Assessing the Assessments in a Senior Computer Engineering Technology Capstone Course

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Abstract

This paper presents an analysis of assessment techniques utilized for ELET 4308, a senior level capstone course in Computer Engineering Technology in the College of Technology at the University of Houston. The current format of the capstone class has been in place since 2004. From the beginning, it has been necessary to study various factors that impact student academic performance and learning to ensure that the course is fulfilling its educational responsibilities. A key component of this evaluative process has been the development and implementation of a multi-faceted assessment plan. The paper provides an exploratory analysis of the most recent assessment instruments used to evaluate each student and team in the class from fall 2006, spring 2007, and fall 2007. Using multiple-regression modeling, we examine the predictive effectiveness of intermediate assessment tools (e.g. midterms, project proposals) in terms of summative course outcomes. While assessment tools in fall 2006 and fall 2007 generally functioned as appropriate predictors, the specific variables varied slightly. However, the effectiveness of assessments in spring 2007 was tenuous. The paper concludes by discussing the implications of the results as well as outlining next steps in the assessment process for the course.

Introduction

The intent of the Computer Engineering Technology capstone course (ELET 4308) is to provide students with a dynamic learning environment that simulates industry expectations (e.g. deadlines and production of deliverables). The assessment and evaluation structure of the course encourages active participation and exposes students to all phases of the project development life cycle. Technical depth of the subject, team work, planning, scope, student commitment and successful execution of the prototypes are some of the factors which play a role in successful completion of the course.

The nature of the capstone class calls for a multi-faceted assessment process. The capstone class emphasizes a course structure that gives students an opportunity to demonstrate growth in different ways rather than focusing solely on objective exams although these are still utilized. A variety of assessment activities provide multiple sources of data that are used to build a thorough picture of student learning and academic performance in this environment. This strategy is consistent with best practices that

suggest a multi-pronged approach to evaluating student learning. At different stages in the class, students submit work and receive feedback regarding their progress. The focus is on continuous improvement.

Given the focus on continuous improvement, a key question is whether course assessments function in concert to support learning. More specifically, do intermediate course assessments serve as appropriate checks on student progress towards successful completion of the ELET 4308 capstone course? The purpose of this paper is to examine the relationship between intermediate and final outcomes in the capstone class.

Methods

The intent of this paper is to use exploratory multiple-regression modeling to determine the predictive validity of several intermediate outcome variables including the mid-term exam, homework assignments, and weekly progress reports relative to summative course outcomes (e.g. final exam, final project scores). The analysis will focus on assessment practices in three iterations of the course in fall 2006, spring 2007, and fall 2007.

As mentioned before, student assessment in the capstone course is multi-faceted. Primary assessment tools and activities for the course are described below.

- **Exams:** Exams in this course are based on two books, 'Kick in the Seat of the Pants' and 'Tools and Tactics of Design', and slides from the guest presentations. The course has two exams, one midterm and a final exam which takes place after the final project presentations. Each of the exams includes a sampling of selection-type items (e.g. multiple-choice, true-false, and matching) and supply-type items (e.g. short answer). The exams count for 20% of the final grade.

- **Weekly Progress Reports:** Students in the Senior Project lab submit a weekly progress report updating their progress. They are required to submit Gantt charts that indicate whether they are on schedule or lagging behind in a particular task. They also submit team meeting minutes which help document what has been planned by the team for the upcoming week. Weekly progress reports are major component in the capstone course. These reports are very professional in format and students are required to adhere to specific industry guidelines. The students end up submitting around 12 progress reports and, together, these account for 9% of the final grade. A rubric for assessing the weekly reports is provided in Appendix 1.

- **Homework:** Students in the capstone class are assigned homework based on the schedule in the syllabus. The content of the homework assignments parallels the content of the exams. As such, these homework assignments are indicators of their progress during the semester. Cumulatively, these homework assignments count for 5% of the final grade.

- **Proposal Presentations:** Students in the Senior Project Class are required to deliver mid-semester proposal presentations. As part of the assessment process, the project idea is thoroughly evaluated by in-class peers, team members, the course instructor and the lab TAs using a common grading rubric [See Appendix 2]. This activity gives students feedback regarding the feasibility of their project. The proposal presentation is also an indicator of the work teams have been conducting during prior weeks as well as an indirect measure of corollary factors like team work, planning and research (technical and market). Grading of the proposal presentations (including a proposal report describing the project) is based on a weighted average of four components: in-class peers, team members, TAs and the instructor's evaluation along with other factors. The proposal presentation constitutes 15% of the final grade.

