Empowerment to Success: The Class Structure in an Honors Engineering Course

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Abstract *— Structuring a quality honors course is a challenge in most disciplines. We have offered an honors section in our introductory computer science class for several years. During this time we have restructured our honors section several times, including shifting both the focus and format. We started with a concentration in Web Design, shifted to Robotics, and then advanced onto student presentations. The layout began as a traditionally structured course, evolved with the introduction of student mentors, and most recently has advanced to student-directed learning. It is evidenced from both our evaluation of the student work and the student evaluations of the course that self-directed learning (i.e., empowerment) has resulted in a satisfactory and successful honors class.*

Index Terms — honors, student empowerment, CS1

INTRODUCTION

In 1997 the Department of Computer Science was approached by the Honors Program to develop an honors section of Introduction to Computer Science, or CS1. The goal was to have this section open to all students in the honors program without regard to major. Because of resource limitations it became necessary to integrate this section into the regular lecture course already structured for Engineering students. Our challenge was to structure the section to justify honors credit and captivate these students while at the same time not overwhelm the non-Engineering students and not place extra strain on the acute shortage of teaching staff [3].

The CS1 class is structured as a three credit semester long course. The lecture is three hours a week with a one hour weekly lab. In all sections, including honors, the students complete eleven weekly programming assignments. The semester culminates with a three week individual programming project that utilizes the concepts learned over the course of the semester.

Since the honors section was created in the fall of 1998 there have been four different course formats. The course structure has changed significantly from offering to offering. As the structure has evolved the level of student involvement has increased. We have found that there exists a direct correlation between this increased level of involvement (i.e., empowerment) and the students perception of, and hence, performance in the class. This is similar to the relationship found in [1].

In this paper we present some details of the four different course structures. In addition, we report on how the empowerment manifested itself in the decision process of the most recent offering. Finally, we address what form future honors sections of CS1 may be like based upon our observations and the student evaluations of the course.

HISTORY I – WEB DESIGN

Although initial contact from the Honors Program came in late 1997, the decision by the department to instantiate the course did not come until days before the start of the fall 1998 semester. Therefore, the structure of this first iteration of an honors section was ad hoc at best.

A Teaching Assistant (TA), with expertise in web design, was assigned solely to this section. The primary focus, therefore, of this first round of course design was to teach the students web design. The web element of the class was in addition to the regular lab assignments of the other sections. The additional work required of the students was compensated for by increasing the weekly lab from one to two hours. Because the thought was that this was not computer science "enough", the students were also required to attend several colloquium hosted by the department. When the TA, due to an emergency, left in the middle of the semester, the focus of the section shifted solely to colloquium attendance because we could not replace the web design instructor by an equally qualified TA.

Our preliminary thoughts regarding this course design were negative. The course structure had several problems. One, the information was coming from a single source and when that dried up the section faltered. Second, adding web design, while maybe timely and interesting to the students, was not rigorous enough for an honors section in computer science. Lastly, while it was appropriate for the students to be exposed to advanced computer science subjects through colloquia, by not augmenting the talks with background and/or supplemental material the students tended to be exposed to the topics but developed little or no understanding and appreciation.

HISTORY II – LEGO MINDSTORM

Due to the scheduling time line the second iteration of the honors section in spring of 1999 was agreed to before the first round was a week old. Therefore, we attempted to

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address the perceived shortcomings of the first semester without a proper and timely analysis of the issues involved.

An assistant professor in the department received a grant to integrate the learning of programming through robotics. He agreed that sponsoring the honors section of CS1 was an appropriate vehicle to carry out his research. This semester's honors section was limited to ten students. The grant bought two Lego MindStorm robot sets, and subsequently the students were split into two teams. Again, the students work with the robots was in addition to their regular lab assignments and the weekly lab hour was increased to two hours.

The teams designed, built, and programmed the robots to deal with increasingly harder problems. They began with simple movements, increased to light sensor readings to follow a painted line, then progressed to obstacle avoidance. The culmination of the semester was team competitions. The two robotics teams competed with each other and against teams from the Mechanical Engineering department.

At the beginning of the semester the initial response of the students was positive – they saw it as fun. But this quickly degraded as they realized the vast amount of time needed to design and implement their tasks. In addition, because the entire semester was team oriented the students complained about the logistics of getting large teams together multiple times per week. This negativity was mitigated somewhat at the end of the semester by the excitement of the team competitions. The positive effect was predicted in [1, 4] because the students saw the benefit of their group work.

We were more pleased with the results of this iteration of the honors section but still had major concerns. The focus was more appropriate to a computer science class than the web design basis of the previous semester but we were uncertain whether the learning was noteworthy. In particular, whether the students actually learned more programming from this hands on experience, than the regular labs provided. In addition, the proper team dynamics (i.e., leadership) and reinforcement of what they learned was lacking.

