Abstract – In the Senior Design Center of the Computer Science Department at North Carolina State University, a model has been outlined that uses teaming as a framework to support professional communication and software development process to improve student project performance. The model described above was used as the basis to form a team of computer science students who entered the IEEE Computer Society International Design Competition (CSIDC 2003). The theme of CSIDC 2003 was Added Value: Turning Computers Into Systems. The NC State student team created "Diet Download," a system that uses a bar code scanner coupled with a PDA to assist a person with following a diet plan as he or she does grocery shopping. This paper describes the experience of the CSIDC 2003 student team on their journey from the formation of their team to their third place finish in this worldwide competition.

Index Terms – Capstone Courses, Teams, Undergraduate Computer Science Education, IEEE Computer Society International Design Competition (CSIDC).

INTRODUCTION

At North Carolina State University (NCSU), the Department of Computer Science (CSC) has established a Senior Design Center with the mission of integrating technical projects, teaming, professional communication skills (writing and presenting), and a software development process into an undergraduate capstone design course. The Center’s approach has evolved from 10 years experience in offering a 15-week capstone senior design project course, CSC 492. The Senior Design Center was established in 1994 to facilitate interaction between the Computer Science Department and North Carolina industry for the purpose of providing computer science seniors realistic project experiences. CSC 492 is a team taught by the Director of the Senior Design Center, a professor of computer science, and by the Associate Director/Team Coordinator of the Senior Design Center, a certified team specialist/technical communicator. Since 20+ unique teams are formed each semester, the Center also provides students with a technical mentor and an extended staff to assist students with team coordination, technical communication instruction, and laboratory support. Additionally, industrial sponsors and provide projects and a contact engineer.

The instructors of CSC 492 assume that students enter the course with a core knowledge of computer science and software engineering, as well as some experience with technical writing and speaking (via prerequisites for the capstone course). The intent of the senior design course is to emphasize software development process, professional communication, and teaming. It has been the experience of the Center staff that the best results are produced when a team shares a common vision and goal, when each individual of the team finds the best way that he or she can contribute to that vision and goal, and further, when each person on the team is able to encourage other team members to similarly contribute. This philosophy was expressed at the most recent NCSU CSC Department graduation by Mr. Gerhard Pilcher, CEO of H.B. Rowe & Co., Mount Airy, NC. Pilcher advised our graduates to recognize their own talents, use them to achieve lifetime goals, and look for these talents in other people [8]. Our approach is to foster this attitude by providing formal team training to students enrolled in CSC 492.

At the beginning of the Spring 2003 semester, a team of four students came together to work on the IEEE Computer Society International Design Competition (CSIDC) offered to them as a senior design project in CSC 492. The theme of the 2003 competition was “Added Value: Turning Computers Into Systems” [2]. Competing student teams were required to submit written interim and final reports to the competition describing their system. The top ten teams from around the world were invited to compete in Washington DC as finalists. The NCSU team placed third at this competition.

The CSIDC strongly believes that effective teamwork optimizes innovativeness and product realization, and the judges expect to see that competing students have bought into this idea [1]. In previous works related to the NCSU CSC Senior Design Center activities, we have reported on the added value of providing teaming instruction, of monitoring student teamwork, and of establishing an environment where open, frequent communication occurs among instructors, students, and industrial sponsors [3, 4, 6].

This paper explores the journey taken by this winning CSIDC student team as they prepared for various course and competition milestones. It describes how teaming elements fueled the software development process that lead to the creation of the team’s product. We also discuss elements of the communication components (i.e., formal written communication, and laboratory support).
Students enrolled in CSC 492 are expected to follow a well-defined software engineering methodology or process. Students are also expected to come to the class with technical skills that enable them to participate in any one of a wide variety of senior design projects. This assumption allows time in the semester to provide students with formal training on the principles of teamwork. This training includes the explanation of team roles, scenarios, and ground rules as well as the manner in which to conduct effective meetings and task planning sessions. Traditionally, in the Senior Design Center, teams are formed based on individual student project and team member preferences, skill sets, and scheduling considerations.

