Mobile tools for automated scoring and analysis at Capstone Expos

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The Capstone Design Expo is the crowning achievement in the undergraduate career of engineering students at the Georgia Institute of Technology and an opportunity to compete for substantial prizes. As coordinators of this event, it is imperative that we award prizes fairly and with much consideration. In the past, we have recorded scores from volunteer judges on paper ballots and tallied them by hand or using a scanner. These methods have been increasingly optimized, but are still labor intensive and require constant monitoring and maintenance. In the Fall semester of 2013, we developed and deployed a new web-based mobile voting system to streamline this process. Here, we describe the technical advantages of using this system and its underlying architecture, as well as the benefits to both students and Expo coordinators. An entirely mobile system such as this will scale easily to any size, allowing event organizers to focus on interactions with teams and important partners. We also show how an entirely web-based system allows for easy offline analysis of demographic and procedural data.

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Introduction

Behind the scenes at any large event, there is a veritable army of staff and volunteers making sure that the entire show runs smoothly. In the case of previous Capstone Design Expo at the Georgia Institute of Technology, dozens of students have helped collect and tally ballots to determine departmental and overall winners at the end of the night. This process has been hectic and time consuming, often delaying the prize announcement, causing low turnout for the closing ceremonies. Over time, we have developed tools to speed this process up, but as the scale of the capstone expo has grown, we are reaching the limits of the capabilities of paper ballots. With 4000 visitors and over 5300 ratings to tally in the limited time before scores were announced, we realized that a new, electronic voting system was needed. A new voting application should have a number of features, including ease of use for voters and voting administrators, instantaneous and accurate results, feedback between voters and administrators in real time, and ease of assigning teams to judges. Finally, we designed this system to allow for easy offline analysis by linking each data type in a database.

Overview of the Voting Application

The entire voting system was managed through a mobile application, freeing up volunteers and voting administrators to move around the expo floor and interact with judges and teams to ensure that all technical questions were addressed quickly. We realized that a platform-specific app would restrict our voter pool to a subset of mobile device users. Therefore, the application was designed as a mobile-ready website, allowing access on iOS, Andriod, Blackberry devices as well as computers. Teams were asked to sign up using an online form, on which they provided demographic information about their team and their home department. Similarly, volunteer voters signed up on an online form and provided their name, email address and listed any conflicts of interest, allowing us to prevent a voter from being asked to judge a team they sponsor. On the day of the event, voters met with a voting coordinator who checked them in on a mobile phone. After check in, teams were assigned to each voter on-the-fly by an algorithm that ensured equal voter coverage for each team. Just before the event, voters were introduced to the application with a brief PowerPoint, following which, the voting was opened.

When the voting opened, each instance of the web application on the voters' phones automatically refreshed to display a ballot consisting of a selectable list of assigned teams. Voters were asked to score each team in 5 categories, such as usefulness of design, quality of analysis, quality of communication, etc. Each category represented with a slider allowing input values from 1 to 5, 1 being the lowest score. With each adjustment of the slider, a message is sent to the database, keeping the scores updated in real time. At the end of the designated voting period, the web app on each phone automatically displayed a message instructing voters to move to the award ceremony area

and prevented further score entry. Finally, voting was tallied for each team automatically and displayed to voting administrators on the administrator panel. The results of the voting could be viewed as overall scores or sorted by department.

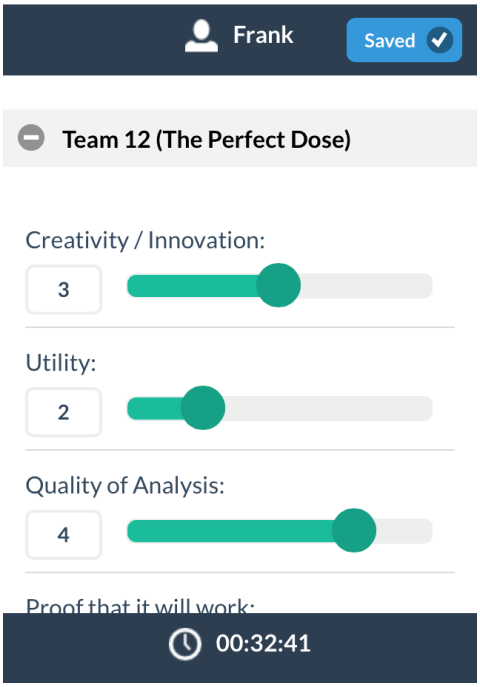

Figure 1. An example of the judge's ballot interface. Dropdowns for each assigned team allow the voter to grade based on multiple criteria using touch sliders.

