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A First-Year Project-Based Design Course with Management Simulation and Game-Based Learning Elements

Mr. Daniel D. Anastasio, University of Connecticut

Daniel Anastasio received his B.S. in Chemical Engineering from the University of Connecticut in 2009. He is pursuing a Ph.D. in Chemical Engineering at the University of Connecticut while acting as a co-instructor for the chemical engineering capstone laboratory and the first-year foundations of engineering course. His research interests include osmotically driven membrane separations and engineering pedagogy.

Ms. Malgorzata Chwatko, University of Connecticut
Prof. Daniel D. Burkey, University of Connecticut
Dr. Jeffrey Ryan McCutcheon

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1. Introduction

Many institutions have introduced students to engineering design principles in the first year of college education in the form of project-based classes[1-3]. The emphasis on design projects in the first year of undergraduate study promotes active learning via hands-on activities and student intellectual development[4]. Group-based project work helps students naturally practice what are commonly referred to as 21st-century skills, or skills that students will use to be successful in the modern work environment regardless of chosen career path. These skills include critical thinking, communication, creativity, and collaboration[5]. An emphasis on design early in the curriculum is beneficial to students, as many programs only begin to stress elements of engineering design methodology in the final year of instruction.

The critical skills that students can build by engaging in design-based courses can be practiced using game-based learning (GBL) and simulations as well. In game-based learning, games are used to help convey information to students in an engaging way[6]. Games also allow students to experiment with different outcomes in a safe, low-consequence environment, encouraging learning via trial-and-error[7,8]. A game is fundamentally different from a simulation, however, as simulations provide unique environments for experimentation, and games have goals and rules. Generally, it is not possible to win a simulation, but once certain goals are met, games can be won[9]. To effectively navigate a game or simulation, one must be able to think critically about the constraints of the game, collaborate and communicate with others, and devise a creative strategy to win, again promoting 21st century skills[10,11].

As both simulations and design courses can allow students to practice critical skills, simulation and game elements can be used effectively in a freshman design course to augment an already existing project-based structure. As many design projects often have a corporate sponsorship or client angle, a business simulation game can be created. Students are encouraged to form "companies" and create products for specific clients, then compete with other "companies" over which device best fits the needs of the client. Success in the business simulation will come down to students' ability to work with others, think critically to arrive at creative solutions, and communicate these solutions effectively, reinforcing elements that are presented through the project-based nature of the course.

This paper will discuss a preliminary study of the first implementation of a design-based freshman engineering fundamentals course (Foundations of Engineering) at the University of Connecticut in Storrs. As project-based courses are not a new development, the authors will predominantly focus the business simulation and game-based systems that were created specifically for this course. These systems include a narrative framework for the projects, specific rules for students to follow, and criteria for evaluating student projects in the context of the business simulation. These systems enabled student design competitions that were not tied to student grades, so students do not need to worry about performing poorly in the class if their projects do not work. Furthermore, the simulation allows students to practice budgeting and making financial decisions in a safe, low-consequence context as they use a fictional currency to buy materials for projects.

This paper will also present preliminary data from the first iteration of this course; the majority of this data is pre- and post-semester survey data where students were asked for their opinions on the course and systems and their own self-perception of their skill development. Student experiences will be expressed primarily as student attitudes toward the course and the additional elements compared to courses they have taken in the first semester of their freshman year. Furthermore, students rated how comfortable they felt with working in groups and communication skills before and after the semester. While the data is preliminary, initial trends in student attitudes are useful at this stage of course development. The paper will conclude with alterations that are currently being enacted upon in the current semester offering of the course (Spring 2015). Ultimately, a longitudinal study is being planned to assess if these methods have an impact on students' skills moving forward from the introductory course.

2. Course Structure

The Foundations of Engineering course (ENGR 1166) is offered only in the spring semester of the freshman year at the University of Connecticut. While the course is a general engineering class, each separate engineering department teaches one section of the course. The purpose of the course is to provide freshmen with general engineering skills that can be applied to any engineering discipline through the context of the selected discipline. The section of the course used in this study was the chemical engineering section.

Over the course of the class, students completed three projects. The first was to design a thermos capable of keeping a vial of water cold when submerged in a hot water bath. The second project involved the design of a water filter to remove clay particulates and food coloring from a simulated contaminated water source. The third was a variation of the American Institute of Chemical Engineers (AIChE) Chem-E-Car competition[12], where students used a reaction of baking soda and vinegar to propel small cars to a target. Students completed these projects in groups of 3 or 4, preparing short written deliverables as a group throughout the course of the project before delivering a final oral presentation about their completed device. Students also completed individual weekly quizzes and two exams (a midterm and a final) on course material in order to grant students more individual control over their final grades. The full breakdown of student grades is shown in Table 1, and course grades were made up of 60% group work (20% for each project) and 40% individual work (quizzes, exams, and peer assessments).

