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Integration of ePortfolios in a First Year Engineering Course for Measuring Student Engagement

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Integration of ePortfolios in a First-Year Engineering Course for Measuring Student Engagement

Abstract

For the past 3 years, the First-Year Engineering Program at the University of Notre Dame has used electronic portfolios (ePortfolios) as an assessment tool for their Introduction to Engineering course sequence. While each year the ePortfolio assignments have expanded, they have been focused largely in three types of reflections: (1) student experiences within the college but outside of the course, (2) the skills gained specifically through course projects, and (3) their four year plan to be a successful engineering student as defined by the ABET a-k criteria. ePortfolio assignments were initially included to allow students to reflect on their education, develop evidence of their blossoming skills, and take control of their graduation plan. After the first year of practice, there was a clear secondary benefit to the faculty and student advisors. Anecdotally, student reflections provide faculty with a measure of student engagement with the course and even possibly indicated retention into their sophomore year. For this reason, a more formal assessment was needed to determine if student engagement could be measured through ePortfolio reflections.

While students are engaged with their ePortfolios, data that describes their interaction with the ePortfolio (number of times they log in, number of artifacts they submit, hits, comments, etc.) is continually collected. This paper will focus on: (1) how ePortfolios have been folded into the Introduction to Engineering course sequence, (2) if student reflections can be used as a measure of engagement and engineering interest, and (3) what markers within an ePortfolio can predict student retention. Specifically, study measures will consist of: (1) instructor categorization of student reflections and evidence types used and (2) assessment of the ePortfolio data features described above as they relate to student retention through the first year. Specifically, ePortfolio data features are continually collected through the use of a computational mining tool. In an initial study of the fall 2012 semester data, students who left the engineering track after one semester had an average of 12.7 logins to the ePortfolio system. Students who left the engineering track after two semesters and students who persisted into the sophomore year had a significantly larger average number of logins, with 18.7 and 19.1, respectively. Future plans include deeper exploration of ePortfolio features as markers of student interest in engineering, specifically identifying students by mid-semester that are at risk for prematurely leaving the engineering track and deploying intervention strategies for those students.

Introduction

The engineering education community is well aware of the current problems in retaining students in engineering. Many reports indicate that less than half of the students who start in engineering will obtain a degree in an engineering major.[1] Therefore, many institutions have dedicated significant time to identifying students at-risk of leaving engineering and implementing retention strategies. Often, these identification methods include statistical methods centered on academic performance or demographics; however, current theories on retention include many more attributes that contribute to student attrition.[2-4] While technical knowledge may play a part in retention, studies have included attitude based variables, which increase the likelihood of identifying at-risk students. Attitude based variables may include student-student interactions, dorm life, personality type, and how the degree is meeting their expectations. Some have even claimed that understanding students attitude about engineering and the university climate provides the highest correlation to retention.[5,6] Because it is already well documented elsewhere, this study will not consider traditional academic data in assessing student retention. Instead, we propose using electronic portfolios, or ePortfolios, as a method for assessing these more difficult to understand attitudes with a future goal of identifying at-risk students in a timely fashion.

While student portfolios are not new methods of documentation for majors such as architecture or art, they have been unexplored by the vast number of engineering schools. Although some have folded them in as an assessment of communications skills,[7,8] few have used portfolios as a means to measure student engagement and their learning process throughout their degree. Previous studies have proven the efficacy of the ePortfolio format as a method of engagement. Many universities have implemented ePortfolios to enhance engagement and measure impacts of programs.[9,10] ePortfolios have even been shown to create shared ownership of student learning between student and instructor by Chen and Black[11] and been used as a tool in advising.[12] We will use ePortfolios to serve as a larger space for students to record their achievements in engineering, starting with specific projects from the first-year engineering course and later being used for advising within their engineering majors. Although the course will set a general template, students are encouraged to treat the ePortfolio as their own creative space where they can collect evidence of accomplishments and connect it to their learning and goals as a student. While students are encouraged to continue the use of their ePortfolios throughout their university careers, this paper will focus solely on students' interactions with their ePortfolio during their first-year.

In the two semester Introduction to Engineering course sequence, all students are expected to create an ePortfolio following a course designated template. Each of the last 3 years has included changes to the template based on instructor and student evaluation of assignments. The course instructors have reflective exercises for future advisors to use as well as exploration activities to aid students in major discernment. The current ePortfolio template included three main sections, which were each updated throughout the course sequence:

(1) Engineering Advising – Required reflection on their engineering major choice and their progress towards engineering skill areas. Seven skills areas were defined, each relating to ABET accreditation required outcomes (a – k). Students are expected to create goals for each skills area and reflect on their current progress towards those goals. Future advisors could use this material to help identify opportunities for their advisees.
(2) Project Updates – Required updates following the completion of each course required project. Minimally, students were asked to include a picture of their project and a reflection on skills developed through the project. This space is expected to act as evidence of how students are meeting their goals outlined in the advising reflections. For instance, successfully completing a group project may be part of the evidence used to describe their development in working well within a team.
(3) Engineering Exploration – Required reflections after attendance at eight engineering related events that took place outside of the course. These events were a recent addition

to the course sequence, allowing students more in-class time to discern their major choice. Events included seminars, engineering student group meetings, professional development activities, etc. and were executed by various groups within the university, some during class time, but most throughout evening hours. Reflections were expected to capture why they attended the event and how that contributed to their growth as a student.

