

STUDENT ASSESSMENT IN A CAPSTONE COMPUTING COURSE

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ABSTRACT

The capstone computing course at our university provides students with experience working on real-world computing and information systems projects. Students have the opportunity to develop both the hard and soft skills that are sought after by industry. The structure of the course has evolved from a traditional face-to-face format to a web-assisted format with only three face-to-face class meetings. With the current essentially online nature of the course, student assessment has required development of improved assessment tools. Both the project work team-level assessment and the peer evaluation individual-level assessment methods have been extensively revised, while maintaining student satisfaction and quality of project deliverables at a high level.

Keywords: Capstone computing courses, student assessment, project-oriented courses, distance education, collaborative skills.

1. INTRODUCTION

A capstone masters-level course is required in most master's programs to bring together major aspects of the academic disciplines related to the major [4] [7]. The aim of our capstone course in computing is to familiarize students with how their trade is plied in organizations, so that the program of study delivers "the practice" part of the promised "theory and practice." The projects are real-world because they entail the development of an application desired by a real-world customer. As in industry, applications are developed by a small, collaborative team which needs to communicate with the customer, coordinate its activity, attend to internal decision-making, and, as observed by Denning and Dunham [6], be sensitive to delivering value. The applications usually require familiarity with current technology. Students learn about real-world technology through their own group's experiences as well as through the reports from other groups. Important soft skills, emphasized by activities throughout the capstone experience, are the ability to communicate on technical concepts and issues orally, in written reports, and via Web media; to both peers and non-technical people. The soft skills acquired through a capstone course are one of the greatest rewards of the capstone experience. These include problem solving, communication, and teamwork skills which are essential for work in industry [8].

A 15- year review [12] of our capstone course in computing (2001-2015) described changes over the years, the most significant one from a two-semester, face-to-face format to a one-semester, web-enhanced course where dispersed students collaborate remotely except for three face-to-face classroom meetings. This paper focuses on student assessment in the course.

The remaining sections of the paper cover the following material: section 2 presents the course management activities, section 3 describes how students are assessed; and section 4 provides conclusions.

2. COURSE MANAGEMENT

Most projects are generated by real-world customers and approved by the instructors, often after discussions and modifications to make the project appropriate for the course. Project sources include faculty research, doctoral student research, internal university needs (databases with web interfaces, IRB system, etc.), and external community systems (computing systems for local hospitals, collaborative research with other universities, etc.), local hospitals or university departments needing various types of computing infrastructure. Project descriptions are posted on the course website and the students complete a survey where they list their project preferences, technical skills, and geographic location. The instructors assign students to teams and projects based on the student survey input. This selection process achieves diversity of academic performance, location, gender, and nationality which helps students develop important social and teamwork skills necessary to develop the project systems [10]. Many of the teams are geographically dispersed [14] which prepares the students for the growing business demand [9].

Our university has campuses in New York City and Westchester, NY. Currently about two-thirds of the students live or work in the greater New York City area. The remaining third are mostly from other regions of the East Coast with some from as far away as California and foreign countries. The distributed team issue is handled by a number of mechanisms and guidelines. For example, to facilitate communication among the project stakeholders, we insist that, except for extenuating circumstances, communication between a team and instructor, and between a team and a customer, be through the team leader, with all team members copied on communication email and given summaries of face-to-face meetings. This reduces communication to the instructor from individual students and keeps all stakeholders updated on project activities. The instructor also creates and uses email distribution lists for the whole class, for each project team including the customer, and for the customers. Project team leaders must be local, either living or working in the greater New York City area, to permit occasional face-to-face meetings with the project customers and instructor. Another challenge is the ability to build trust among team members. The term “jelled team” has been used to describe a strongly knit team that relies on trust. The probability of project success for “jelled teams” increases significantly when compared to other teams [11].

An extensive course website maintained by the instructor efficiently presents all the course information for convenient centralized access as follows:

- Homepage – instructor information, textbooks, course description and goals, course requirements, and grading system.
- Syllabus – weekly readings and assignments.
- Projects – a table of the semester’s projects provides for each project the customer’s name and contact information, the project description, and the names of the students on the project.
- Students – contains student photos so students know their classmates and the instructor can recall a student, possibly years later, to provide letters of recommendation.
- Project Deliverables – lists and describes project deliverables.

- Grades – contains table of graded events and the current student grades indexed by the last 4 digits of their university ID number.
- Link to the Blackboard educational software system [1] used for quizzes, discussions, and collecting digital assignments.

