AC 2012-3467: THE DEVELOPMENT OF AN ONLINE GRADING SYSTEM FOR DISTRIBUTED GRADING IN A LARGE FIRST-YEAR PROJECT-BASED DESIGN COURSE

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The Development of an Online Grading System for Distributed Grading in a Large First Year Project-Based Design Course

Abstract

This paper presents an online grading system that was developed to collect, process, and return the grades produced by juries using a series of rubrics in a first year project-based design course. It discusses the design requirements, features, and implementation of the online grading system, as well as reactions from course faculty and staff members. It is shown that this system has a number of advantages over analog grading methods, including scalability, real-time feedback on the status of grading, the reduced potential for human error in compiling grades, the ability for jury members to grade remotely and to revise their grades after submission, the ability for course administrators to easily review grading results and remove statistical outliers from the score set, the ability to return both provisional and final grades to the course faculty, staff, and students in a timely manner, and the ability to archive and export grading data for future use. Although the online system is a clear improvement over paper-based rubrics, it is also shown that small details can interfere with usability and thus user satisfaction and that compatibility with mobile devices is a necessary, but still unaddressed, requirement.

Introduction

The logistical problems associated with distributing, collecting, grading, and returning assignments and the difficulties in ensuring fairness and consistency in grading tend to increase non-linearly with the number of students enrolled in a class. This is especially true in project-based design courses where evaluation is subjective, deliverables are team-based, and the philosophies and expectations of course faculty members may vary substantially.

Online course management programs like Blackboard[1] and Moodle[2] can be very helpful in the dissemination of information and the collection of assignments in very large courses like those offered as part of the freshman core curriculum. However, the automated grading capabilities of these programs are generally limited to question banks with clearly defined right and wrong answers. More advanced computer-assisted grading systems have been developed for the assessment and grading of more subjective assignments such as essays[3-8], business case studies[9], and student software programs[10]. However, fully automated systems are still limited to applications with well-defined rules and objectives.

Computer-assisted grading rubrics that guide the grading process and compile the final results are a more promising alternative. Anglin and Anglin[8] report that using computer-assisted grading rubrics during essay grading reduced the grading time by half compared to traditional hand grading without a rubric and by two-thirds compared to hand grading with a rubric. In addition to the "reduced time in grading assignments," Czaplewski[9] notes that computer-assisted grading rubrics can lead to increased "validity and accuracy of grading – making grading more evenhanded," increased feedback for students, and increased student satisfaction. Kryder[11] and Taylor[12] also observed that the use of grading rubrics increased the consistency of grades across multiple graders, especially when teaching assistants (TAs) were involved. The advantages of

computer-assisted and web-based grading rubrics have led to the development of online tools for the assessment of student design work like those offered by the IDEALs project[13].

However, these systems still do not fully address the problems of real and perceived teacher bias in grading[14], grade inflation[15], and professor pleasing. For example, 51% of respondents in a 2004 faculty survey on capstone design courses rated their perception of grading fairness as only "(3) fair - I seldom hear complaints" and none rated their perception as a "(5) all bias and distortion have been eliminated"[16]. These types of concerns have led many students to prefer that design projects be evaluated by external jurors because they "want the jury process to be more objective and believe that the presence of external jurors will help achieve this"[17]. This led one school to "to take professors out of the grading process" entirely and "replace them with professional evaluators who never meet the students," who "don't worry that students will punish harsh grades with poor reviews" and who have "no temptation to skew results in any way other than to judge the students' work."[15]

This paper presents an online computer-assisted rubric-based grading website that was developed in conjunction with a distributed jury-based grading system to improve the fairness, consistency, and efficiency of grading in a large required first year project-based design course[18-19]. This work provides a brief overview of the course, its deliverables, and the breakdown of the final grade. It discusses the design requirements, features, and implementation of the online grading system. Reactions from course faculty and staff members based on end-of-semester survey results are presented. Finally, the current limitations and future development directions of the online grading system are discussed.