In addition, students are encouraged to add other details and information to their ePortfolio that would be appropriate for a professional setting. Students are especially urged to include other course projects, internships, or personal accomplishments that they feel appropriate.

While students are expected to complete all ePortfolio assignments as a portion of the course grade, they are graded largely for completion. Student engagement and effort towards assignments is widely variable; therefore, by exploring student responses and interaction with the ePortfolio system, student engagement may be a measurable quantity.

Methodology:

The data evaluated and discussed in this paper was collected from student ePortfolio assignments completed within the first-year engineering course sequence at the University of Notre Dame. Below, the study setting and methodologies are described in full.

Setting

The University of Notre Dame is a medium sized, Midwestern, private institution with a traditional student composition, i.e. the vast majority of students complete their undergraduate studies in four years and are in the age range of 18-22. The overall student body is 53% male and 47% female, while the College of Engineering is approximately 75% male and 25% female. First-year students are admitted to the First-Year of Studies program regardless of their intended future major. Students select their major (whether engineering or something else) near the end of their first-year when they register for classes for the upcoming fall semester. Beyond admission / selection into the university as a whole, there are no admission or selection criteria for entering any of the disciplines of engineering; rather, it is based on student interest alone.

With few exceptions, first-year students that are considering an academic pathway within engineering complete a standard first-year curriculum, including the two-semester course sequence, “Introduction to Engineering,” taught within the College of Engineering. Each year the course sequence has enrollments of approximately 450 – 550 students. The course has two main objectives: 1) to expose students to the engineering profession and engineering major options, and 2) to demonstrate the processes of planning, modeling, designing, and executing specified project deliverables. The course curriculum uses a project based learning approach, with students completing a total of three group projects across the two semester sequence. While students do have some exposure to various engineering disciplines, very little of the course is dedicated to detailed descriptions of individual major options. Instead, various ePortfolio assignments were used to encourage student exploration of engineering majors.

Methods

In order to assess student engagement, a multi-part assessment was conducted. Students completed ePortfolio assignments throughout the fall and spring semesters; however, this study will focus on Fall 2012 and Fall 2013 data.

Student ePortfolio assignments from the Fall 2013 semester were read and graded by instructors of the first-year course. A common rubric was shared between all instructors for three mid-semester assignments, assessing students based on perceived interested and engagement with the course. First, students were expected to attend and reflect on two events outside of the engineering course by the end of October. Both engineering exploration assignments were assessed for each student on the four point scale described in Table 1.

TABLE 1: Rubric for Student Interest in Engineering Based on Engineering Exploration Reflections.

Rating	**Interest Measure**
0	No rating could be discerned by reflection
1	Interest seems low and easily dissuaded from continuing in engineering. May state interest in major outside of engineering. Possibly mentions things unrelated to engineering as reasoning.
2	Does show some preference for engineering but may also mention other major possibilities. May indicate that he/she didn't know what engineering was.
3	Relates exploration towards engineering and possibly even specific fields. May emphasize determining what type of engineering he/she wants to major in. Student seems likely to continue on in engineering.

Additionally, a project update assignment was assessed in two parts –students' reflections on their project and the evidence they provided. Evidence was considered to be any item added to the ePortfolio in addition to the written reflection (i.e.: pictures, video, coding segments, and project reports). Minimally, students were expected to write a 2-3 sentence reflection and include a picture of their finalized project. The rubric used is included in Table 2.

TABLE 2: Rubric for Engagement with Course Project Based on ePortfolio Project Update

Rating	Reflection	Evidence
1	Missing any reflection or short and shallow	No evidence or single required picture only
2	Some reflection given and apparent time spent on activity	Some pictures or diagrams included. Obvious effort shown
3	Reflection deep and detailed – effort and interest clear	High amount of evidence shown, often including multimedia such as videos, pictures and programming segments.