Three 3-hour classroom meetings are important to bring the local students together (students outside the greater New York City are not required to attend) so they can meet some of their teammates and form face-to-face bonding. The first meeting occurs after the first week of the semester. By this time:

- the students have introduced themselves online through a Blackboard forum, reviewed the course website, and submitted project preference information to the instructor
- the instructor has received the students' project preferences and associated information, formed the student project teams, assigned teams to projects, chosen project team leaders, and posted the information on the project's page of the course website

At this meeting the instructor and students introduce themselves face-to-face (half hour), the instructor gives a lecture on the nature and value of conducting real-world projects in a capstone course (one hour), the instructor reviews the specifics of the course material and describes each of the projects (one hour), and the students group themselves into their project teams and begin planning project activities (half hour). At the second mid-semester meeting the students make PowerPoint slide presentations of their project prototypes. Material covered in these presentations includes, as appropriate and as time permits, a subset of the following items: brief description of project, summary of project specifications, frequency of meetings with customer/stakeholders and usual method of communication, plans to address changes in customer requirements, summary of user stories collected (if any), analyses accomplished (object-oriented might include defined classes and operations), design decisions and the trade-offs encountered, work breakdown structures, PERT chart, and/or Gantt chart, components built/planned, testing strategy, what was accomplished to complete the prototype, what will be added in the remainder of the semester, what has been easy/difficult during this half of the semester, and a prototype demonstration. Many customers attend the second meeting. At the third (semester-end) meeting the students present their final project system. This meeting is similar to the second meeting, and most of the customers attend the final presentations.

The project teams hold weekly meetings (often using such applications as Skype, GoToMeeting, Google Hangouts, etc.) and submit weekly progress reports. The graduate assistant monitors the reports and occasionally drops in for a short time on team meetings. Each team submits a technical paper draft each quarter. The first quarter (Q1) draft must be in the proper paper format, include an appropriate title, abstract, introduction, literature review citing appropriate references, and an approach or methodology. The second quarter (Q2) draft must include a list of key terms, essentially finalized literature review, a methodology, and preliminary findings/results; if a system is being developed, the system should be essentially complete (80-20 rule); and if experiments are being performed, preliminary results should be presented and discussed. The third quarter (Q3) draft must contain all sections and be essentially complete except for final updates; if a system is being developed, the system should be essentially complete except for final updates; and if experiments are being performed, essentially completed results should be presented and discussed. The fourth quarter (Q4) final paper must be in final form for the conference proceedings.

3. STUDENT ASSESSMENT

3.1 Overall Student Grade Determination

In this projects course, 80% of the student’s grade is based on the project work and the remaining 20% on the individual work of taking quizzes based on the reading material (Table 1). Grades on the project work are assigned on a quarterly basis with increasing points as the semester progresses. The maximum number of points that can be earned during the semester is 1000 (100%). Current grades are posted on the course website at each quarter (Q1, Q2, Q3, Q4), indexed by the last four digits of the student’s university ID for anonymity.

Table 1. Course grades.

Grades A=93, A-=90, B+=87, B=83, B-=80, C+=77, C=73, C-=70								
Project Work					Individual Work			
Student ID	Q1 - 10%	Q2 - 20%	Q3 - 20%	Q4 - 30%	Quizzes - 20%	Total	Total %	Letter Grade
	100 pts	200 points	200 points	300 points	200 points	1000	%	Grade
U1234	84	180						
...						
...						
U9003	80	170						

As described in the next two sections, the number of project-work points assigned to a student at a quarterly checkpoint is determined by computing a team assessment relative to the other teams and an individual team member assessment within the team.

3.2 Team Project Work Assessment

The team assessment is computed from instructor and graduate assistant (GA) input, together with the format correctness and Turnitin scores of the technical papers (Table 2).

Table 2. Team assessment: 8 teams, two instructors, one graduate assistant.