Background

The online grading pages and the distributed grading system discussed in this work were developed for the KAIST Freshman Design Course formally known as ED100: Introduction to Design and Communication. The course has between 500 and 600 students and approximately 23 sections per semester. Each section has a different project topic or theme and is offered by one faculty project advisor and two teaching assistants. The students choose their sections through a lottery and are then assigned to a team with 4 - 6 members. Each section has its own Moodle page where students can submit assignments and access section-specific information. The course has a Moodle main page where students in all sections can receive general course announcements, download assignments, and post questions on public forums. A Moodle faculty page is also provided to aid in course administration.

The mid-term and final deliverables determine 80% of the students' final grades. These include:
- The mid-term design review including the presentation and discussion (10%)
- The mid-term report based on the design process and progress to date (10%)
- The final poster including the presentation and discussion (10%)
- The final paper based on the writing, figures, references and appendices (20%)
- The technical evaluation based on the content of the final paper (20%)
- The prototype / proof of concept based on its purpose, method, and results (10%).

Approximately half of the deliverable grades focus on the design process and outcomes of the student projects while the other half focus on the students' abilities to communicate and discuss their ideas. The grading juries assign these scores. Homework assignments, attendance, class participation, and peer review scores determine the last 20% of the students' grades. The faculty project and communication advisors and TAs assign these scores.

The evaluation of all deliverables and assignments in ED100 is subjective. Six rubrics (one for each course deliverable) were developed to help students to prioritize their efforts, assist in self-assessment and revision, and establish a uniform set of criteria to be used across all sections. Each rubric is divided into categories with fixed point values. Detailed criteria for each category are listed but the value of each is not specified. Instead, graders are asked to give each criterion a general rating: excellent (check plus), average (check), poor (check minus) and missing (zero). Both the criteria and the format of the rubrics were chosen to structure the grading process without restricting the grader, to eliminate unnecessary deliberation about the exact point value of each criterion, to allow for differences in project difficulty and student and faculty backgrounds, and to address the challenges of working and grading in an English-as-a-Foreign-Language (EFL) environment. PDF copies of the rubrics (1 team per sheet) are published on the Moodle main page at the beginning of the semester and are available to all students, faculty, and staff members. Grading "worksheets" (5 teams per sheet) are also available for download on the Moodle faculty page.

The grading juries for the course deliverables are composed of 2 faculty members and up to 4 teaching assistants. All course faculty members, including design and communication lecturers, design project advisors, and communication advisors serve on grading juries. Administrative TAs are generally exempt because they are needed to help coordinate grading and run the end-of-semester poster fair.

No one may serve on a jury that evaluates the students from his or her own section. In addition, no one may serve with the other faculty and staff members from his or her own section. Each member of the grading jury evaluates the students' work independently from the other graders using the grading rubrics provided. After grading is complete, the scores are analyzed using a custom algorithm. The statistical outliers are hand-checked and then removed from the score set. Finally, the remaining scores are averaged. Students receive this averaged grade as their score.

Each faculty and staff member serves on a total of 3 juries: one for the mid-term report and design review, one for the final poster and technical evaluation, and one for the final paper and the prototype / proof of concept. Each jury sees approximately 8 different teams. Thus, each jury member sees approximately one third of the projects completed each semester. This gives each member of the course an overview of the work being done by the students and a good basis for comparative grading while reducing the students' exposure to any one grader in the course. After the juries complete their work, approximately 3600 sets of scores must be collected, analyzed, averaged, and returned in order to produce the final student grades. To facilitate this process, the grading website described in this paper was developed.

Requirements of the Online Grading System

The online grading system was designed to meet the needs of the three major classes of stakeholder in ED100: the students, the course faculty members and teaching assistants, and the course administration. The students require fast, convenient, and secure online access to their grades and feedback for each of their deliverables. Similarly, the faculty members require fast, convenient and secure online access to the course grading rubrics, the ability to revise the grades that they assign using the online grading rubrics, and the ability to view their students' grades.