Finally, this paper will explore the results of using a data mining tool with the ePorftolio system to act as a predictor of student retention. While results from the evaluation measure will be presented, this paper will not go into detail of the mining tool and classification algorithms used. However, full details on the experimental techniques explored can be found in Aguiar et al.[13] While many ePortfolio features and student academic features have been considered in this previous work, only the most important features of the ePortfolio tool will be detailed here. For this work, we focus on the number of times a student has logged into the ePortfolio system, pieces of evidence included, and ePortfolio hits. Note that ePortfolio hits are the number of visits to a student's ePortfolio pages which may originate from the ePortfolio owner or external visitors. At this time, we are unable to discriminate between these two types of visits; however, we suspect that ePortfolio hits are largely coming from the owner of the ePortfolio as he/she creates content, edits pages, and makes assignment corrections.

Results

Instructor Based Assessment

The primary purpose for starting this study was to determine if anecdotal observations by course instructors correlated to the retention of students. In many cases, student ePortfolio assignments appeared indicative of student retention. In this formalized examination, each of the eight instructors assessed their own small group sections (30-35 students in each section, ~2 sections per instructor) resulting in a total of over 400 students rated. The authors note that ratings bias may be present from having instructors act as the only raters for each student. Each instructor was given the same rubric and an initial training session for rating student responses. Any bias present is believed to minimally impact the rating results and overall conclusions of this study. Three examples below depict how the rubric from Table 1 correlated to statements made in the ePortfolio. As shown in these three examples, ratings were often determined by specific phrases that indicated student major choices.

Rating of 3 (Attended a Society of Women Engineers Event)
Apart from discerning between the different disciplines, the girls also helped in giving advice

about what our engineering experience at Notre Dame will be like and how to make it successful…Overall, this event was extremely helpful in strengthening my confidence that chemical engineering, even just engineering in general, is a good major for me.

Rating of 2 (Event held for Integrated Business and Engineering Minor)
I realize there is more that I can do with an engineering major than I previously knew. Although I am not totally sure that I want to major in engineering, I am confident that engineering will not inhibit my ability to change fields, but open me to new job opportunities.

Rating of 1 (Attended lecture by Dean of college of Engineering)
This event initially peaked my interest due to the fact that I was unsure of whether I wanted to pursue engineering further or not….At the conclusion of the Dean's lecture, I had a rejuvenated sense of what I want to do with my life… I want to pursue business like my father, not engineering like my brother.

Additionally, project reflections were used to gauge student engagement with the first-year engineering course. Due to length, examples of project reflections can be found in the appendix. Multimedia, such as video and programming code, are not included here.

Table 3 below reports the mean rubric scores for all students enrolled in the Fall 2013 course as well as those that have continued into the Spring 2014 engineering course (indicated as "Retained in Engineering") and those who left the program sequence after the fall course (indicated as "Left Engineering").

TABLE 3: Ratings of Student Engagement Based on Instructor Evaluation

	All Students	**Retained in Engineering**	**Left Engineering**
Exploration 1	2.37	2.38	2.06
Exploration 2	2.47	2.5	2.09
Project Reflection	2.10	2.11	1.93
Project Evidence	1.80	1.82	1.63

It should be noted that the retention rate from the first semester of this course is ~85%, resulting in very similar populations for the "All Students" and "Retained in Engineering" groups. For all assignments evaluated, the full student population and the retained population scoring is nearly identical. In contrast, those who left engineering had, on average, lower scores in each of the four assignments evaluated. However, only Exploration 1 ($p<0.1$) and Exploration 2 ($p<0.05$) assignments indicated statistically significant differences between those who remained in engineering and those who left after the first semester.

Data Mining

A computational tool was used to analyze features from students' ePortfolios following the completion of the 2012-2013 academic year. In Figure 1, the number of times a student logged in to the ePortfolio system during the Fall 2012 semester was compared for three student groups: (1) students who remained in an engineering major into sophomore year, (2) students who dropped after the spring semester of their first-year, and (3) students who dropped after the fall semester of their first year.

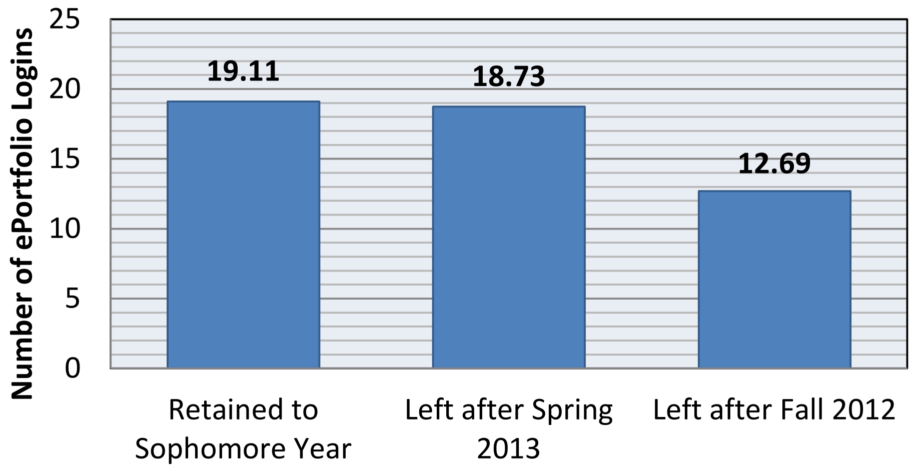

Figure 1: Number of ePortfolio logins during the Fall 2012 semester.