- **Final Project Presentation:** Students in the Senior Project Class are required to deliver final project presentations (including a prototype demonstration) at the end of the semester in front of an audience that includes esteemed industry guests. Projects presented by students are evaluated across several criteria [See Appendix 3, 4] and the most innovative and practical ideas are submitted for a patent application through the University Of Houston, College of Technology. Also, papers are published and presented at conferences all over the world. The evaluation process for the final project presentation is the same as the proposal presentation (including a final project report) and includes in class peer, in group peer, TAs and the instructor evaluation. The final presentation is worth 31% of the final grade.

The complete grade breakdown structure for the capstone course can be seen in Appendix 5.

Analysis and Results

One of the basic functions of regression and multiple regression analyses is to help gauge the strength of relationships between a dependent variable and one or more independent variables. In this case, we want to examine whether intermediate outcomes in ELET 4308 have a predictive relationship with final outcomes. If we assume that intermediate outcomes serve as proxies of student progress, results of this analysis provide some insight into the potential effectiveness of the feedback process in class. For example, if there is a positive relationship between proposal scores and the final project this justifies the focus on feedback during the proposal stage. If the opposite is true, then the process needs to be re-examined.

The number of students in the analysis varies from class to class and is included in Table 1.

Table 1. N for each ELET 4308 Class

Class	*N*
Fall 2006	41
Spring 2007	23
Fall 2007	38

The dependent and independent variables included in the analysis are briefly described below. These labels are consistent across the three semesters.

- HWSUM – The sum total of homework scores for each student during the semester. (independent variable)
- WPRSUM – The sum total of weekly progress report scores for each student during the semester. These totals reflect group work. (independent variable)
- Proposal – Proposal presentation score. (independent variable)
- Midterm – Midterm exam score. (independent variable)
- Final Exam – Final exam score. (dependent variable)
- Project – Final project total score. (dependent variable)

Analysis for Fall 2006

It was hypothesized that of the four independent variables, the weekly progress reports (WPRSUM) and proposal scores had the highest likelihood of having a relationship with the final project since these items most closely related to the content of the final project. Analysis of the data partially confirmed this hypothesis. While the proposal variable was a statistically significant predictor of final project outcomes (Project), the cumulative weekly progress report variable (WPRSUM) did not make a statistically significant or practical contribution to the model's effectiveness and was excluded. Based on the R-Square statistic, the proposal variable accounted for 22% of the variability in the final project scores. Tables 2 and 3 provide a brief summary of the final regression analysis results.

Table 2. Regression Statistics for Proposal vs. Final Project Evaluation, fall 2006

R Square	0.2204962
Adjusted R Square	0.2005089
Observations	41

Table 3. P-value for Proposal variable, fall 2006

	Coefficients	*Standard Error*	*t Stat*	*P-value*
Intercept	-42.35792	98.35677	-0.43066	0.66910
Proposal	3.88493	1.16966	3.32143	0.00195

Multiple regression modeling was applied to the homework and midterm variables relative to the final exam scores since there was a common content base (the textbooks). Results of this analysis suggest both variables were statistically significant predictors of final exam outcomes. From a practical standpoint, the combination of homework and

midterm scores accounted for 30% of the variance in final exam scores. Results are presented in Tables 4 & 5.

Table 4. Regression statistics for HWSUM and Midterm vs. Final Exam, fall 2006

R Square	0.302929
Adjusted R Square	0.266241
Observations	41

Table 5. P-values for HWSUM and Midterm, fall 2006

	Coefficients	*Standard Error*	*t Stat*	*P-value*
Intercept	-0.64768	15.28832	-0.04236	0.96643
HWSUM	0.221301	0.087811	2.520191	0.01605
Midterm	0.531704	0.174038	3.055109	0.0041

Analysis for Spring 2007

Analysis of spring 2007 data followed the same pattern as fall 2006 where proposal and weekly progress report scores were linked to the final project while homework and midterm scores were compared to final exam scores. In the first set of comparisons, neither the proposal nor WPRSUM variable demonstrated any predictive characteristics relative to the final project. Isolating the relationship of proposal scores did not make a difference as, alone, it accounted for less than one percent of the variance in the final project scores. Results of this analysis are presented in Tables 6 & 7.

