ND. LEVEL BLOCK DIAGRAMS & OPERATIONAL FLOWCHARTS DUE		

APPENDIX I (CONTINUED)

EET 401 SENIOR PROJECT COURSE OUTLINE

FIRST SEMESTER

COURSE GRADING:

Item	Percent of Final Grade	Grading Criteria
Proposal	10%	Clarity, Technical Content, Library Research.
PRS	20%	Completeness, Clarity, Concurrent Engineering (CE) Aspects.
Project Plan	20%	WBS Analysis, Schedule (Gantt & Network) , Resource Analysis.
Design Specification	35%	Clarity, Technical Content, CE Aspects, Test Plan.
Professionalism	15%	General Development Approach, Teamwork, Approach to Peer Design Reviews, Meeting Minutes, Presentations, General Attitude, Lab Notebook.

THE USE OF CORRECT ENGLISH GRAMMAR AND SPELLING WILL BE REFLECTED IN THE OVERALL GRADE OF SPECIFIC PROJECT DOCUMENTATION. POINTS CAN BE LOST FOR POOR ENGLISH GRAMMAR AND/OR SPELLING. UP TO 10

AT THE END OF THE SEMESTER THE PROJECT PAPER DESIGN (I.E. THE DESIGN SPECIFICATION) MUST BE COMPLETED AND SUBMITTED FOR GRADING ALONG WITH CORRECTED VERSIONS OF THE OTHER PROJECT DOCUMENTATION (I.E. THE PROPOSAL, PRS, AND PROJECT PLAN). THE PROJECT DOCUMENTATION IS USED AS A BASIS FOR IMPLEMENTATION IN EET 402.

STUDENTS MAY BE REQUIRED TO SUBMIT DoCUMENTATION TWICE IN ORDER TO MEET DOCUMENT REQUIREMENTS. THE RESUBMITTED DOCUMENT WILL BE REGRADED. THE FINAL GRADE FOR THE DOCUMENT WILL BE THE AVERAGE OF THE INITIAL GRADE GIVEN TO THE DOCUMENT AND THE GRADE OF THE RESUBMITTED DOCUMENT.

APPENDIx II

EET 402 SENIOR PROJECT COURSE OUTLINE
SECOND SEMESTER

CLASS	TOPIC	ASSIGNMENT	DUE LECTURE
1	Lecture on Course Requirements. Return of Design Specifications & Comments. Modular Design and Design Reviews. Phased Project Deliveries.	Revision of Design Spec. Revision of Project Plan.	3
2	Formal Presentations		
3	Student Presentations on Project Commitment, Modules, & Phased Deliveries REVISED DESIGN SPEC. DUE . UPDATED PROJECT PLAN DUE Open Lab	Phase 1 Delivery	5
	Lecture on Progress Reporting Student Phase 1 Demos PEASE 1 DELIVERY DUE	Phase 2 Delivery Phase 2 Delivery Progress Report	9 6
	Open Lab Student Presentation on Phase 2 Progress PHASE 2 PROGRESS REPORTS DUE		

APPENDIX II (CONTINUED)
EET 402 SENIOR PROJECT COURSE OUTLINE
SECOND SEMESTER

COURSE GRADING

Deliverable	Percent of Final Grade	Grading Criteria
1. Updated Project Plan	10%	Completeness in Terms of Defined Activities, Clarity, Depth of Dependency Analysis, Reasonableness of Estimates.
2. Progress Report	5%	Clarity and Completeness.
3. Updated Design Specification	20%	Technical Completeness, Concurrent Engineering (CE) Aspects, Test Plan, Clarity, Modularity of Design).
4. Peer Reviews of Design.	10%	Preparation, Content, Completeness, Understanding, Clarity, Accuracy.
5. Final Report	10%	Content, Completeness, Clarity
6. Project Model Presentation/ Demonstration	30%	Construction of Project, Modularity, CE Implementations, Level of Operation, Clarity of Presentation, Technical Understanding.
7. Professionalism	15%	General Development Approach and Attitude, Adherence to Commitments, Oral Reports and Minutes, Achievement of commitments, Teamwork, Management of Project Dependencies, project Communication with Instructor/Peers.