There was no statistical difference between the first two student groups – those that remained in the engineering course sequence throughout their first-year. However, there was a statistically significant difference in the number of logins for a student that dropped after only one semester ($p<0.005$).

Additionally, pieces of evidence submitted during the Fall 2012 semester were also compared. Because previous studies had revealed little difference between those students who left after the spring semester and those who were retained into sophomore year, these two groups were combined for future assessments into the group "Retained in Engineering", as shown below in Figure 2.

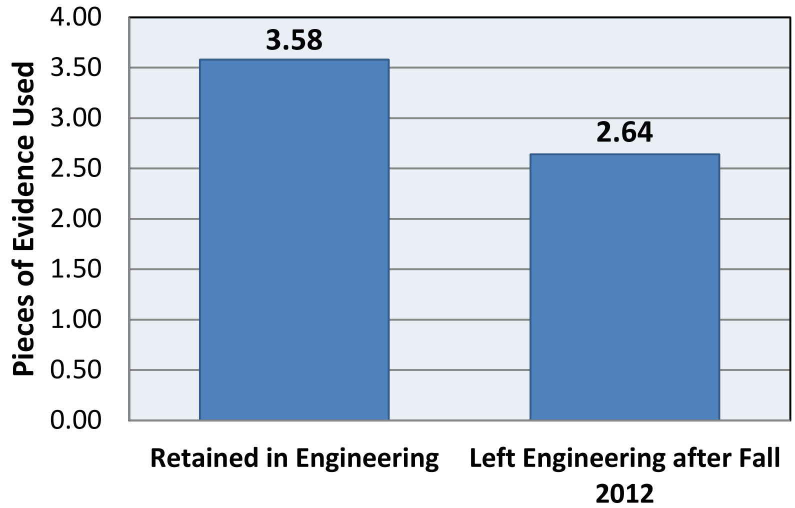

Figure 2: Number of pieces of evidence submitted during Fall 2012 Semester

Again, there is a statistically significant difference between the students who continue in engineering and those who leave ($p<0.05$). Students who were retained in engineering had on average only one more piece of evidence than those who did not; however, requirements of ePortfolio assignments would play an important role in the pieces of evidence expected from a student.

Finally, Figure 3 below shows the number of hits on each ePortfolio during the Fall 2012 semester. In this case, those that were retained had over five times as many hits as students who left engineering after the fall semester (670 hits compared to just 126 hits).

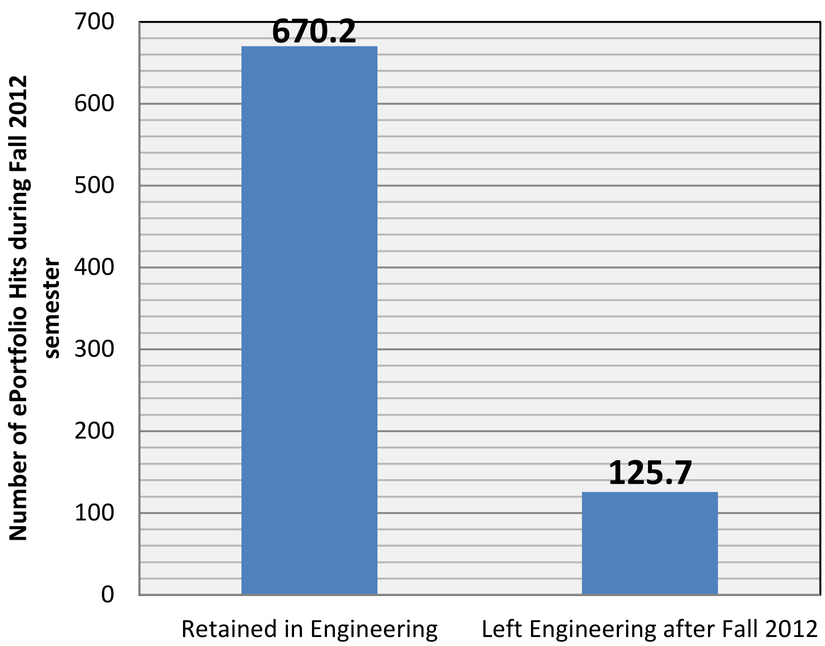

Figure 3: Number of ePortfolio hits during the Fall 2012 semester

Again, there is a statistically significant difference between the students who remain in engineering at least through the spring semester and those who leave during or after their first semester in engineering ($p<0.005$). In fact, of all ePortfolio measures currently under study, the number of ePortfolio hits is the strongest indicator of student retention when looking at the end of the semester.