Table 1. Assignments as contributors to student grades for the Spring 2014 semester

Item	Points per Item	Number of Items	Total Points (percent of grade)	Notes
Proposals	50	3	150 (15%)	Team grade
Progress reports	50	3	150 (15%)	Team grade
Presentations	100	3	300 (30%)	Team grade
Peer Assessment	30	3	90 (9%)	Individual grade
Midterm	1	100	100 (10%)	Individual grade
Final Exam	1	100	100 (10%)	Individual grade
Quizzes	10	10	100 (10%)	Individual grade
Final Assessment	10	1	10 (1%)	Completion based

The class was first run in this manner during the Spring 2014 semester. The class met once a week for a 2.5-hour period, where approximately one hour was devoted to lecture and 1.5 hours devoted to design time. Optional two-hour design periods (labeled as office hours) were offered three times a week if students needed more time to design and test. The course had 65 students, one primary instructor, and four teaching assistants. The operating budget for the materials, storage, and tools needed for the design projects was $4000 for the semester.

3. Simulation & Game Elements

3.1 Management Simulation Elements

The management simulation elements frame the course as students forming companies to build specific devices for a client. The specific needs of each client change depending on the project to add variety to each project. For instance, students needed to design a lightweight thermos. In the filter project, weight was not an issue for the client, but ease-of-use was. The clients were used to show students that the most important factors of a design will vary from project-to-project.

Students were also given budgetary constraints in the form of a fictional currency developed for the course. These elements were intended to promote proper planning and allow students to balance device efficacy and cost.

3.1.1 Company Group Structure

In order to add more business management element, student teams were labeled as “companies.” Each company had a chief executive officer (CEO), a chief financial officer (CFO), and a chief technology officer (CTO). Groups of four had two CTOs. Each company officer had a specific role to fill in their company, which are described in Table 2. These roles were intended to allow students to experience approaching a problem from different angles and with different responsibilities, focusing on team building and collaboration.

Table 2. Summary of student roles within companies

Officer Role	Primary Responsibilities
CEO	• Served as group leader • Coordinated meetings with the instructors/teaching assistants for extra help and investments (see section 3.1.2)
CFO	• Responsible for maintaining an accurate company budget • Responsible for placing orders with the class materials stockroom and the machinist (see section 3.1.2)
CTO	• Primarily responsible for researching and disseminating technical information regarding the project to the rest of the group

Each company submitted deliverables themed as reports they may write in industry or in academia, including a project proposal and a progress report. Expected content for each deliverable is summarized in Table 3. It should be noted here that the final presentation for the thermos and filter projects were PowerPoint presentations, and the final presentation for the Chem-E-Car project was a poster. Each company was responsible for producing one deliverable, and all students in a company would share the grade earned.

Table 3. Summary of student group deliverables

Deliverable Name	Expected Content in Deliverable
Proposal	• Clear statement of the project's overall goal • A statement of design approach; what aspects will the company primarily focus on? • A hypothesis as to what materials and design should be best • A proposed budget for the project
Progress Report	• A diagram of the initial design and possible iterations • Preliminary test data • An updated budget for the project
Final Presentation	• Final device diagram and features of the device • Results of device testing • Final budget and cost of device

At the conclusion of each project, student companies were dissolved. New companies were formed based on student performance on the previous project. For instance, students who produced devices that performed within the top third of the class were paired with students who created devices that performed in the bottom third of the class. The changing of groups was done for three main reasons. First, it prevented disproportionately strong groups and disproportionately weak groups from persisting through the semester. Next, it allowed students to experience a project in a different company role (i.e. CEO, CFO, and CTO). Finally, it allowed students to interact with many other students in their class, helping them build their communication and collaboration skills.

3.1.2 Class Economy and Material Purchasing

In order to allow students to practice the budgeting aspect of management, an in-class currency was developed (known as Chegdollars). Chegdollars could be used to purchase materials used during the design periods or to purchase the services of the class machinist, a teaching assistant, for specialty material modification using saws, drills, glue guns, etc. Students were only allowed to use materials purchased from the class stockroom to construct devices during each project, and the machinist could only manipulate certain materials. Students placed orders for materials and services via paper forms that were collected by the teaching assistants.