The course administration requires the ability to oversee the grading process, including the ability to view and export all grades by project and deliverable and the ability to remove inappropriate grades that would unfairly skew the jury average. It also requires a way to prompt jury members to correctly use the grading pages. For example, it is necessary to alert jury members when they have not completed their grading, to return an error message when they attempt to assign grades outside of the acceptable range, and to remind them to check the appropriate student files during grading. Finally, the system has to protect the privacy and impartiality of the individual graders. Thus, jury members are not permitted to view the scores assigned by other members of their juries and the average scores are not available until the first round of grading is complete. (When time allows, the averaged grades are released and jurors are permitted to revise their scores if desired.) Jury members are also not alerted when inappropriate grades are removed from the pool. When notification is deemed necessary, it is done via personal email from the course director.

Description of the Online Grading System

The online grading system consists of three sets of webpages - one for each of the major groups of stakeholders in the class. Each stakeholder group accesses the system through a different URL. Mid-term grading pages are opened approximately 24 hours after the mid-term report is due. The final grading pages open on the first day of the end-of-semester poster fair. They remain open for approximately 10 days. When the grading pages are open, users are prompted to log in with their KAIST Portal username and password (figure 1). Otherwise, a notice is displayed to inform users that the grading pages are currently closed. Each grading page can be opened or closed independently to ensure that students cannot observe the grading process and that jury members cannot change their responses once the grades have been released. The grading pages are opened and closed by the course Moodle TAs according to the course schedule or at the request of the course director.

Freshman Design Course Grading Page

This page is for jury grading.
If you are not a member of FDC faculty, please leave this page.

ID: [   ]
PW: [   ]
[Login]

Figure 1. Faculty Log In Page

Faculty Grading Pages

The faculty grading pages provide access to the interactive grading rubrics where course faculty and staff members can evaluate the deliverables of their assigned teams. Jury members select which deliverable to grade using a drop down menu in the top left corner of the page (figure 2). Clicking the "change category" button reloads the page with the new grading rubric and team assignments.

Figure 2. Deliverable Selection Drop Down Menu

The grading rubric criteria are shown on the left side of each faculty grading page (figure 3). To the right are grade-entry panels - one per team. The criteria and grade-entry panels are in separate frames so the grading criteria are always visible. A scroll bar at the bottom of the page allows the grader to move back and forth among all of his or her assigned teams.

Within each grade-entry panel, four circular radio buttons corresponding to zero, check minus, check, and check plus are provided for each criterion. A text entry box that accepts integers from zero to the maximum value listed follows each group of grading criteria. The radio buttons are not linked to the text entry box. Their role is only to prompt the grader to consider each criterion individually and to remind the grader of his or her evaluation based on that criterion when determining the numerical grade. The radio buttons also provide more detailed feedback to the students. The letter grade based on the value for each group of criteria is calculated and displayed to the right of the text box to ensure that the numerical and letter grade both match the

intent of the grader. This is important because the mapping of numerical grades to letter grades depends on the local culture and is different in the US and Korea. The values from all of the text boxes are summed and displayed along with the corresponding letter grade at the bottom of the page. A text box that accepts strings is also provided so the grader can leave more detailed comments for the students if desired.

Figure 3. Example Faculty Grading Page (2 Teams Shown)

Jury members can access the files that their assigned teams submitted for grading using a link built into the team name at the top of each grade-entry panel. All graders can access all files for their assigned teams (figure 4). Grades are saved and submitted using the "Save" button in the lower left corner of the grading page.

The system has a number of validation steps to ensure that the grading process is complete and correct. For example, after the save button is pressed, the system highlights all empty fields in red and displays a pop-up dialogue box that reminds the user to complete his or her grading. (The user may choose to turn off this notification if he or she wishes.) Similarly, a check box was added to the bottom of the prototype / proof of concept (PPoC) grading page to remind jurors to look at the students PPoC documentation and not simply rely on what they saw at the poster fair (figure 5). The page will not save until the box is checked. After saving is complete, the page reloads with the updated information.
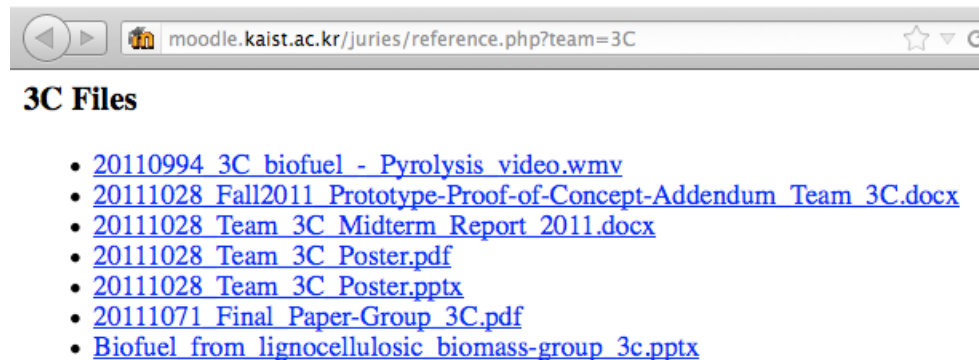