Discussion/Future Work

The instructor based assessment indicated that student interest in engineering can be determined through fairly simple reflective exercises. Reflections on course projects offered minimal distinguishable characteristics between students that leave and those that are retained. We believe this is a result of the group nature of these projects, where all students from a project group had the same evidence available to use in their ePortfolio at the time of the reflection. Reflective assignments that focused on out of classroom events had more distinguishable markers for retention. We believe these assignments contained better markers due to the reflection requirements. For the Engineering Exploration assignments, students were asked to include personalized reasons for attending events and the growth they experienced because of it. These types of reflections led more naturally to student responses that included their doubts, interests, and career aspirations.

With many universities experiencing a rise in class sizes, reading multiple reflections from every student in a timely manner is likely not a practical solution to increase retention, though these reflections are useful additions when advising and interacting with students. The cost in staff and faculty time would be immense and place a heavy burden on those within the course if this were the only means of identifying at-risk students. Instead, using a combination of a computational tool and instructor reading would provide with a much needed balance in the cost of faculty involvement.

Data mining has provided a few much needed indicators of student retention. Many of the features that appear to be clear markers here are tied to the course requirements. For instance, students had eight ePortfolio assignments over the course of the semester, two of which had opportunities to go back and make corrections. If students fulfilled just the course requirements, they would be expected to login 10 times – where the average for students that drop is 12.69. Additionally, the course has only two assignments were pieces of evidence are required as part of the grade. Those who leave after one semester had an average of just 2.64 pieces of evidence. Perhaps unsurprisingly, being near the minimum requirements may be an indication that students are not engaged with the course, signaling a waning interest in engineering.

The strongest indicator of student retention though was number of hits on a student ePortfolio. Additionally, this large difference in number of hits cannot be directly correlated to expectations set from the course. While many of these hits may come from an instructor viewing the ePortfolio, it is not expected that instructor views would vary widely from student to student. Self-created hits, on the other hand, could vary greatly between students. Those who are more engaged with the course and their ePortfolio may spend more time documenting their projects and explorations. In addition, coming back to edit and update multiple ePortfolio pages would indicate that the student considers documenting and reflecting on their engineering experience an important part of their education. Most students also leave their ePortfolios open to other members of the university community. Therefore, if they are creating authentic, meaningful entries, other students and faculty may be more likely to visit and read their ePortfolio. Finally, students who are engaged with the course and their ePortfolio may use this to show off their work to friends, family, and possible employers. Overall, a high hit count on an ePortfolio would indicate a truly living document that is an authentic reflection of the student owner.

Collectively, we interpret the data mining results to indicate that ePortfolios can accurately measure interest and engagement; however, not all ePortfolio markers will be of equal utility. Both the course requirements and the student buy-in to the process will be important characteristics that need to be considered when identifying the relevant features at different universities. Currently, this identification has occurred after the semester ends, when it is likely too late to intervene with the students who choose to leave engineering, but future work will focus on similar analysis in a timely fashion for intervention. Using ePortfolio hits and logins, data which is easily attainable in real time, we can determine the markers of an at-risk student. By allowing the computational model to flag these students, the instructor's time commitment for very thorough evaluation is decreased to only those students flagged by the data mining tool. This could provide faculty then with a chance to carefully assess why a student is choosing to leave engineering and help him/her determine if it is a premature choice (i.e. – leaving because of one midterm grade) and intervene with strategies already in place at the university.