Table 6. Regression Statistics for Proposal vs. Final Project Evaluation, spring 2007

R Square	0.00968
Adjusted R Square	-0.03748
Observations	23

Table 7. P-value for Proposal, spring 2007

	Coefficients	*Standard Error*	*t Stat*	*P-value*
Intercept	278.6025	44.36638	6.279585	3.15E-06
Proposal	0.243816	0.538282	0.452952	0.655228

Similar results were evident in the analysis of midterm and homework scores. Neither variable was a significant predictor of final exam outcomes. Together these components account for less than 10% of the variance in final exam scores. Results are presented in Tables 8 & 9.

Table 8. Regression Statistics for HWSUM and Midterm vs. Final Exam, spring 2007

R Square	0.093894
Adjusted R Square	0.003283
Observations	23

Table 9. P-values for HWSUM and Midterm, spring 2007

	Coefficients	*Standard Error*	*t Stat*	*P-value*
Intercept	41.60255	21.51469	1.93368	0.06743
HWSUM	0.30337	0.25006	1.21318	0.239196
Midterm	0.17306	0.16972	1.01959	0.320098

Analysis for Fall 2007

Analysis results for fall 2007 are more consistent with findings from fall 2006. Following the same basic analytic strategy as before, proposal scores and weekly progress reports were examined in relation to the final project. Results indicated both of the independent variables tested in the model were statistically significant predictors of the final project scores, together accounting for 35% of the variance. Tables 10 & 11 present these outcomes.

Table 10. Regression Statistics for WPRSUM vs. Final Project Evaluation, fall 2007

R Square	0.351293
Adjusted R Square	0.314224
Observations	38

Table 11. P-value for WPRSUM, fall 2007

	Coefficients	*Standard Error*	*t Stat*	*P-value*
Intercept	-211.573	116.1391	-1.82172	0.077053
WPRSUM	0.932057	0.255192	3.652376	0.000842
Proposal	3.758136	1.000887	3.754807	0.000631

In terms of the final exam, only the HWSUM variable was statistically significant predictor, unlike fall 2006 where the midterm was the sole predictor. Results are presented in Tables 12 & 13.

Table 12. Regression Statistics for HWSUM vs. Final Exam, fall 2007

R Square	0.230432
Adjusted R Square	0.209055
Observations	38

Table 13. P-value for HWSUM, fall 2007

	Coefficients	*Standard Error*	*t Stat*	*P-value*
Intercept	43.1551	9.1695	4.706398	3.67E-05

HWSUM	0.34763	0.10588	3.28321	0.00229

Discussion

There were two general findings based on the analyses of the ELET 4308 outcome data. First, intermediate student outcomes did serve as significant predictors of end of course outcome measures in fall 2006 and fall 2007 – although predictor variables were not entirely consistent in these two iterations of the course. In fall 2006, project proposal scores were the best and only significant predictors of final project performance as measured by the project rubric scores. However, in fall 2007 both project proposal and weekly progress reports were significant predictors of final project scores. Additionally, the combination of weekly progress reports and project proposal scores accounted for more of the final project score variance in fall 2007 than the proposal alone in fall 2006 (35% vs. 22%).

The total homework score and midterm score were both statistically significant predictors of student outcomes on the final exam in fall 2006. Together these variables accounted for roughly 30% of the variability in the final exam scores for fall 2006. In fall 2007, the homework total score was the only statistically significant predictor variable for the final exam score and accounted for 23% of the variability in the final exam scores. However, when coupled with the midterm exam score, the combination accounted for 29% of the variability.

The second major finding was that in-course student outcomes (e.g. homework, weekly progress reports, proposal scores, and midterm) were not effective predictors of end of course outcome measures (e.g. final exam, final project scores) in spring 2007. Indeed, there were no statistically significant predictor variables with regard to the final exam in spring 2007 nor were there any statistically significant predictor variables relative to the final project.

The findings suggest two intermediate steps to improve the assessment process. First, results from the fall semesters indicate the need to increase the level of measurement reliability of the weekly progress reporting and midterm exams. A key issue is determining whether variability is due to the grading process or the quality of student products.

Unlike the proposal score, the progress reports happen over a period of time leaving the door open to more variability in scoring. For this reason, the instructor communicates and discusses expectations with graduate assistants regarding the rating process in the beginning and throughout the course. The instructor also monitors the scoring over time to ensure that any wide discrepancies are addressed. It is clear from the 2007 results that having a good weekly progress reporting process enhances the predictability of the final project scores. This, in turn, provides instructors with another solid opportunity for feedback. Therefore, we will continue to monitor the predictive validity of both measures to determine whether further improvements need to be made to rating process or if there

is a more basic instructional issue that must be addressed. The same interpretation is true of the midterm and homework assignments.