Materials in the stockroom were priced in accordance to perceived usefulness in each project. For example, in the thermos simulation, students could buy a paper cup for 10 Chegdollars, a Styrofoam cup for 30 Chegdollars, and a block of Styrofoam for 50 Chegdollars. These limitations were imposed to encourage student creativity, as students had limited access to funds and they were incentivized to produce low-cost (in Chegdollars) devices (see section 3.2). This element encouraged students to plan their designs thoroughly, as spending most of their budget at the start of the task would either limit student options for iteration or require that students find other in-game sources of Chegdollar funding.

In the event that a company ran out of Chegdollars, they had an option to pitch to an "investor" (in this case, the instructor) for more Chegdollars. This element was included to make the economic aspects of the class less punitive if a company's design did not work as expected. The meeting could be informal, but students needed to effectively articulate how much extra money they needed and what exactly they intended to do with the money. It is up to the investor to decide if the students have effectively delivered their argument. The pitch meeting with the investor was designed to promote students' communication skills; students who articulate their points more effectively often earn more Chegdollars, and there are no negative ramifications of a failed pitch beyond not earning the desired Chegdollar amount.

For the final project, the Chem-E-Car, students were given no initial Chegdollar budget. Instead, students needed to prepare a short pitch presentation to be given to a panel of investors (the instructor and teaching assistants). Students had to show a proposed schematic, give an expected budget, and articulate what aspects of their design made them a desirable investment. Each team was then assigned two investors, who not only provided additional funding via pitch meetings, but would additionally serve as mentors during the design periods. Investors could help students refine their car-launching technique or ask leading questions to guide their groups when they got stuck. The investor system benefitted both students and the instructors and teaching assistants; students were guided through the most complicated project and the teaching assistants were able to get to know the students on a more personal level. Many teaching assistants stated that they enjoyed this element of the course.

3.2 Competitive Game Elements

It was determined early in course development that student grades should not be tied directly to the results of the final device test, as students should be primarily be graded on their design methodology and quality of deliverables. However, there was still a desire to motivate students to produce high-quality devices and foster competition between companies, which would be present in a business environment. The device competition elements were turned into a game-based extra credit system, where students could earn additional non-grade points called reputation for creating devices that performed well or met other goals. A sample of the reputation awards for the Chem-E-Car simulation is shown as Table 4.

Table 4. Sample awards and their reputation values for Chem-E-Car

Award Title	Description	Reputation Earned
Most Accurate Car	During final test, the company's car was closest to the target	34
Fastest Car	During the final test, the car had the fastest linear velocity	33
Most Fuel Efficient	During the final test, the car traveled the farthest relative to the mass of baking soda and vinegar used	33
Best Overall Performance	A weighted average of the previous three categories	100
Best Presentation	Best presentation as voted by the instructor, teaching assistants, and the rest of the class	10
Most Creative	Awarded to the car that the students in the class have voted most creative	10
Lowest Car Cost	The final car has the lowest material cost in the class	15
Top Third	Awarded to all cars that finished in the top third of overall performance	100
Middle Third	Awarded to all cars that finished in the middle third of overall performance	85
Bottom Third	Awarded to all cars that finished in the bottom third of overall performance	70

Note that even students who did not produce cars that performed in the top third of the class were able to earn some reputation from participating in the competition. Furthermore, there are several awards that are not tied to the performance of the car, such as Best Presentation and Most Creative that allow more ambitious designs to be rewarded by their classmates. At the end of the semester, student reputation dictated the amount of extra credit grade points earned by individual students, as shown in Table 5. Extra grade points scaled nonlinearly with reputation points, incentivizing students to earn as many as possible by creating high-quality devices during the projects.

Table 5. Conversion table for reputation points to bonus grade points (in a class graded out of 1000 grade points)

Final Amount of Reputation Points	**Extra Grade Points Earned**
Less than 300	0
300-349	1
350-399	3
400-449	6
450-499	10
500-549	15
550-599	21
Over 600	28

Students maintained their own reputation totals throughout the semester. When companies were dissolved and reformed, each individual student was able to keep all reputation points they had earned during the semester thus far. Penalties for violations of simulation rules (such as using outside materials) or for minor safety violations (such as not wearing safety goggles when directed) were incurred in a loss of reputation points (or loss of experience points, if the violation was severe enough to merit that deduction).