Acknowledgements

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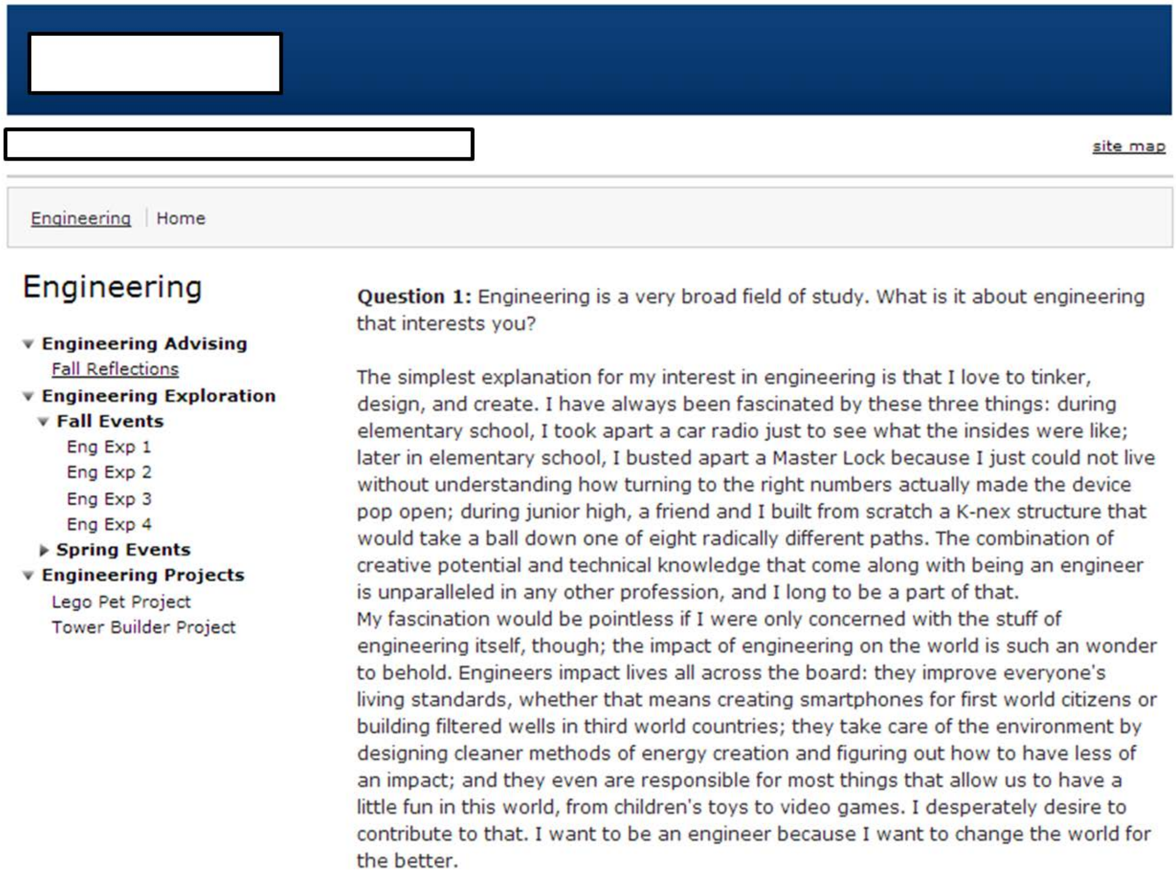
Appendix



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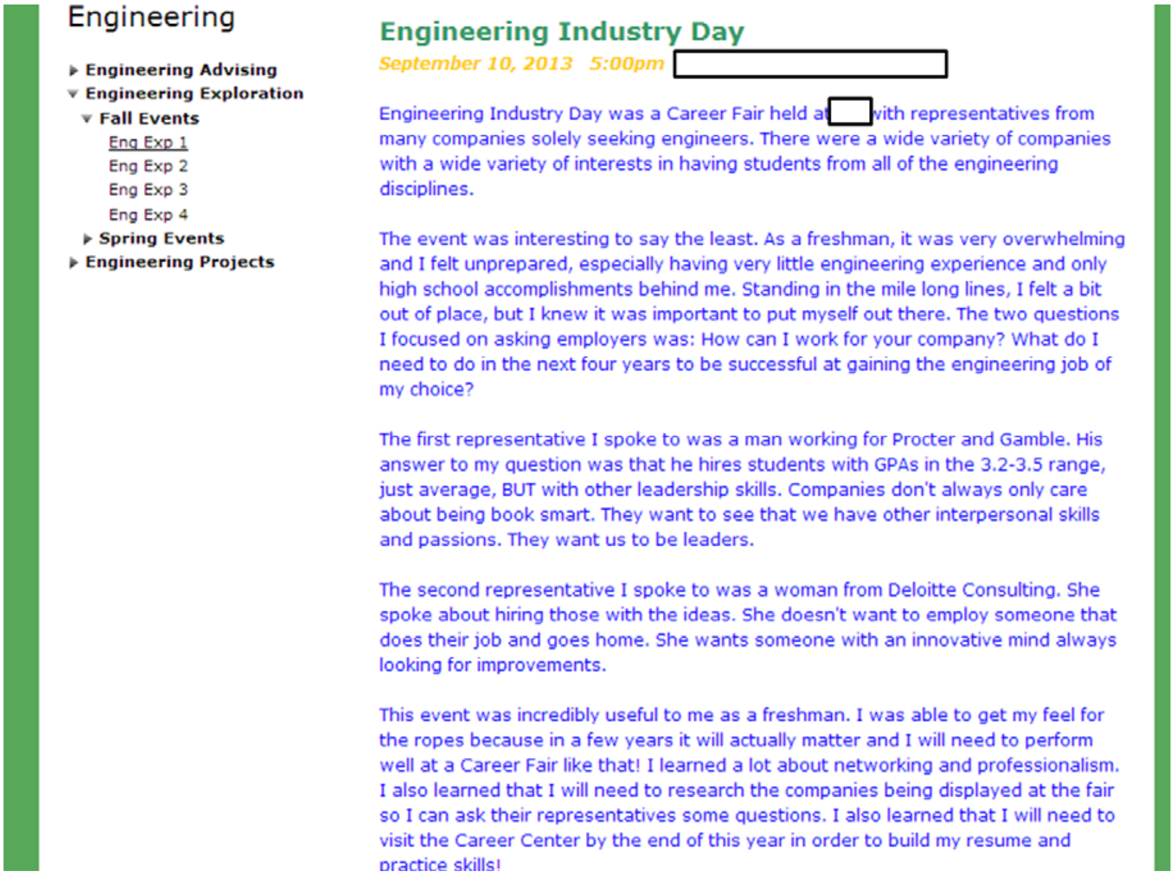
Question 1: Engineering is a very broad field of study. What is it about engineering that interests you?