In both fall 2006 and 2007, cumulative homework scores were significant predictors of final exam performance. In both cases, inclusion of the midterm exam scores made a positive contribution to the overall predictive quality of the multiple regression model although the midterm variable was not a statistically significant variable in fall 2007. As with the weekly progress reports, we must examine the midterm process from fall 2007 in order to gauge differences with 2006.

The second improvement step is to monitor the assessment process for spring 2008 in light of the results of spring 2007. The lack of predictability in spring 2007 raises concerns about how students are evaluated and receive feedback. It is critical to determine whether results were an aberration or the result of some fundamental breakdown in the process. The instructor will continue to track student data and assessment tools and look for irregularities and inconsistencies.

Conclusion

Starting in fall 2008, ELET 4308 is going to be offered as a one year course. As a result there will be more research time available to students and more planning will be required for the completion of their projects. The students will be able to incorporate more features in their projects and the prototype will be closer to the actual project to be implemented. These changes will prompt modifications in the grading structure as well as the tools used to assess student learning. These changes will be informed by the analyses presented here as well as the results of new analyses from spring 2008.

ELET 4308 is not just a senior course but a glimpse of the corporate world experienced by students before beginning their professional careers. The innovative ideas introduced by students are molded and refined into proper form by the end of the project. Some of these ideas have been issued patents and been published in technical/research journals [1-5]. The environment provided by the capstone class simulates the industrial environment and gives the students a solid foundation for technical and management skill building ultimately leading to successful job placement in major companies. Assessment is a vital component of this growth process. Therefore, it is critical that the various assessment tools in the capstone course contribute to overall instructional effectiveness. This can only be accomplished through continuous monitoring and analysis of student outcomes.

References

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Biographies

FARROKH ATTARZADEH

Dr. Attarzadeh is an associate professor in the Engineering Technology Department, College of Technology at the University of Houston. He teaches software programming, operating systems, digital logic, and is in charge of the senior project course in the Computer Engineering Technology Program. He has developed a concept referred to as EMFA (Electromechanical Folk Art) as a vehicle to attract young students to the STEM fields. He is the Associated Editor for student papers at ***the Technology Interface*** (http://engr.nmsu.edu/~etti/), Manuscript Editor for the ***International Journal of Modern Engineering*** (IJME, http://www.ijme.us/), and Conference Associate Chair for the ***IJME-NAIT Joint International Confere***nce (http://www.ijme.us/IJME_Conference_2008/index.htm). He is a member of ASEE and has been with the University of Houston since 1983.

MIGUEL A. RAMOS

Miguel A. Ramos is the Director of Assessment and Accreditation Services for the College of Technology at the University of Houston. He earned a Ph.D. in Educational Research, Measurement and Evaluation from Boston College in 2004. Dr. Ramos has worked as Program Evaluator for Boston Connects, a school-community-university partnership designed to address non-academic barriers to school success via a web of coordinated health and social service resources in ten public elementary schools. He has also worked as a federal education researcher for the Southwest Educational Development Laboratory evaluating the effectiveness of reform models developed to improve student academic performance by enhancing systemic coordination of academic resources. In addition, Dr. Ramos has served as a consultant in a variety of contexts investigating a range of issues including program effectiveness, organizational communication, assessment and public policy, and research methodology.

ENRIQUE BARBIERI

He received a Ph.D. in Electrical Engineering from The Ohio State University in 1988. He joined Tulane University where he served on the faculty of the Electrical Engineering Department (1988-96) and was a tenured Associate Professor and Chair of the Electrical Engineering & Computer Science Department (1996-98). In 2002 he joined the University of Houston as Professor & Chair of the Department of Engineering Technology. His research interests are in control systems and applications to

electromechanical systems. He is a member of IEEE and ASEE and Chairs the Executive Council of the Texas Manufacturing Assistance Center.

Appendix 1: Weekly Progress Report Evaluation

Evaluation Form for Weekly Progress Report

Progress Report No.:

Team No.:

Team Members :_____

Project Title : _____

Date Progress Report Submitted :_____

Time Period Covered in the Report: _____To _____

WPR Sections	Max Possible Points	Points TA1	Points TA2	Points	Comments
1. Project and Purpose	**2**				
2. Accomplishments from the previous week	**5**				
3. Planned activities for the current week	**5**				
4. Resources utilized 4.1 Labor usage 4.2 Financial resource usage 4.3 Project schedule Status	**5**				
5. Current or continuing problems	-			-	
6. Comments and suggestions	-			-	
7. Supporting Documents	**3**				
Total Points	**20**				

Please complete the top portion of this evaluation form in Word and turn it in with every weekly progress report.