3C Files

- 20110994_3C_biofuel_-_Pyrolysis_video.wmv
- 20111028_Fall2011_Prototype-Proof-of-Concept-Addendum_Team_3C.docx
- 20111028_Team_3C_Midterm_Report_2011.docx
- 20111028_Team_3C_Poster.pdf
- 20111028_Team_3C_Poster.pptx
- 20111071_Final_Paper-Group_3C.pdf
- Biofuel_from_lignocellulosic_biomass-group_3c.pptx

Figure 4. Links to Student Files for Grading

☑
I certify that I examined the prototype / proof of concept materials at the poster fair and in the final paper during final deliverable grading.
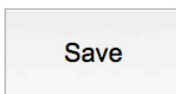
Save

Figure 5. Example of a Validation Step in the Faculty Grading Pages

Administrator Results Pages

The administrator results pages are similar to the faculty grading pages but have more options and display more information. The biggest difference is that the administrator results pages display the grading results from all of the jury members for all of the teams in the course, rather than the results for a single grader. For example, figure 6 shows the scores of all 5 (fictitious) jury members for team 1A's final poster. Scrolling to the right would reveal the jury members and their evaluations for teams 1B, 1C, and 1D as well. Course administrators can choose which deliverable and which project to view using the two drop down menus shown in figure 7.

Grading Category: Final Poster Evaluation

Grading Criteria	username16	username18	username43 (1A)	username31	username44	Avg.
Poster Content						
The poster delivered the design problem clearly						✓+
The poster delivered the design process clearly						✓
The poster delivered the final design concept clearly						✓
Conclusions summarize what the audience / community learned						✓
Sub-Total Score	34 / 40 (B)	39 / 40 (A+)	33 / 40 (B-)	32 / 40 (B-)	40 / 40 (A+)	35.6 / 40
Poster Effectiveness						
The poster was persuasive and convincing						✓
The poster was able to "stand on its own" without other help						✓
Sub-Total Score	13 / 15 (B)	14 / 15 (A-)	14 / 15 (A-)	12 / 15 (B-)	11 / 15 (C-)	12.8 / 15
Poster Formatting and Style						
The poster was easy to read						✓+
The poster was attractive						✓+
The poster distributed graphic/blank space/text effectively						✓
The poster made effective use of visual aids						✓
Sub-Total Score	13 / 15 (B)	13 / 15 (B)	13 / 15 (B)	12 / 15 (B-)	14 / 15 (A-)	13 / 15
Poster Mechanics						
The poster was an appropriate size (115 x 85 cm)						✓+
The poster was grammatically correct						✓+
The poster used appropriate word wrapping (no split words)						✓+
The poster contained references where appropriate						✓+
Sub-Total Score	13 / 15 (B)	13 / 15 (B)	14 / 15 (A-)	14 / 15 (A-)	15 / 15 (A+)	13.8 / 15
Poster Presentation						
Prepared presentations lasted no more than 30 seconds						✓+
Questions were answered well						✓
Presenters were appropriately dressed						✓
Sub-Total Score	13 / 15 (B)	13 / 15 (B)	13 / 15 (B)	12 / 15 (B-)	15 / 15 (A+)	13.2 / 15
Overall						
Final Grade	86 / 100 (B)	92 / 100 (A-)	87 / 100 (B+)	82 / 100 (B-)	95 / 100 (A)	88.4 / 100 (B+)

Each jury member column has Mark | Unmark buttons.

Comments for the students: presentation was OK, but the students couldn't answer some of my questions about the overall design process.