The simplest explanation for my interest in engineering is that I love to tinker, design, and create. I have always been fascinated by these three things: during elementary school, I took apart a car radio just to see what the insides were like; later in elementary school, I busted apart a Master Lock because I just could not live without understanding how turning to the right numbers actually made the device pop open; during junior high, a friend and I built from scratch a K-nex structure that would take a ball down one of eight radically different paths. The combination of creative potential and technical knowledge that come along with being an engineer is unparalleled in any other profession, and I long to be a part of that.
My fascination would be pointless if I were only concerned with the stuff of engineering itself, though; the impact of engineering on the world is such an wonder to behold. Engineers impact lives all across the board: they improve everyone's living standards, whether that means creating smartphones for first world citizens or building filtered wells in third world countries; they take care of the environment by designing cleaner methods of energy creation and figuring out how to have less of an impact; and they even are responsible for most things that allow us to have a little fun in this world, from children's toys to video games. I desperately desire to contribute to that. I want to be an engineer because I want to change the world for the better.

Figure A1: Example of Initial Reflective Exercise in ePortfolios



Engineering

- Engineering Advising
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Engineering Industry Day

September 10, 2013 5:00pm [redacted]

Engineering Industry Day was a Career Fair held at [redacted] with representatives from many companies solely seeking engineers. There were a wide variety of companies with a wide variety of interests in having students from all of the engineering disciplines.

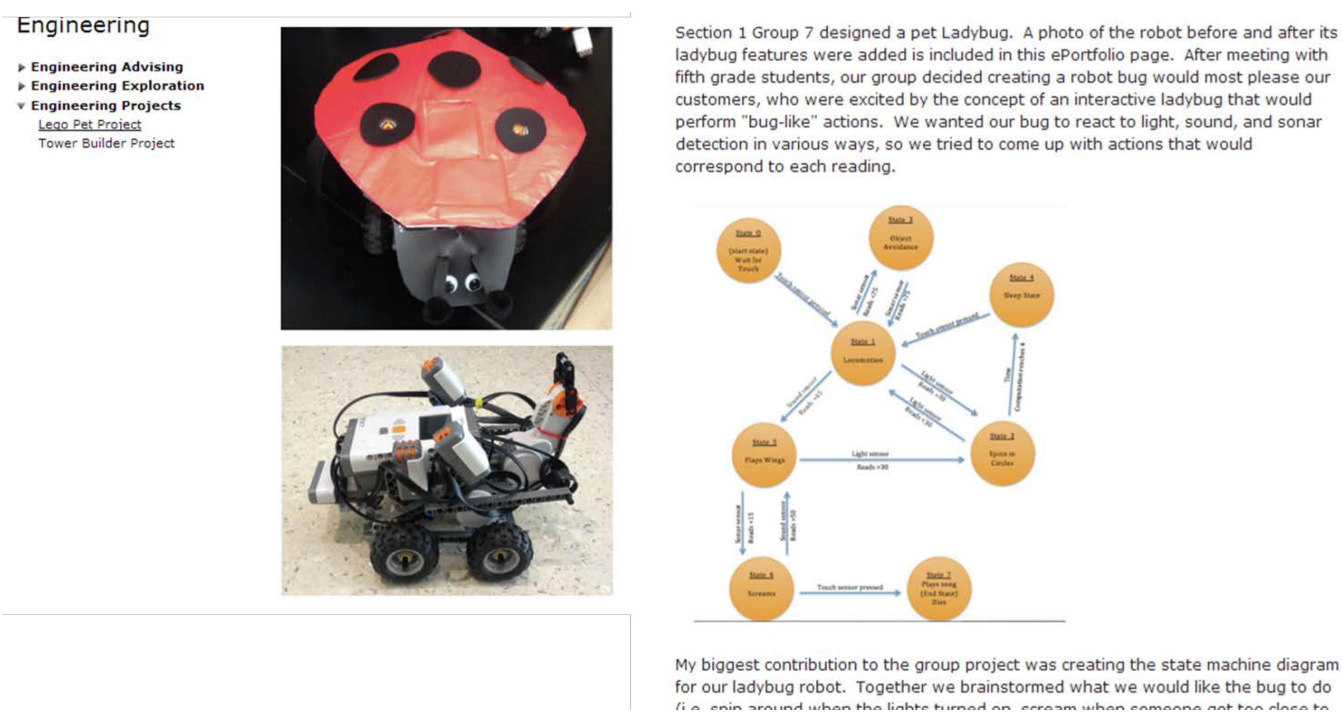
The event was interesting to say the least. As a freshman, it was very overwhelming and I felt unprepared, especially having very little engineering experience and only high school accomplishments behind me. Standing in the mile long lines, I felt a bit out of place, but I knew it was important to put myself out there. The two questions I focused on asking employers was: How can I work for your company? What do I need to do in the next four years to be successful at gaining the engineering job of my choice?

