A PROJECT MANAGEMENT ACTIVITY FOR STUDENT TEAMS IN A COMPUTER SCIENCE UNDERGRADUATE CAPSTONE PROJECT COURSE: TASK PLANNING

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Abstract
Technical knowledge is necessary for the education of computer science students, but it is not sufficient to guarantee career success. The complexity of computer science and the dynamic nature of related technological applications make the development of effective writing, speaking and teaming skills an essential component of educating the computer scientist. This paper describes how a project management activity has shaped the capstone project experience offered by the North Carolina State University Department of Computer Science Senior Design Center. The Center facility provides a required industrially-sponsored capstone experience to undergraduate computer science seniors. Students are placed on teams and expected to solve a problem by creating a unique software system using an iterative development methodology. Students are coached on various activities related to teaming one of which is referred to as task planning, a project management opportunity. During task planning, students plan and manage their semester project with the guidance of a team specialist. Many phases of the activity are described: estimation of hours and definition of project scope; team member accountability and development of software design; conflict resolution and proactive leadership; illumination of project deliverables; follow through; and task planning as a model for team interactions. The Team Specialist in the Center has facilitated task planning with over 500 student project teams – it has proven to be an extremely powerful exercise and has become the pivotal activity in this capstone project experience. Task planning can be adapted for team-based project courses within any discipline.

Keywords: Capstone project course, project management, teaming, accountability, proactive leadership, conflict resolution, software design, project scope definition.

1 INTRODUCTION
Undergraduate programs in computer science traditionally focus on teaching students the basics of algorithms, data structures, software design, programming languages, and computer organization and operating systems. Mathematics, science and humanities courses are also required at a level typical of a science or engineering degree. The North Carolina State University (NCSU) undergraduate computer science (CSC) curriculum is accredited by the Accreditation Board for Engineering and Technology/Computing Accreditation Commission (ABET/CAC) whose standards demand that students learn to work as a team and communicate professionally in the discipline [1].

The NCSU CSC Department also collaborates with our Strategic Advisory Board (SAB) which is comprised of industrial professionals from around the United States. The group meets annually with University professionals to assess the curriculum and to ensure the program properly prepares our graduates to meet the demands of the workplace [2]. For over 20 years, the SAB has stressed the importance of exposing our students to teamwork. We have responded to our SAB as well as to the ABET/CAC by including and maintaining a large number of assignments and projects that require teamwork in our curriculum; students are expected to collaborate effectively and produce results.

Once our undergraduates reach their senior year, they are required to participate in our senior design capstone experience, an industrially-sponsored project course. The Department’s Senior Design Center (the Center) operates with the mission of integrating technical projects, professional communication skills (teaming, writing and speaking), project management, and a software development process into an undergraduate capstone design course. The Center was established in 1994 to facilitate interaction between the CSC Department and North Carolina industry for the purpose of providing computer science seniors realistic project experiences by offering a 15-week senior design project course, CSC 492. Students in the course are required to participate in an industrially-sponsored project that must be completed in accordance with a software development process...
adapted exclusively for CSC 492. Typically, each student is assigned to a 4-person team, is expected to contribute to the design, implementation and documentation of a project, and is expected to make at least one technical oral presentation. These projects are not offered on a contractual basis. Students earn a grade which is assigned by course instructors. The senior design project course offered by the Center is meant to serve as a learning experience for students as they transition from the academic environment to a professional one.

The goal of this paper is to describe a project management activity, task planning, which effectively facilitates teamwork within a capstone project course for computer science seniors. The educational environment, goals and general operation of the course are outlined, and information about the structure of the activity and its effects on teams are described.

2 BACKGROUND

We have previously reported on the pedagogical model of the Center [3], [4], [5], [6], [7], [8], [9], [10]. This capstone course is team taught by professors of computer science (technical advisors) and by a certified team specialist. Industrial sponsors provide project descriptions and a contact engineer who also serves as a mentor for the team. Students are expected to demonstrate software engineering principles by following a well-defined software development methodology. This experience was created so that students could be challenged to integrate all of the skills that they acquire during their entire undergraduate curriculum – that is, technical expertise of their discipline, public speaking, technical writing and small group interaction/teamwork. Over the past 25 years in the Center, over 200 sponsoring companies have participated in the program, and approximately 2400 students have been mentored and placed on more than 600 teams.