Save

Figure 6. Example Administrator Grading Page (1 Team, 5 Jury Members Shown)

The administrator pages have two important features that are not included in the faculty grading pages. First, an additional column is present to the right of the final jury member's evaluation. This shows the average score for each criterion, each sub-total, and the final score across all members of the jury. This is the same information that is displayed on the student and faculty results pages. The qualitative scores are averaged by assigning values as follows: zero (0), check minus (1), check (2), check plus (3) and then rounding up. For example, two checks and two check pluses would result in an average score of 10 / 4 = 2.5 or a check plus. The numerical means are shown with one significant figure. Missing responses are not included in the average.

Figure 7. Project Selection Drop Down Menu

Second, the administrator page permits the removal of individual responses or entire juror evaluations from the average. Checking the square button to the left of each row in the grading form will highlight that response in red and remove it from the average (figure 8a). Clicking the "Mark" button at the top of a column highlights and removes all of the responses from that juror from the average (figure 8b). The "Unmark" button returns the removed juror to the average. All changes must be saved before they are applied to the database. The student results pages are not opened until this process is complete.

Figure 8. Grade Outlier Removal Options: Partial (Left) and Full (Right)

The statistical analysis of grades is currently done in an external program and grading outliers are removed by hand after the mid-term and final deliverable grading has finished. The outlier detection scheme for the course is beyond the scope of this paper and will be addressed in detail in future work.

<u>Faculty and Student Results Pages</u>

The faculty and student results pages display the averaged scores from the grading juries once the statistical outliers have been removed (figure 9). Faculty members can access the grades for the teams that they advise by clicking the "Change to Result Mode" button in the top left corner of the faculty grading page. Students access their team's grades through a separate log in page. Both faculty members and students choose which deliverable results to view using a drop down menu similar to the one shown in figure 3.

Name	Portal ID
username1	userid1

3 : Final Poster Evaluation [change category]
[Change to Grading mode]

Grading Category: Final Poster Evaluation

Grading Criteria	1A	1B	1C
Poster Content			
The poster delivered the design problem clearly	✓+	✓	✓+
The poster delivered the design process clearly	✓	✓	✓
The poster delivered the final design concept clearly	✓	✓+	✓
Conclusions summarize what the audience / community learned	✓	✓	✓
Sub-Total Score	35.6 / 40 (B+)	34.5 / 40 (B)	36 / 40 (A-)
Poster Effectiveness			
The poster was persuasive and convincing	✓	✓	✓
The poster was able to "stand on its own" without other help	✓	✓	✓
Sub-Total Score	12.8 / 15 (B)	12.17 / 15 (B-)	13.17 / 15 (B+)
Poster Formatting and Style			
The poster was easy to read	✓+	✓	✓
The poster was attractive	✓+	✓	✓
The poster distributed graphic/blank space/text effectively	✓	✓	✓
The poster made effective use of visual aids	✓	✓+	✓
Sub-Total Score	13 / 15 (B)	10.5 / 15 (C-)	12 / 15 (B-)

Figure 9. Excerpt from an Example Faculty Results Page

Implementation of the Online Grading System

The online grading system described above uses the HTTP protocol for communicating between a centralized server and client machines. The system is implemented using the PHP language. It is based on an Apache HTTP 2.0 web server, and uses MySQL to store the data. In this system, the front end users (students, faculty members, TAs, and course administration) access the online grading system via a standard web browser (i.e. Internet Explorer, Firefox, Chrome, etc.). Pages are composed of HTML and contain Javascript to handle the user interaction.

The application follows the MVC (Model-View-Controller) architecture. The model component manipulates all of the information related to grading. It stores the users' profiles, the grading criteria, and the responses of each grader for each criterion. The view component renders the grading pages requested by the user. Finally, the controller component enforces the grading policy and access restrictions when the user retrieves or saves grading data. By having this MVC architecture, the business logic of the application is separated from the representation and persistence layers for easier maintenance.