4. Assessment

Assessment of these methods was primarily based on student attitudes. Students took surveys during the first week of class asking them to rate how they felt about the project elements, simulation elements, and game elements of the course on the Likert scale. Students were also asked to rate how comfortable they felt with certain aspects of the class, such as how comfortable they felt working in groups and how comfortable they felt with public speaking, on the Likert scale. Students were given the same survey during the final week of the course to assess how their attitudes had changed after completing the three projects. The pre-survey was completed by 65 students, and the post-survey was completed by 62 students.

Furthermore, teaching assistants and the instructor observed students closely during design periods to see how companies were approaching each project and which students were contributing most to each design. Teaching assistants often engaged students in conversation, asking students for their opinion on the projects, simulation elements, and course overall while giving advice on how to approach the projects.

In an effort to gauge student learning as a result of the projects, pre- and post-project quizzes were given. However, students often scored highly on the pre-project quizzes, and differences between the two quizzes were not statistically significant. Ultimately, to gauge the initial impact of this course on the students, the instructor of the first sophomore-level class students take in Chemical Engineering (Introduction to Chemical Engineering) was asked to comment on how the class who had experienced the project-based course performed to the previous three classes of the course that had a more lecture-based Foundations of Engineering course. This information will help guide the Foundations of Engineering course and will lead to a more formal assessment of student learning in the future.

5. Summary of Student Experiences

On both the pre-survey and post-survey, students were given several statements and were asked to assess their agreement with them on the Likert scale. The vast majority of students agreed to at least some extent with statements such as "This class is different from others I have taken in the past" on the pre-semester survey. On the post-semester survey, 50 out of the 62 students surveyed strongly agreed that attending the design office hours felt mandatory for completing the projects. This result is substantiated by the observations of the teaching assistants observing the in-class design time. Many of the student companies did not appear to use this time efficiently, as it was difficult for teaching assistants to fill the high volume of materials orders during class time. Students were allowed to spread out across a nearby lobby, making it difficult to assure that students were staying on-task during the entire design period. Overall, however, 36 of the 62 student respondents indicated they agreed to some extent with the statement "I enjoyed this class overall," with 18 students neither agreeing nor disagreeing with the statement, and 8 students somewhat disagreeing with the statement.

In order to assess student self-perception of their skill development in the course, responses to some of the pre- and post-semester survey were compared. Specifically, student attitudes toward two statements related to their comfort levels with collaboration ("I enjoy(ed) working in groups") and communication ("I am comfortable presenting technical information to the class") were examined. The attitudes of the students are summarized in Figures 1 and 2.

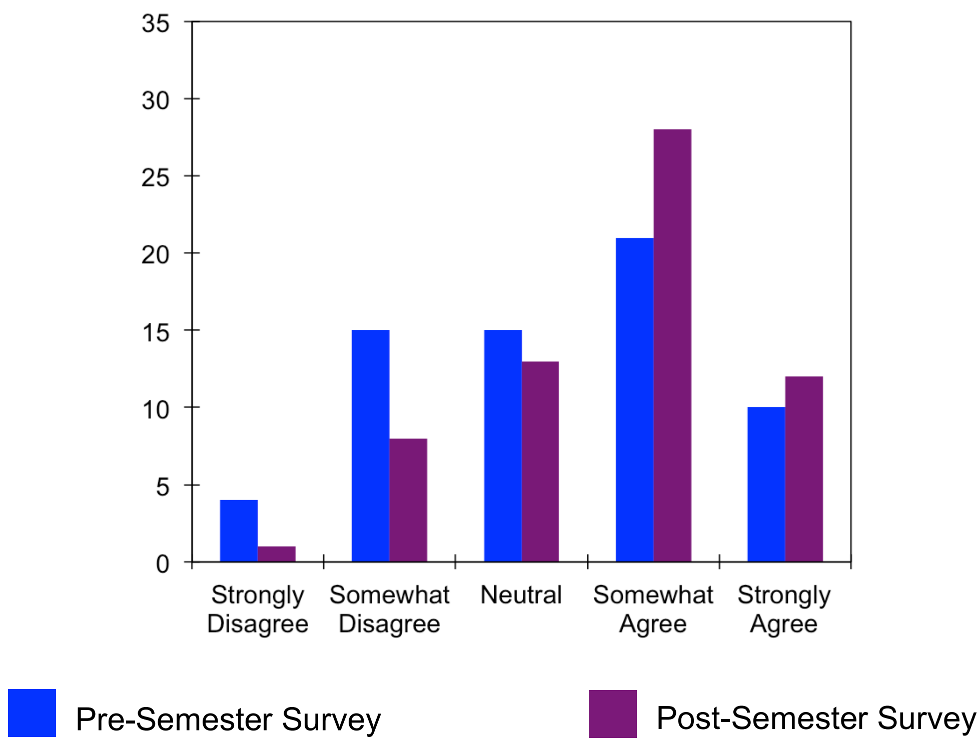

Figure 1. Student responses to the statement "I feel comfortable presenting technical information to the class" (Likert scale), where the y-axis represents the number of students