Team	Instr 1	Instr 2	GA	Format	TurnItIn	Average
1						
2						
3						
4						
5						
6						
7						
8						

The instructor assessment comes primarily from the content quality of the team technical papers. The graduate assistant’s input comes primarily from the quality of the weekly project team status reports and occasional spot checking of the quality of the team meetings. The format input comes from the graduate assistant’s checking of the correctness of the IEEE format of the technical papers

(length and quality of the abstract, correct citing of references, completeness of references, etc.). The Turnitin input comes from the score of the Turnitin software that measures the degree of potential plagiarism [13]. A Turnitin software score under 20 indicates low potential plagiarism and the score increases as more plagiarism is suspected. Therefore, to obtain a reasonable value in the range 0-100 the Turnitin score is subtracted from 100. After the first two quarterly checkpoints, the Format and Turnitin scores are dropped in order to focus more on the content and quality of the project work and because the teams have usually by this time correctly formatted the paper and properly cited the earlier work.

3.3 Individual Team Member Assessment of Contribution to the Team Effort

Peer evaluations are used to assess the project contributions of each team member. Obtaining individual student grades on teamwork has been reported in the literature. Clark, Davies, & Skeers [5] created an elaborate web-based system to record and track self and peer evaluations, Brown [3] has a system similar to ours but which uses more granular numerical input, and Wilkins & Lawhead [15] use survey instruments. This course employs the numeric peer evaluation scheme reported by Brooks [2], with extensions to include input from the instructors, the graduate assistant, and the project customers.

The students are required to provide peer evaluations four times during the semester, one at each of the quarterly checkpoints. For these peer evaluations each student distributes 10 points among the other members of the team based on the student’s estimate of the team effort contribution of the other team members. The students are told that the main criterion for allocating points is the value of a student’s contribution to the project work, with secondary consideration given to a student’s attendance at weekly meetings and the student’s work ethic and attitude.

A sample peer evaluation summary chart with associated grades is shown in Table 3 for a four-member team. Each of the four team member evaluation columns shows the evaluation of a team member evaluating the other team members, each team member allocating a total of ten points among the other team members as suggested by Brooks [2]. This study extends the evaluations to the customer, the instructors, and the graduate assistant. Therefore, the table includes additional columns, shown in yellow, for evaluations from the customer, the instructors, and the graduate assistant. The summary column shows the adjusted sum of each row of evaluations after subtracting the expected average (the total of the sum column must add to zero), and the grade column shows the individual team member grades. In this example, a team grade of 85% is first determined and then individual grades are adjusted relative to the team grade, and the formulas in the spreadsheet cells perform the calculations automatically.

Table 3. Team summary chart with peer evaluations and extensions.

Team Member	Eval 1	Eval 2	Eval 3	Eval 4	Eval Cust	Eval Inst1	Eval Inst2	Eval GA	Sum	Grade
1		4	2	7	5	5	4	5	12	97
2	5		4	1	1	1	2	1	-5	80
3	0	3		2	1	1	2	2	-9	76
4	5	3	4		3	3	2	2	2	87
Total	10	10	10	10	10	10	10	10	0	85

3.4 Summary of Student Assessment on Project Work

The sequence of grade computations at each quarter is as follows:

- 1 Obtain team grades by completing the team project grade sheet (Table 2).
- 2 Complete the peer evaluation summary chart and enter the team grade from Table 2 into the lower right-hand corner to finalize the individual grades (Table 3). This adjusts individual team member grades relative to the team grade.
- 3 Enter the individual grades into the course grade sheet (Table 1) and post it on the course website.

At each quarterly checkpoint, each student is also asked a number of general questions – the number of hours per week spent on project work, their specific contributions, their strengths and how these were used, their areas needing improvement, and what has enhanced and/or challenged their team’s performance – and the responses might influence an instructor or graduate assistant evaluation of a student’s contribution to the team effort. For additional input the instructors can discuss team member contributions with the team leader.

Since this is a project-oriented course with no midterm or final exams, student grades depend mostly on their contribution to the project work. The usual expected time commitment per student for a 3-credit course is three hours per week in class and twice that outside of class, for a total of nine hours per week. However, because this is essentially an online course where students save commuting time, the expected time commitment is about ten hours per week, and this additional time commitment is one of the advantages of a distance-learning course.

4. CONCLUSIONS

Capstone courses are important to computing and information systems education. Students develop hard and soft skills, are exposed to a wide range of topics, and foster interdisciplinary collaboration. The project deliverables also provide valuable systems for the customers and support student and faculty research. This enhances relationships between the university and local technology companies, and affords students the opportunity to acquire internal and external publications. Our yearly internal conference is complete with a review process and proceedings, and we have found that working to produce publications is a strong motivating factor for the students. Current students report high satisfaction with the course and graduates working in industry report the value of having had the experience of working on real-world projects.

5. REFERENCES

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