The first representative I spoke to was a man working for Procter and Gamble. His answer to my question was that he hires students with GPAs in the 3.2-3.5 range, just average, BUT with other leadership skills. Companies don't always only care about being book smart. They want to see that we have other interpersonal skills and passions. They want us to be leaders.

The second representative I spoke to was a woman from Deloitte Consulting. She spoke about hiring those with the ideas. She doesn't want to employ someone that does their job and goes home. She wants someone with an innovative mind always looking for improvements.

This event was incredibly useful to me as a freshman. I was able to get my feel for the ropes because in a few years it will actually matter and I will need to perform well at a Career Fair like that! I learned a lot about networking and professionalism. I also learned that I will need to research the companies being displayed at the fair so I can ask their representatives some questions. I also learned that I will need to visit the Career Center by the end of this year in order to build my resume and practice skills!

Figure A2: Example of Expected Reflection for Engineering Exploration Assignment



Engineering

- Engineering Advising
- Engineering Exploration
- Engineering Projects
  - Lego Pet Project
  - Tower Builder Project

Section 1 Group 7 designed a pet Ladybug. A photo of the robot before and after its ladybug features were added is included in this ePortfolio page. After meeting with fifth grade students, our group decided creating a robot bug would most please our customers, who were excited by the concept of an interactive ladybug that would perform "bug-like" actions. We wanted our bug to react to light, sound, and sonar detection in various ways, so we tried to come up with actions that would correspond to each reading.

My biggest contribution to the group project was creating the state machine diagram for our ladybug robot. Together we brainstormed what we would like the bug to do

Figure A3: Robotics Course Project Reflection Example with Multiple Pieces of Evidence

Engineering

- Engineering Advising
- Engineering Exploration
- Engineering Projects
  - Lego Pet Project
  - Tower Builder Project

For our pet project me and my group designed a Stitch robot. For this project we used a variety of sensors including a light, sound, distance and touch as well as two motors. The purpose of the project was to design a pet like robot that would fit a fifth graders wishes. To do so we met with several fifth graderes who gave input on what they would like to see in this pet. After getting first hand information about what the client base want the next step is to take the ideas and filter the plausible from the surreal. Once a reasonable pet with reasonable features has been agreed on the next step is to with the group design the robot and create a program that can be used to tell the robot to perform the task. LabView was the program we used to create and design programs to run on the robot. The program was designed to allow the robot to perform a number of task such as: Avoid objects, hula dance, run away from load noises, sing a song and display text. The robot was designed to move from one state to another with only monior or none human interaction.

Figure A4: Robotics Course Project Example with Single Piece of Evidence

Engineering

- Engineering Advising
- Engineering Exploration
- Engineering Projects
  - Lego Pet Project
  - Tower Builder Project

Using a NXT Robotics Lego Kit, a group of four other students and myself built and programmed a pet robot tiger (Shown Below).

The tiger was autonomous and was able to interact with its environment using a variety of sensors. The tiger was able to play notes from "Eye of the Tiger", roar, stop when it was hungry, go to sleep, attack close objects, and avoid objects that were in its way. In order to interact with the environment, sensor inputs were used to send the robot into a different state, or case, in a LabView case structure. The case structure was set inside a While Loop so that the tiger would continuosly process sensor inputs and decide which case the tiger should enter into. The final case invovled a true constant loop conditon so that the robot would turn off if the on/off button was pressed. LabView programming was an essential tool needed to complete the project and my understanding of the program has greatly increased. With my LabView knowledge, I helped debugg the tiger's programming so that it would interact properly with its enviroment. Attached are the report I wrote for my group and a state diagram of the robot with state transitions and their appropriate sensors, as well as videos of our project demonstration.

Pet_Report.docx
State__Diagram.pptx

Robot_Project_1.MOV
Robot_Project_2.MOV
Robot_Project_3.MOV

Figure A5: Robotics Course Project Example with Linked Multimedia Evidence