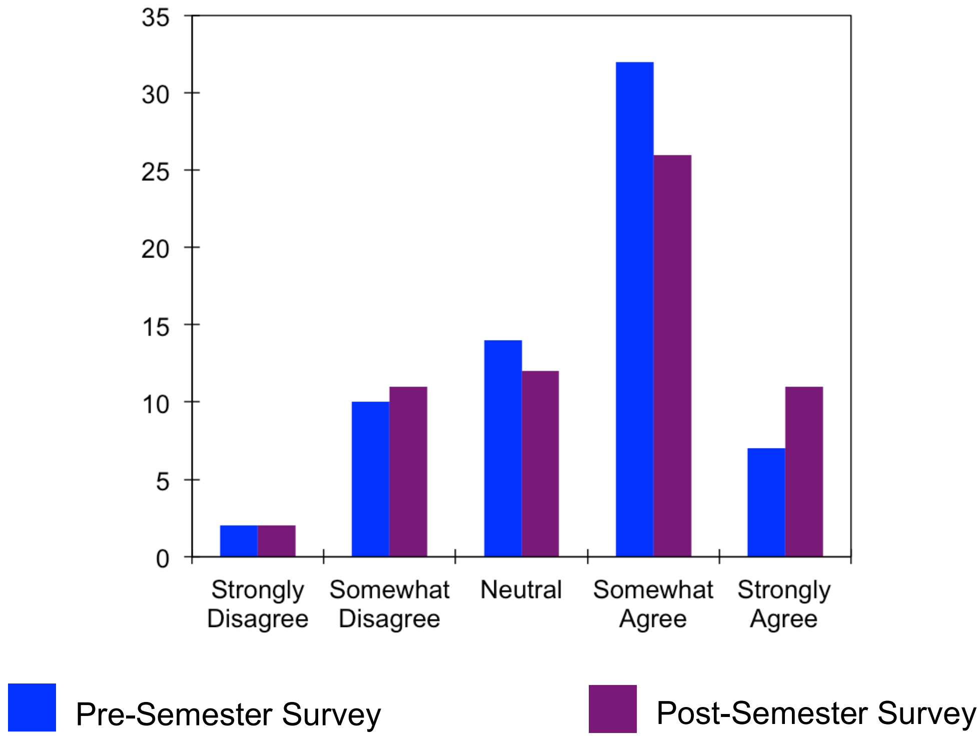

Figure 2. Student responses to the statement "I enjoy(ed) working in groups on projects" (Likert scale), where the y-axis represents the number of students.

Figure 1 indicates that 10 more students felt more positively about presenting data in front of the class at the end of the semester, when they had presented their designs to the class three times. This increase may also be attributed to practicing communication skills in meetings with investors. Figure 2 indicates that students generally had stronger positive attitudes toward group work at the end of the semester compared to the beginning. This result is encouraging, as the class has made a positive contribution toward students' approach toward group work, preparing them for usual levels of group work as they progress in the engineering curriculum.

Students were able to write general comments on the post-semester survey. The feedback was mixed, with some being very positive and others being very negative. The positive feedback stated that students appreciated the ability to gain hands-on design experience early in the curriculum. One student wrote, "The projects were an eye-opening way to look at chemical engineering – it was definitely a proper intro class for the major." Negative comments focused on the time commitments required for the course, as well as the content covered during the lecture and how it related to the projects. Another student wrote, "I was not clear about what was being taught and what [the instructor] was expecting us to learn." Moreover, the comments revealed that many students did not realize that the reputation tasks were extra credit and were concerned that they would have their grades reduced if their devices did not perform well. Addressing these comments was high priority when refining the class for the next offering.

Additionally, the students were asked to evaluate their attitude toward the simulation and game elements in the post-semester survey. The results of this poll are summarized in Table 6.