HISTORY III - MENTORING LEGO

The summer of 1999 was used as a time to analyze and evaluate the results, and more importantly the pros and cons of the structure of the honors lab using the Lego robots. We felt that although the faculty member's involvement assisted the process, the students wandered aimlessly in their team projects due to the content and structure of the lab. To wit, the group dynamics became a major issue. Generally, the students who understood the academics of the lab were not the natural group leaders. The leaders then became those who could lead but did not have the ability to dissect and analyze the material properly.

With this in mind, we decided to use exceptional students from the previous course as mentors for the new section. The mentors' goals were to provide experience and direction. This should have enabled the groups to spend less time on ancillary problems, such as building the robots, and more time on learning programming skills [5]. To meet this goal the session was structured so that the mentors met with the teams during lab time, as well as arranging and overseeing additional group meetings as needed.

What resulted was too heavy of a reliance on the student mentors to provide guidance. Since the mentor's involvement was purely voluntary, with no financial compensation or academic credit received, the mentor's enthusiasm waned as the semester progressed and their own work load increased. Therefore the robots got built and the software written but somehow the process turned tedious for students and mentors alike. Although no grade was given for the extra honor's work there was a distinct drop off in grades in the regular lecture and lab work by the honors students.

This semester turned out to be the least valuable to the honors students, in addition to possibly being a detriment to their outlook and interest in the course as a whole. We again felt that a significant amount of time was spent on the design of the robots without the benefits of an increased understanding of programming. This coupled with the reliance on mentors and everyone's lack of enthusiasm led us to believe that we needed to revamp the entire approach to the honors section of CS1.

HISTORY IV – EMPOWERMENT

With the entire year and increased resources available, we were able to completely analyze and overhaul the structure of the honors section. We evaluated several factors, including content, goals, time and resource demands, and student feedback.

We set the structure based on three main areas: invited talks; a portfolio; and a team research project and presentation. The first half of the semester was focused on invited talks and the second half of the semester focused on the projects. The last three weeks of the semester were dedicated to the regular final project that was assigned to all the CS1 sections. The portfolio addressed the research of the speakers and the evaluation of the course, and therefore was prepared over the course of the semester.

Instead of relying on the departmental colloquium series, we invited departmental faculty, outside researchers, and undergraduate seniors to speak to the class. The seven speakers were asked to talk about a computer science subject that was general enough in scope to appeal to freshman and a diverse group of majors, but with sufficient technical content to expose the students to computer science subject matter and research. The departmental faculty talks were on Cryptography, Computer Vision, and Neural Networks. The two outside speakers, both entrepreneurs, presented research and development of their companies products, one on Biometrics and the other on Computer Vision. Two senior level computer science students talked about their summer

internships. One of the students gave a formal presentation on wireless technology (Blue Tooth) based on his work with Agilent Technologies. The other student presented an overview of his work in Japan on Beowulf clusters. To introduce an element of discussion and dissection of the speakers themes, every week a ten minute summary was given. On a rotating basis, three students were required to give the summary of the topic presented the previous week.

The portfolio consisted of two sections. The first section was a summary on each lecture presented by the invited speakers. If the students had missed the presentation or were not able to generate enough notes from the talk they were encouraged to substitute a summary based on their outside readings of the topic. The second section was an in depth discussion of the structure of the honors section and their perceived notion of what they learned over the semester.

The second half of the semester was dedicated to the student team projects and presentations. The students were broken up into groups of four. The teams were chosen based on discipline. Approximately half the class was computer science majors. The other ten students came from electrical engineering, civil engineering, mechanical engineering, biochemistry and the liberal arts. The distribution of majors allowed us to set up groups with two disciplines represented on each team. We accomplished this by putting two computer science majors in each group and then clustering a specific major with the other two team members. For example, one team had two computer science students and two mechanical engineering majors while another team had two computer science majors and two biochemistry students. We thought by structuring the teams this way a natural subject would emerge for the group presentations.

The requirements for the student presentations were simple, similar to the organization described in [2]. Each team had to give a PowerPoint presentation, in which all members of the group participated. The presentation had to be approximately thirty minutes in length. The students were allowed, in fact encouraged, to pick any computer science related subject that they were interested in. The topics were not required to be the same as those presented by the outside speakers. The week after the initial team meeting, each team was required to submit in writing a rough outline of the areas to be covered. The only advice the instructor gave regarding the outline was on the scope of the subject proposed by the students.