Faculty Advisor (signature) _____ Date : / /2008
Dr. Farrokh Attarzadeh

Appendix 2: Proposal Presentation Evaluation Form

Proposal Evaluation

Team no.:
Project Proposal Title:
Team members
Instructor: Dr. Farrokh Attarzadeh

Criteria	Possible Points	Points TA1	Points TA2	Points	Comments
▪ **Peer evaluation**-Peers in other teams	10				
▪ **Peer evaluation**-Peers in your team	10				
▪ **Faculty evaluation of the presentation** ▪	10				
▪ **Proposal Document:** ▪ Logical format ▪ Media ▪ Typographical errors ▪ Neatness ▪ Consistency ▪ Accuracy of information presented ▪ Completeness	12				
▪ **Introduction**	4				
▪ **Project Objectives**	4				
▪ **Project Description**	25				
▪ **Plan of Action**	5				
▪ **Verification**	3				
▪ **Cost Analysis**	5				
▪ **Project Schedule**	4				

▪ **References**	3				
▪ **Senior Project Questions**	5				
Points Possible	100				

Appendix 3: Final Project Presentation Form

Final Project Evaluation Form

Team no.:
Project Title:
Team members:
Instructor: Dr. Farrokh Attarzadeh
Date:

Criteria	Possible Points	Points Earned R1( )	Points Earned R2( )	Points Earned R3( )	Comments
• **Peer evaluation-**Peers in other teams	20				
▪ **Peer evaluation-**Peers in your team	20				
▪ **Faculty & TAs evaluations of the presentation**	20				
▪ **Project Document:** ▪ Logical format ▪ Media ▪ Typographical errors ▪ Neatness ▪ Consistency ▪ Accuracy of information presented ▪ Completeness	20				
▪ **Executive Summary**	10				
▪ **Newsletter**	20				
▪ **Introduction**	5				
▪ **Background**	5				
▪ **Product Requirement**	10				
▪ **Design Alternatives**	10				
▪ **Design Specifications**	20				

▪ **Design Description**	40				
▪ **Construction Details**	25				
▪ **Costs**	10				
▪ **Conclusions**	10				
▪ **User Instructions**	20				
▪ **Project Schedule**	10				
▪ **References**	5				
▪ **Components of the Project Binder:** ▪ A binder cover ▪ A cover sheet for the documents inside the folder ▪ Table of contents (for the documents inside the binder) ▪ Senior Project Presentation Slides ▪ Senior Project Report (refer to the guidelines specified in the document in this folder under the title "Senior Project Report) ▪ Senior Project Proposal Presentation Slides ▪ Senior Project Proposal Document ▪ Progress Reports (organize them as 1, 2, 3, etc.) ▪ Minutes of the meetings (organize them from the first to the last minutes of the meetings) ▪ **Copy** of all the invoices from all the sources ▪ **A CD containing**: (a) All of the above items with proper folder names, (b) All digital pictures with appropriate labels, chronicling the progress from the beginning to the end, (c) Any digital movie of your project, and (d) Any other useful information pertinent to your project	 3 3 4 10 -- 5 5 5 10 5 10 10 - -				
Points Possible	350				

Appendix 4: Final Project Demonstration Evaluation Form

Project Demonstration Evaluation Form: Final

Project Demos

Team No. _____

Reviewer: _____

Category	Below Average	Fair	Average	Good	Excellent	Comments
Hardware						
Software						
Workmanship						
Degree of Completion						
Demo (worked, did not work)						
Comments:						

Additional Comments:

Appendix 5: Senior Project Grade Breakdown

Senior Project
ELET 4308/ELET 4208

Grade Breakdown

I. Midterm……**10%**
II. Homework, proposal, progress reports, Project……..**60%**
- Homework……..…**5%**
- Proposal……...**15%**
  - Presentation…….…..…**8%**
    - Peer in class evaluation……1%
    - Peer in group evaluation……..…2%
    - TA evaluation……..…2%
    - Instructor evaluation……..……..3%
  - Proposal Document…….....**7%**
- Progress Reports……...**9 %**
- Final Project…….....**31%**
  - Presentation…….……..**7%**
    - Peer in class evaluation……1%
    - Peer in group evaluation……...1%
    - TA evaluation……...2%
    - Instructor evaluation…….3%
  - Project Document…….……**12%**
  - Prototype's Completion……**12%**

III. Final……...**10%**
IV. Advisor Evaluation……**10%**
V. TA Evaluation……...**10%**

Total **100%**

Figure 1. Grade Breakdown Structure for the capstone course