Table 6. Student attitudes toward the business simulation and game elements, evaluated on Likert scale

Number of students responding	**Disliked a Lot**	**Somewhat Disliked**	**Ambivalent**	**Somewhat Liked**	**Liked a Lot**
Companies and Roles	1	5	18	25	13
Changing companies after each project	3	7	9	27	16
Using Chegdollars	1	10	14	28	9
Purchasing materials	1	5	10	34	12
The Chem-E-Car Investor System	2	7	8	21	23
The Reputation extra credit system	2	4	11	24	21
Performance-based Reputation awards	3	2	10	26	20

Student attitudes toward the game elements were significantly more positive than their attitudes toward the class overall. The majority of students at least somewhat liked all of the game and simulation elements. The most popular elements included the Chem-E-Car system of personal investors and the reputation extra credit system, likely due to the additional personalized help and the additional grade points these systems provided. These results indicate that these systems are effective at generating student interest and should be bolstered with improved course content.

Finally, discussions with the instructor of the sophomore-level Introduction to Chemical Engineering course indicated that these students did not seem significantly more or less prepared for his course. Furthermore, the instructor did not indicate that the grades of students who took the project-based course were significantly different from the grades of those who did not. The instructor indicated that, like all sophomore classes he has encountered, the students struggled with using Microsoft Excel to analyze data and with unit conversions. This feedback was used to help shape the course content in future offerings.

6. Spring 2015 Iteration

In order to address student feedback, the course has been adapted for the Spring 2015 semester. The course content has shifted to emphasize the acquisition and analysis of data using software packages like Excel, and data presentation using proper technical writing techniques and PowerPoint skills is explained to and expected of all students. The class now meets twice a week for 75 minutes each. The first period is a lecture period, which is based on information students will find most useful at that stage of the project. The second period of the week is a dedicated to design, where students are expected to build a simple prototype and test it at least three times for reproducibility. Rather than have several short design office hours, an optional four-hour design period has been made available once a week if students need additional build and test time. The design period is long enough to accommodate students with late afternoon or evening classes. Furthermore, a non-design office hour period is offered at a separate occasion for students with questions about the course content.

As many students felt they did not have enough time to complete projects, one of the projects was removed. To determine which project to remove from the new iteration, student feedback, shown in Figure 3, was considered. The majority of students (40) selected Chem-E-Car as their favorite project, citing that it was either the one they considered to be the most fun or the one they learned the most from. Conversely, the water filter earned the most votes for the project students liked the least. Students often cited that the project was confusing, and that lecture material did not help with the filter project as much as it did for others. As the filter was the least popular project among students and by far required the most material preparation, the project was dropped for Spring 2015. With the removal of the filter, students are able to spend 4-5 weeks on a given project. This change also allows for the first design period of a project to be a no-cost "play" period, where companies can perform experiments using materials they will use to construct their device. Not only are students allowed to then make informed decisions about materials, but they are allowed and encouraged to practice good experimental techniques when taking their data.

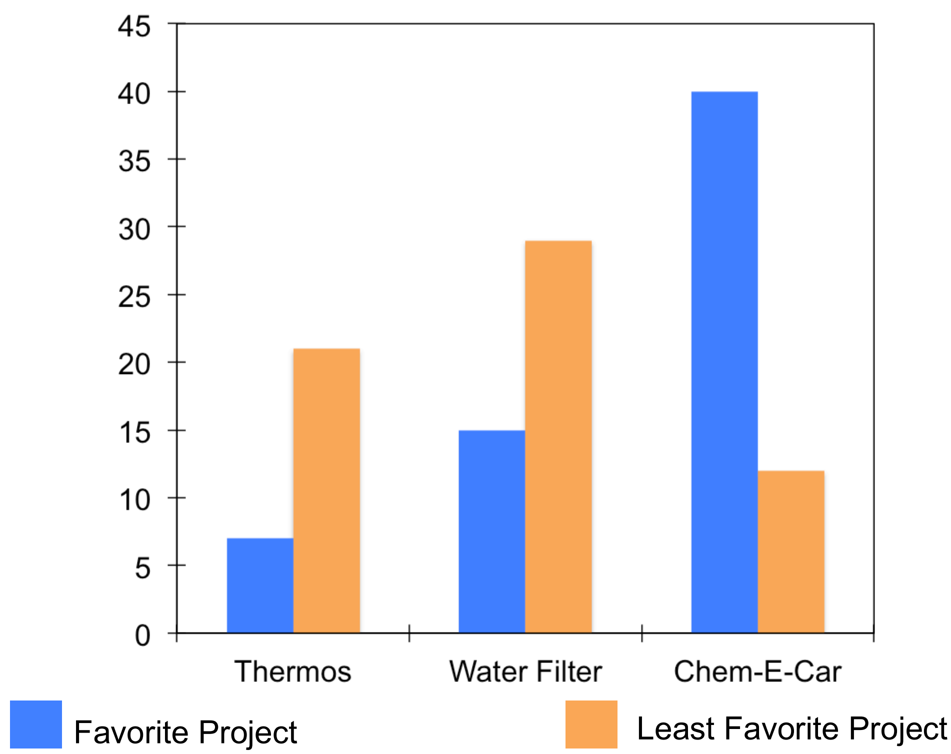

Figure 3. Favorite and least favorite projects, as voted by students. Y-axis represents the number of students.