Before the grading pages can be opened, the database is initialized by the course Moodle administrators. First, project-team information, and the grading criteria are inserted into the database. Next, the basic user information is defined. This step sets the jury member profiles (user ID, name, role, project, etc.), the student profiles (student ID, name, project number, team number, etc.) and the administrator profiles. Finally, the jury assignments are made. Once the initialization is complete, the Moodle administrators can modify or manually update the data using database management tools such as phpMyAdmin.

After closing the grading pages, the Moodle administrators can export the results as an Excel file. The file includes all of the raw grades, simple statistics (means and standard deviations for all grading juries), and outliers that have been marked in grading system by the course administration. This file can be used in the outlier detection process or for archival or research purposes.

Effectiveness of the Online Grading System

From the perspective of the course administration, the online grading system has been a great success. During the Fall 2009 semester, it took 3 administrative TAs over a week to process 3600 sets of scores by hand. This task was slow, laborious, error-prone and unsustainable. It also did not permit the jury members to revise their evaluations or for any feedback to be returned to the students. The online grading system has addressed these problems, making the grading process faster, easier, more accurate and more efficient for the course administration. Without the online grading pages, the distributed grading system could not have continued to be used in a class with 500+ students.

From the grader perspective, the online experience is similar to grading by hand. The online grading system offers some advantages to the jury members including web links to the student files, automatic point summing, and numerical to letter grade conversion. However, these are balanced by the inconvenience of having to enter scores that were assigned offline or on paper into the web form. We have not measured the difference in speed in grading by hand using paper-based rubrics versus using the online grading system but have neither observed nor expect a significant difference. Graders move back and forth between hard copies and the online system depending on their preferences and location. Most (Fall 2010: 82.6%, n = 46) but not all course faculty and staff members said that they preferred the online format to grading on paper.

The feedback from the course faculty members and teaching assistants collected through surveys at the end of each semester has been fairly neutral. The comments from course faculty and staff

members generally express recommendations for improving the grading pages. The most common responses focus on the difficulty of using the grading pages on mobile devices (smart phones and tablets) and the fact that horizontal scrolling between the grade entry panels was not available until Fall 2011. As a result, only 17.5 to 29.4% of faculty and staff members reported using mobile devices for grading posters and prototypes during the end of semester poster fair. The rest used printed grading worksheets and clipboards during the end-of-semester poster fair and transferred their scores to the online system at a later time.

Despite the presence of warning messages and validation steps, there are usually a few individuals (mostly TAs) who report grading their prototypes solely based on what they saw at the poster fair instead of checking the additional documentation that is available through the online grading system. A few users have also indicated dissatisfaction with the number of warnings issued by the system. This indicates that warnings and verification steps are not totally effective and should be used sparingly.

The average rating of the online grading pages using a 5-point Likert scale ranged from 3.0 to a 3.5 (n = 28 to 46) during the four semesters that the system has been in use. The course faculty members consistently rate the pages higher than the teaching assistants. Returning course faculty members and TAs generally rate them higher than those teaching the course for the first time. These ratings seem to indicate an acknowledgement by the course faculty and staff that the system has room for improvement and are likely skewed by the fact that a higher percentage of the survey respondents are new to the course. As the pages improve, it is likely that the ratings will as well.

Conclusions

Ensuring the fairness and consistency of grading is challenging in large project-based design courses. Jury-based evaluation and grading rubrics can be helpful in addressing these challenges, but scalability becomes an issue as the class size grows. Online grading systems, such as the one presented in this paper, have a number of advantages over analog grading methods, including scalability, real-time feedback on the status of grading, the reduced potential for human error in compiling grades, the ability for jury members to grade remotely and to revise their grades after submission, the ability for course administrators to easily review grading results and remove statistical outliers from the score set, the ability to return both provisional and final grades to the course faculty, staff, and students in a timely manner, and the ability to archive and export grading data for future use. As a result, online grading systems can be very helpful in reducing the logistical problems associated with collecting, processing, and returning the grades produced by grading juries.

The online system presented in this work is a clear improvement over paper-based rubrics and may serve as an example for others interested in developing similar tools. The online grading pages are well liked by the course administration and have been well received by the course faculty and staff. However, it was also shown that small details can interfere with usability and thus user satisfaction and that compatibility with mobile devices is a necessary requirement that must be addressed in the future.

Acknowledgements

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