The individual contribution by a member of a team is evaluated and included in his or her final grade. Accountability to the team is expected of every team member. Individual contribution is measured by instructors’ evaluations as well as evaluations completed by student peers. Each student is expected to give at least one oral technical presentation and is required to maintain an individual log summarizing all work and number of hours spent related to CSC 492. The log contains information about work done individually and with other team members. This is a particularly useful tool when monitoring open-ended projects because it allows instructors to gauge and evaluate, on an ongoing basis, progress versus time spent on the project. Instructors are able to monitor project activities and adjust scope, if necessary.

The work of the entire team is also figured into the final grade of each student. Instructors and sponsors monitor student teams, and throughout the semester, if needed, they attend and/or facilitate team meetings. Teams provide the Team Coordinator with copies of all meeting agendas and minutes, which are read, acted upon if required, and filed. When a conflict cannot be resolved within a team, the Team Coordinator will mediate, if requested by the students. In addition to status report documents and presentations, project schedules are frequently examined by the instructors to ensure that teams are on task. Problem solving sessions and design/code reviews with the instructors are scheduled, as needed, when initiated by the team. Quality of documentation and evidence of project progress contribute to the team grade.

Supplemental instruction related to various software development methodologies and writing and speaking is also provided. Although technical skills are obviously required to complete the project, CSC 492 focuses on the choice and use of an appropriate software development methodology, the communication of that process, and the teamwork that provides energy to this entire scenario [4, 5, 6].

On the first day of class in the beginning of every semester, students are informed of details related to the above structure. They are told that they are expected to work an average of 10 hours/week (including class time) on their senior design project. At this time, brief project descriptions are presented to the class, and students are given time to reflect on projects, fill out an information sheet, and submit it to the Center staff the next day.

CSIDC 2003

In 1999, the IEEE initiated the CSIDC to encourage teams of undergraduate students to create an innovative product that would be of use to society. The students are expected to see the product through from inception and design to development and testing. In the final stages of the competition, the students are also expected to “market” their product by demonstrating it and “selling” it to a panel of judges. The theme of CSIDC 2003 was “added value.” Students were challenged with using “a PC or handheld computer to solve a problem” in society [2]. At the NCSU CSC Senior Design Center, we offered the CSIDC opportunity to our students as 1 of 20 projects in our senior design project course.

I. Preparation For The Journey: Forming The Team

The Spring 2003 semester at NCSU began on January 9, 2003. After reviewing available senior design projects for the semester, a class of 76 computer science students were asked to complete information sheets listing their expertise and interests; 1st, 2nd, and 3rd project choices; team member preferences, and class/work schedules. The Center staff carefully examined submitted information sheets and reviewed student interests, comments, and schedules when forming teams.

Of the bids received, only 2 of 76 students chose CSIDC as a project choice, and even then, it was their 3rd place choice. In retrospect, we believe that the open-ended nature of the design competition intimidated most students. (After all, CSC 492 is a required course and most just want to graduate!) The instructors had their first problem. To widen the circle of prospects, the Center staff then looked at student choices of possible teammates and that brought in two other potential team members.

As we were attempting to form the team, one of the potential team members paid us a visit. He honestly stated that the competition intrigued his sense of creativity, but he was concerned that it might require technical challenges that he was not ready to tackle. A friend and classmate of this young man also conferred with us and confidently stated that although he did not choose the CSIDC as one of his project choices, he would be very willing to work on a team with his creative friend, and further, he was willing to accept any technical challenge that would arise as a part of the competition. The other student who chose the CSIDC project did so because he felt it would be an “open ended assignment so a team could make something challenging and of interest.” He also mentioned on his information sheet that he was working toward a minor in mathematics. A fourth student mentioned that he had worked with one of the above students and that he was double majoring in mathematics/computer science. It was our instinct that the perspective and
II. The First Step Of The Journey: Finding The Right Problem To Solve

One of the required tasks for CSC 492 was for student teams to submit written Problem Statement & Feasibility Reports by February 4. This was a relatively simple task for most 492 teams because industrial sponsors provided them with a basic problem statement and their reports served as a clarification of some of the upfront details. For the CSIDC team, however, this proved to be quite an exercise in creativity and consensus building! The team brainstormed at a local eatery in preparation for a meeting with course instructors about potential project topics. They discussed problems that many people are faced with on a daily basis. The guidelines of the competition, however, also forced the team to examine both the innovativeness and the marketability of products that could potentially solve such problems.