APPENDIX II (CONTINUED)
EET 402 SENIOR **PROJECT COURSE** OUTLINE
SECOND SEMESTER

CLASS	TOPIC	ASSIGNMENT	DUE LECTURE
8	Open Lab		
9	Student Phase 2 Demos	Phase 3 Delivery	13
		Phase 2 Progress Report	11
10	Open Lab		
11	Student Presentations on Phase 3 Progress		
	PHASE 3 PROGRESS REPORTS DUE		
12	Open Lab		
13	Student Phase 3 Demos		
	Lecture of Project Final Report, Presentations, Demonstration.	Final Project Report, Demos., Presentations.	14
14	Final Presentations & Demonstrations	NO LATE PROJECT WILL BE ACCEPTED.	
		NO INCOMPLETE GRADES WILL BE GIVEN.	
	FINAL REPORTS DUE		

NOTE: ATTENDANCE OF ALL CLASSES IS MANDATORY

APPENDIX III: PROJECT GUIDELINES AND REQUIREMENTS

1. Projects may be stand-alone, smaller projects, or part of a larger project being implemented by a team of two or three other students. Team projects must be organized with one member functioning as the project leader and the other members being individual contributors. Normally the project leader must have some industrial experience related to the project.

2. All projects must have both a hardware and software content, and be planned to achieve a working hardware/software model. A rule-of-thumb for the project Size is to limit the size to one that can be completed by a competent and experienced engineering technologist within approximately 2-3 work weeks.

3. Projects can be based on a previously designed or commercially available device but the student must make an original contribution that requires both hardware and software design. The original contribution can be a novel system application requiring additional hardware and software design, or an extended design that increases the functionality of an existing design.

4. The original contribution aspect of a project should repreSent at least 25% of the available design. That is, approximately 25% of the project must be designed and built by the student.

5. It is highly desirable but not required that projects be real industrial projects defined in partnership with a co-op, summer or current/potential employer. In these cases the industrial partner is expected to provide the detailed requirements, parts and any special equipment required to complete or test the project at NJIT or at the industrial partner's plant.

6. Simulation is required for at least one module of the project hardware design. The selected module must be approved by the instructor. The simulated module must also be laid out and/or built on a Printed Circuit Board. The student is required to use a CAD program (i.e. PADS 2000 or ORCAD) to draw the circuit schematic, produce the bill of materials (BOM), design the circuit board, and route the circuit board.

7. All projects are required to be developed using the principles of concurrent engineering and program management. In this regard both hardware and software designs must be implemented in accordance to a detailed project plan and using meaningful aspects of concurrent engineering. As a minimum, students are required to

demonstrate the application of three primary aspects of concurrent engineering in their project designs:

Design for manufacturability.
Design for testability.
Design for serviceability.

8. In some cases paper design projects may be approved. These projects will normally be large system oriented projects requiring more than one semester to complete. They are usually associated with NJIT and/or industrial sponsorship.

9. Students are required to conduct at least one major "design review" meeting for their projects. Periodic oral and written reports on project status are also required.

10. Students are required to write the following documents pertaining to their projects:

Project Proposal
Project Requirements Specifications
Project Summary Plan
Design Specification

Draft versions of the above documents must be submitted to the instructor for grading. Final versions of all of the documents must be submitted at the end of the semester. These final documents must update and correct the draft versions in accordance to the comments made by the instructor.

11. Students are required to obtain a laboratory notebook similar to those sold in the NJIT bookstore. The notebook should be used to record the entire history of the project including efforts that are not successful.

Notebook entries should be made which document each day's activity on the project. These activities include design analysis, implementation and testing, meetings, telephone calls, draft designs, block diagrams, test data, and efforts that are unsuccessful. Entries should be completed to a level which would permit another Engineering Technologist to take over the project using the notebook.

Each page of the notebook should be pre-numbered and dated as entries are made. The front page of the notebook should be set aside for the faculty advisor's comments and grade.

12. Project documentation should be submitted for grading in accordance to the schedule and course outline.