Management structure

From the Administrator Panel, voting coordinators are able to update the event as well as manage teams and voters. The event details pane allows the coordinator to control the start and end time of voting as well as the content of messages displayed to the voters before and after the event. The team management pane provides functions for adding and updating team information on the fly, as well as disqualifying teams, if necessary. Similarly, the voter management pane allows the administrator to update and add voters at any time, as well as check voters in and algorithmically assign their teams. Additionally, if a voter is unable to complete the ballot on their mobile device, an administrator may permit the voter to complete a paper ballot and subsequently enter the scores through the back-end interface. Following the event, voters' scores are tallied automatically and displayed as categorized results or as overall results for the expo. On each score list, the team name, number, major, and average score are listed.

Judging Assignments

One of the problems unique to the design expo experience is that in order to have a high confidence in our scores and thereby achieve fair scoring, an equal numbers of votes cast must be cast for each team. Thus, the assignment of judges and teams is of utmost importance.

This issue is compounded by the fact that not every judge may end up showing up to the expo. In this case, a subset of teams to which the judge was assigned will be at a disadvantage (and our confidence in their score would be decreased). Since it cannot be guaranteed that each judge will be present at the expo, teams should be assigned to judges who arrive on the day of the event. Because of the scale of the 2013 Capstone Expo at Georgia Tech, it becomes a tough problem to randomize team assignment and keep team coverage even using paper ballots. Thus, we have elected to use an algorithm to assign teams. The algorithm proceeds as follows:

1) For a given judge, take the entire set of teams in the expo
2) Remove teams that are listed as conflict of interests with this judge
3) Group the teams by the number of judges already assigned to each in decreasing order.
4) Randomize the order of teams with respect to the number of judges already assigned
5) Assign the top n teams, as decided by the organizers.

Security

To ensure the security of the personal data collected for team members and voters, the entire site was protected with 2048 bit SSL encryption, provided by GoDaddy. To prevent the possibility of tampering with scores, each user was given a secret login link with a unique MD5 hash. Finally, to prevent cross site injection of scoring data, each user's form was dynamically linked to a unique token and data was only accepted with the presentation of the proper token.

Data Analysis

Each score, category, team, voter, and affiliation (major) is linked in an online relational database. Data analysis is facilitated by the nature of the pre-defined relationship structures. This system allows grant writers and Capstone coordinators to easily mine the scoring data for actionable patterns.

As a demonstration of the possible data analytics that a tool such as this online voting system enables, we used demographic information supplied by each team to determine if the inclusion of women in capstone teams affected scoring outcomes. We found that teams with at

least one woman (n=78) had a higher average score by 0.25 points than teams

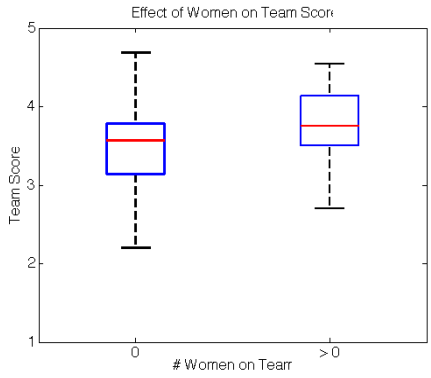

Figure 2. The inclusion of at least one female member on a senior design group increases the average score ($p << 0.05$)

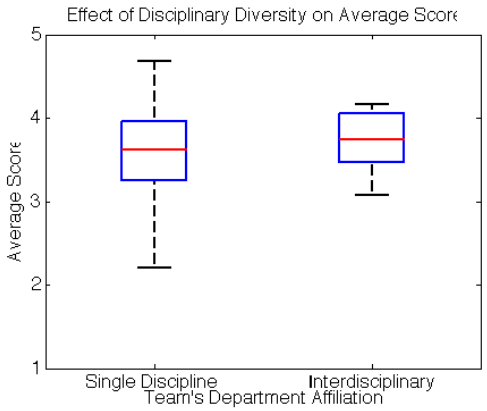

Figure 3. There was no statistically significant difference between the average scores for interdisciplinary teams and teams from single disciplines.

that had no female members ($n = 41$, $p << 0.05$), [Fig 2]. While this measure of diversity indicated the benefit of diverse team structure, we determined that there was no significant difference ($p = 0.36$) between average scores for interdisciplinary teams and teams comprised of members from a single discipline. Similarly, we found that score was not affected significantly by the size of the team.

Conclusion

We have developed a custom web application architecture and demonstrated that this platform is suitable for event-based online judging on a large scale. We will continue to add features to this technology for future expos to reduce barriers between industry partners and teams, facilitating networking between teams and potential employers. Additionally, the inclusion of survey questions that directly address ABET criteria could enable the use of this technology to rapidly evaluate and compare students and student teams across classes and throughout departments. The flexibility of the technologies described here will permit the Capstone Expo program at the Georgia Institute of Technology to expand to meet the needs of the entire College of Engineering in years to come.