After meeting with instructors, the team decided to focus on two areas: diet control and primary education. One of the team members expressed concern over the fact that diet control seemed to be mainly an issue in the United States and since the competition was an international event, he was concerned that the relevance of any product related to this problem would not be highly valued on a global scale. On the other hand, another potential idea was built around education in the classroom that included wireless computer solutions for schools that were in dire need of assistance in the technical arena; however, the predominant reason these schools had a problem with providing technical assistance to their students in the first place was because of limited resources, so how could these schools afford an application that would help them with this problem?! This did not seem like a feasible market for any type of new application/product.

The team needed to come to an agreement about project topics. This forced them to define a decision making process. They made a list of potential projects and took a vote. In the event of a tie, they would restate their cases and vote again until the tie was broken. Each vote carried an equal weight, but it eventually became apparent which decision was the best. Finally, they agreed on developing an application that would assist people with maintaining a healthy diet. “Diet Download” was born. It was to be a PDA application that would enable users to keep track of their diet. To make it portable and easy to use, Diet Download would incorporate an integral barcode scanner and databases to help track food products and their consumption. Diet Download would have five main functions: a diet plan, a grocery list, a pantry inventory, a meal system, and a user statistics system. The system would be implemented using the Model-View-Controller design pattern [5].

Dieting the problem and feasibility of a potential solution was a challenge for the team. Frequently, they came to instructors for consultation, brainstorming, and encouragement. The consensus building process that occurred as a result of this experience, however, served the team well throughout the remainder of the semester.

III. A Major Milestone Of The Journey: Creating The Interim Report

In CSC 492, it is required that the students identify team roles (managerial, functional or both). They are then given the flexibility of changing these roles, if necessary or desired. During the first half of the semester, the 2003 CSIDC team chose a team leader and lead facilitators for architecture design, database design, and research.

Per the course syllabus and calendar, the team was expected to define system requirements and the overall design of their product and communicate about these components via written documents and oral presentations. The competition expected them to produce a written interim report outlining such items as “Project Benefits,” “Innovation,” “System Organization,” and “Principles of Operation.” Organizers of the competition have stated that the interim report served as a screening tool that would eliminate student teams that had not provided evidence of sufficient progress from entering the final stages of the competition. It also provided a mechanism to encourage teams to actually make progress on their products [1, 2]! The timing and content of the interim report meshed well with the structure of CSC 492, so the team was able to stay on track with other teams in the class. Numerous drafts of the report were submitted to instructors for feedback and discussion.

The guidelines of the competition and the interim report did indeed help the team to define tasks for each team member. In CSC 492, students are given the opportunity to learn about project management, so the team worked with their mentor to create a task plan specific to the competition deadlines and those of the class. This was to be the first of many task plans developed by the team.

While developing the Diet Download system, the student team needed to consider numerous design tradeoffs. These tradeoff considerations ranged from the timeframe to complete the project to which IDE was best to use. When deciding on a course of action, the team met as a whole and discussed the issues involved, including what would happen in the future based on the decisions made at that point. After the discussion, the team was usually in agreement, but in cases when not everyone agreed, a vote was taken.

For example, a constraint was discovered in AppForge MobileVB 3.1 that restricted functions from returning arrays and that required all objects to be explicitly typed. This posed a problem when returning lists of items from various databases since built-in Collection classes could not be used in VB. Instead, the team would need to implement their own wrapper classes for arrays. However, the team felt that the benefits that AppForge MobileVB provided outweighed the nuisances that it brought along. Using AppForge permitted easier integration with the scanner and also provided the ability to emulate code.
The team worked hard at making compromises and being patient as they all tried to accommodate each other’s style of tackling tasks. Each of them became more proactive and assertive about owning various elements of the project, and they communicated more often and more effectively about obstacles and progress.

On April 8, the team was notified that they made the first cut and they were invited to submit a final report. Diet Download was on the move!