Table 7 shows how grades are determined in the Spring 2015 iteration of this course. Given the extra time students now have, the deliverables have changed accordingly. The proposal is now based off the data students gather during the initial "play" period. Students must synthesize the data and state how it will apply to their initial design. The following week, after students have built and tested their first design, students must produce an initial progress report. In this report, students present the data from their first design and express how they intend to iterate on it. The iteration report follows, where students test their iteration, discuss how it differed from their first attempt, and then conclude by considering what elements of each design they wish to incorporate in their final design. The presentations are the same as the previous iteration of the course, and deliverables are predominantly graded using rubrics that emphasize student effort and critical thinking. Students are provided with report templates that explicitly state what elements are needed in each report.

Table 7. Assignments as contributors to student grades in the Spring 2015 semester

Item	**Points per Item**	**Number of Items**	**Total Points (Percentage of Grade)**	**Notes**
Proposals	100	2	200 (14.3%)	20% individual, 80% full report
Initial Progress Report	100	2	200 (14.3%)	20% individual, 80% full report
Iteration Report	100	2	200 (14.3%)	20% individual, 80% full report
Final Presentation	100	2	200 (14.3%)	Team grade
Peer Assessment	20	2	40 (2.8%)	Individual grade
Homework	20	10	160 max. (11.4%)	Individual grade
Midterm Exam	200	1	200 (14.3%)	Individual grade
Final Exam	200	1	200 (14.3%)	Individual grade

In order to give students more individual control over their grades, a new grading scheme was developed for the written deliverables. Each deliverable is worth 100 points and contains four 1-2 page sections, which include an introduction, a detailed device summary and diagram, a discussion of test results, and an update of the company budget and planned next steps. Each student in a company must claim ownership of one of the pages and should be primarily responsible for that page's content. Each page is worth 20 points individually, and one completed report is worth 80 points. To reach the complete 100 points, students earn up to 80 points from their company's completed report. Each student then earns up to 20 points based on the score from their individual page. This system is represented graphically as Figure 4. Students are now directly responsible for 40% of their grade for each deliverable.

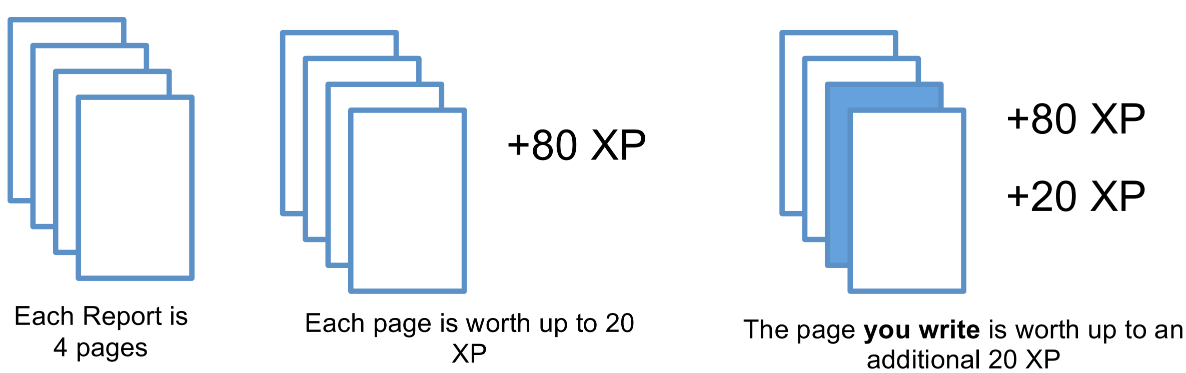

Figure 4. Alternative report grading method to allow individual students to have more of an impact on their personal grades, as presented to students

Previously, the deliverables were graded solely by one instructor of the course, which was a heavy burden on that instructor. By splitting deliverables into four sections with detailed templates and rubrics, grading can be spread to multiple instructors and/or teaching assistants. To assure consistency of grades, each grader is responsible for grading the same section for each deliverable for the entire semester. With this system in place, two instructors and two teaching assistants are able to grade deliverables for nineteen student companies in an afternoon. In order to assure that students gain experience writing a variety of sections and graders, students are not allowed to write the same section for two consecutive deliverables. More importantly, this system actively encourages students to communicate the strengths and weaknesses of sections they have already written to their teammates, enabling an atmosphere where students can teach their peers and reinforcing what they have learned. This communication is essential as it helps all teammates improve the quality of their sections, which will in turn help all students in the group.