EMPOWERMENT VS. STRUCTURE

Even though the course was structured, the students were given free rein and complete freedom to choose a topic for their group presentations. Our hope was that if they choose a subject they were interested in, whether the interest was generated from the invited talks or from their own readings, that they would spend more time and go to greater lengths and depth to research and present their material. We found this to be true.

We anticipated that the structure of the teams by disciplines would automatically create topics of interest. But, the presentation areas that the students selected were not as discipline specific as we expected. Nevertheless, all the topics chosen were appropriate to a computer science honors section. Since the students were not provided detailed instruction on the content of their presentations, our general expectation was that the students might do a superficial coverage of the material. However, we were surprised and pleased at the range of topics picked and the level of complexity and self-motivation exhibited by the students. Only one of the team's topics coincided directly with an outside presentation done earlier in the semester and that was a subtopic of Cryptography. However, the students did not rely on the material provided by the faculty speaker but in fact investigated and researched new material.

The other presentation subjects were: The Search for Extraterrestrial Intelligence (SETI); DNA supercomputing; NASA's Interplanetary Network; and Digital Imaging. The SETI group introduced concepts of probability, radio telescope arrays, and an in depth coverage of distributed computing and its applications. The DNA supercomputing group presented topics as diverse as boolean logic, parallel computing, computational complexity, and then proceeded to use them in a complete analysis of the advantages and disadvantages of DNA versus silicon chip computing. The Interplanetary Network "Media" group covered networking protocols, high bandwidth technologies, wireless communication, as well as parallel processing. The Digital Imaging Group, while the least theoretical, still addressed a large number of relevant computer science subjects, such as pipelining and architectural design, OpenGL and graphics. In addition, they mentioned such areas as distributed computing, and operating system requirements. The Cryptography group covered an in depth discussion of Boolean logic, algorithms, and theory of encryption. This subject was not treated trivially as the students also attempted to delve into and explain NP-completeness as part of their presentation.

STUDENT EVALUATIONS

During the semester of Empowerment, due to credit hour restrictions, we could not enforce a requirement of an extra lab hour for the honors students. In the previous offerings we were providing two hours of laboratory time. Previously, in the first hour the students could do their regular lab assignments, required of all sections. In the second hour they could engage in the special activities associated with the honors section. Eventually credit hour regulations caught up with this arrangement and we could not enforce the requirement of an extra lab hour for the honors students. As it turned out this may have been the biggest downside to the Empowerment structure. In their evaluations of the

course the students biggest complaint was the one hour limit on lab time.

On the other hand, the students felt that the biggest advantage of talks/presentation structure was their ability to develop an understanding of what computer science is. As one student wrote "… it gave me a glimpse of the array of applications of computer science". Another student put it in more straight forward fashion saying "I never knew that Computer Scientists could go into some of these fields… I thought all they did was program stuff".

One of the students took two different semesters of the Honor's section. The first semester was the Mentoring Lego round, the structure with the student mentors, the second time was the latest course iteration. His evaluation of the Empowerment semester was especially valuable because he compared the structure and content to his Lego class. He commented that "The structure of the honors section was very methodical and well-kept compared to last year." He also said that he felt the portfolio and presentations were more interesting and informative than the Lego labs.

Our hope that the newest structure would also excite the students about computer science was evidenced by a student comment that he particularly liked the Cryptography section. He went on to say that after discussions and his presentation he became very interested in this topic and hopes to study it further.

FUTURE FORMATS

For the next offering of a CS1 honors section we will make slight modifications to the current structure. However, the current focus of the course on a variety of computer science topics proved to be satisfactory and thus will stay the same.

The major change to structure will be the elimination of the ten minute group summaries presented at the beginning of every lab period. This originally was designed to reinforce the subject matter presented by the invited speakers, and also to give absent students an overview of the speaker's topic. However, it accomplished neither of these tasks well while using precious lab time. An instructor led discussion of the topic would serve the students better, and all students, whether absent or not, are encouraged to do their own readings on each speaker's lecture material.

The other change to structure that we would like to implement is to increase the lab time from one hour to two. This would allow the students to spend one hour working on the programming assignments due for the regular section while allowing an hour for the special honors material. Unfortunately, this change does not look possible under current credit hour restrictions.

CONCLUSION

We found that methodical organization is not mutually exclusive with empowerment of the student. A class can be well structured and yet still allow a large measure of freedom for the student to take control of learning. Our initial and subsequent reaction to the Empowerment format was that with some slight modifications we accomplished our goals. That is: generating enthusiasm; knowledge; interest in computer science; and a better understanding of what computer science really is. Many computer science majors realize that there is more to their chosen discipline then just programming in their junior year. This group of honors students realized the same in their first semester of college. After much analysis and changes in focus and structure, we believe that we have developed a successful honors course.

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