V. Another Major Step Of The Journey: Diet Download & The Final Report

Time was pressing, but the team had set themselves up for success. During the latter half of the semester, team roles evolved as members learned from one another and their skill sets merged. Team roles were defined by whoever had the most time to accomplish a given task. One was able to finish what another had started. The design architect became the GUI programmer and the researcher wrote code for the diet module and data graphing functions. The team leader spearheaded task planning, documentation and presentation preparation, while the remaining team member worked on testing and quality assurance.

The students had another holiday in the middle of April, but they managed to produce a rough draft of their final report before the break. Over the holiday, mentors met with a member of the team to review parts of the report and brainstorm ways to convey the message more clearly.

A prototype product emerged as the focus of the final report. On April 28 after several rounds of collaborative edits and rewrites, the report was submitted to the competition with five minutes to spare!

The team and mentor were relieved. The push had been intense and stressful, but they felt that they had given as much as they could to the project. The semester was not yet over, however. CSC 492 required that the team prepare another oral presentation, written document and demonstration.

VI. Yikes! We’re Going To Washington!

Project notebooks and data were filed and grades for CSC 492 were finalized. Commencement at NCSU was May 17 that spring, and two of the CSIDC team members graduated. The news came on May 19 – Diet Download and its creators made it to the top ten world finalists of the 2003 CSIDC!

Now, the pressure was really on! The prototype was functional but a number of the requirements had been stubbed. To actually present the product at an international competition, the team felt that thorough usability testing, more complete functionality testing, and refactoring of code was in order to put their best foot forward in Washington.

The team immediately reorganized themselves. One graduate moved back to Raleigh and worked in the lab for most of the day every day. The other graduate worked all day at his full time job, stopped for fast food, and came to the lab at night with his brown paper bag and burger! The other team
members came to the lab during various hours while attending summer school and working.

The six weeks before the competition unfolded as an extension to the semester. All the previously established patterns were continued. Mentoring, team interactions, task planning, and product development proceeded enthusiastically. The team’s motivation was self generated, but as before, the mentorship was necessary to keep their work realistic.

The team’s free-thinking, creative team leader pushed for a multimedia-based component in the presentation to be given in Washington. The team scripted a video, assigned acting roles to each other, and elicited the help of a local, professional TV production studio to produce a 3½ minute leader for their formal presentation. The team came to the harsh realization that they were better computer scientists than actors, but had fun anyway!

The final consolidation of the team’s identity occurred when the CSC Department provided monogrammed golf shirts and business cards emblazoned with the NC State logo and “CSIDC 2003.”

Final preparation for the competition was to be a presentation and demonstration to computer science faculty two days before the team left for Washington. What occurred we have come to label “The Thursday Flop in Front of the Faculty.” Sleep deprivation, multimedia issues, and dead PDA batteries left the audience shaking their heads. Twenty-four hours later, the value of this experience was realized. Attention to presentation details created Friday’s recovery and a peaceful plane ride on Saturday up to Washington.

During the competition, the team stayed true to form -- the primary work approach that characterized each student during the semester was particularly noticeable at this event. The final days of the competition were at times, tense, but always marked by the team's collective discipline, spirit, and commitment to effective communication and excellence. The NC State team placed 3rd in this international competition, a respectable win, worthy of their efforts.

**CONCLUSION**

The approach of the Senior Design Center of the Computer Science Department at NC State University is based on a principle that teaming fuels software development processes and professional communication. The teaming framework that the Center provides supports students as they work through phases and tasks associated with software development. Teaming instruction includes how to structure meetings, meeting minutes/agendas, logs to ensure individual contribution to the team, and task planning. Perhaps the most important component of this training is the open recognition of a variety of leadership styles and that everyone has something to contribute; the challenge is to enable students to recognize their own strengths in relation to each other’s. The open nature of professional communication within the Center contributes to a climate in which the final ingredient, student creative input, can flourish.

The Center staff learned many lessons from this CSIDC experience. The diverse, complementary skills of these students that were recognized at the time of team formation proved to be instrumental to their success. The students valued the importance of consensus building to aid their decision making processes, and their ability to see beyond struggling for power among themselves gave them the momentum that they needed to compete at this level. The team also remained open to interaction with mentor and staff; they continually made efforts to ask questions, seek guidance, and ponder advice about product changes or enhancements. The entire process affirmed our belief that formal team training and monitoring has the power to leverage the best from a group of students.

**REFERENCES**