Quizzes have been replaced with homework, which are one or two simple problems that give students additional practice with course concepts beyond the projects. These homework questions allow students to practice with information given during lectures and assist students with exam preparation. The way homework is graded reflects an aspect of game-based learning allowing students to customize their experience. There are 200 points available from homework in a semester, but students can only earn a maximum of 160 points. This system allows students some leeway in their homework assignments, as points lost on an earlier assignment can be made up by completing a later one. This system also discourages students from letting homework overwhelm the projects, as there are ample opportunities to make up lost points.

Other changes were made to streamline the simulation and game elements. It was clarified to students early on that device performance only impacted extra credit, which was changed from “reputation” to “net worth” to reflect the business theme. The materials ordering system was streamlined, moving from a paper order form to an online Google Form tied to a Google Spreadsheet that only the instructors and teaching assistants could access[13]. The spreadsheet automatically tracks what materials are ordered by each company, allowing for the teaching assistants to easily fill orders as they are placed between classes and track each company’s budget. Another element for the Spring 2015 semester was optional design challenges, where students could impose limitations on their final design for extra net worth. For example, if students complete a thermos without using a cup, which is often the most convenient and cost effective method, they will earn a small amount of net worth. Any number of students can attempt these challenges, which are designed to promote creativity by removing obvious solutions and increasing difficulty of the projects if students desire it.

7. Spring 2015 Mid-Semester Evaluation

At the time of writing, students have completed one project and, thus, one complete round of deliverables. At this time, students were surveyed for their opinion about various components of the class, the new system of deliverables, the business elements, and their opinion of the class overall. Of the 69 students in the course, 66 completed the survey.

In general, students were mixed in their opinion of the course overall. While many students (32) like the course to some extent (either strongly or somewhat), some students (24) dislike the course to some extent primarily due to the perceived harshness of grading, particularly on homework assignments. As this class is the students' first in engineering, the authors attribute this attitude to an adjustment period where students are learning and understanding instructor expectations. The fact that the students are improving with each deliverable supports this hypothesis. Students showed improvement on the second deliverable, with the average section grade rising from 15 ± 3 to 16 ± 2 XP out of a possible 20. While this change is not statistically significant, the average did rise slightly and the range of grades has become narrower.

The vast majority of students (53) said that they prefer the new deliverable system to a more traditional group work system where all students work on the report together and share the same grade, with 28 strongly preferring the new method. Initially, students appeared to struggle with the first deliverable as they were becoming acclimated to the system of deliverables, and some students did not communicate effectively with their group members. Additionally, students appeared to struggle with some of the finer points of each deliverable, namely proper data presentation with error analysis and technical writing, which prompted short in-class reviews of those topics during the lecture period. As stated previously, student grades continue to steadily improve as they acclimate to the class and these systems. Most of the students (48) agreed to some extent with the statement "I feel I am gaining useful skills in this class." The majority of students (50) agreed with the statement "I communicate the reviewer comments from my graded deliverable sections to my teammates," indicating that the students are using the peer education element of this deliverable structure.

8. Conclusions

While student feedback to this course has been mixed, the student opinion of the game and simulation systems added to a project-based freshman design course was very positive. The business simulation and game elements appear to have a positive impact on student attitudes toward communicating information and working in groups. Many students indicated they feel a project-based class of this nature in the first year of college was beneficial to their understanding of engineering as a field and engineering design specifically. While there are several improvements that are currently being implemented into this system, student feedback to the business game elements was highly positive. These early trends show there is promise in combining project-based, business simulation, and game-based learning elements to engage students in a freshman design course.

This paper served as a preliminary report on student attitude toward the course and its many elements. As this study has primarily relied on survey data, a more rigorous method of assessment is currently being devised. The students participating in the Spring 2015 offering of this course will have their performance and retention tracked through the sophomore-level courses. The performance of these students will then be compared to the performance of a control group of students in the Spring 2016 offering of this course, which will be project-based but will lack the simulation and game elements.

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