In any given semester, approximately 20-33 individual teams are formed and are assigned to a real client problem. The faculty involvement in the Center is different from the typical lecture-oriented course in that the students are completely responsible for technical content of the project. The role of technical advisors is to provide commentary on student-generated designs, implementation, and test plans; the role of the team specialist is to help students with details related to professional communication (teaming, writing and speaking) and project management. Industrial mentors from sponsoring companies also work closely with students throughout the semester.

The intent of the senior design course is to emphasize software development process, teaming, writing, speaking and project management. This involves one-on-one contact with each student team which is labor intensive and specialized. The team specialist comes to know each member of the team at a level that is unfamiliar to the students. This personalized attention is unique in such an environment. For purposes of this discussion, professional communication components refer to the communication skills students must develop to be contributing members of teams, to manage a project, and to clearly convey their technical ideas through formal writing and speaking.

In CSC 492, each team is expected to meet with the team specialist to participate in a project management activity. This exercise was created early in the history of the Center. Student teams are formed within the first week of class based on student rationale for first, second and third choice of projects. During one semester, there was a team that stood out from the others. The team specialist felt that this particular team, on paper, looked like they would become a performing team [7] within a few weeks: the students had complementary skills, they wanted to be and were more than capable of working on the assigned project, and the team leader was class valedictorian at the time. The team leader approached the team specialist within the first month of the semester, however, stating his concern that the work of the team was not coming together – he asked for assistance with problem solving. The team specialist met with the team and learned that the project had been conveniently divided into four modules, one module per team member. She soon discovered, though, that the modules had not been broken down into tasks and subtasks (with assignees), module interfaces had not been defined, and dependencies were not noted. After 3 hours, the team specialist and students had identified these details and the team was challenged with a new approach to solving their problem. Throughout the semester, the team referred back to this exercise, updated it, and used it as a guide to communicate, clarify issues, and produce results. That team had the most effective process and the highest quality product that semester. Inspired by this experience, the team specialist has completed a similar project management activity with every team, every semester since that time and it has been coined Task Planning.
3 METHODOLOGY – TASK PLANNING

Task planning refers to formal one-hour sessions during which the students learn how to leverage team strengths and identify team deficits to accomplish project goals under the guidance of a facilitator (in our environment, a team specialist). The steps each student must take to accomplish the project are referred to as tasks. Task planning sessions occur after the first 3 weeks of the semester. By this time, the team has met with their sponsor and they have a sense of what their project involves. During task planning, a list of tasks and due dates are established. The students are asked to bring their calendars for the purpose of organizing tasks related to their CSC 492 project and to tasks related to their other courses, professional commitments, and life activities. Students are encouraged to define iterations (i.e., a set of features or requirements, design to accommodate those requirements, code that follows that design, and testing of that code). The team specialist facilitates this definition based on the time frame of the semester and time commitment expected from each member of the team so that the team may finish one or two iterations before their midterm break; this gives the students a sense of completion and accomplishment early in the semester. During these sessions, the team specialist asks students about their strengths and weaknesses and explores with them the possibility of working on either optimizing strengths or strengthening weaker areas based on the time and resources available to them.

3.1 Estimation of Hours & Definition of Project Scope

Each student in the course is expected to work 10 hours per week. At the beginning of the task planning session, this number is used to determine total number of work hours expected from the team within the defined time period. Students are told that during the session they will be expected to estimate time that it takes them to do certain tasks. When students are asked why the instructors may think that this is an important activity, a discussion about real-world application ensues: insight into how managers create budgets and project proposals using hour estimates is eye opening to many students. Oftentimes there are students on the team who have professional work experience and they also willingly share stories about this process.

After this introduction, students are asked to define the first iteration of their project (i.e., a set of features or requirements and related code design, implementation and testing). Each student must identify their personal tasks and they are each asked to estimate time for completion of those tasks. This is challenging for most students, so when asked to estimate, the team specialist asks them to pick between a range of hours; since this provides parameters for the students, they tend to be able to respond more readily. Once tasks and estimated hours are determined, the team and team specialist align them with the calendar. This allows them all to look at the overall scope of the project and begin to determine what realistically can be defined as successful project completion.

3.2 Accountability & Development of Approach

As the session continues, each team member owns more and more of the project; that is, they become accountable to each other as they take on personal tasks and orally commit to completing them. The team specialist, once again, asks the students to review the set of requirements that they have defined as their first iteration and to express code design related to the accommodation of those requirements. One student, with the assistance of their teammates, is asked to draw the beginnings of this design on the whiteboard. As a result of these actions, this collaboration is often the first time that the team members speak aloud about various approaches to their problem. When this happens, the team specialist steps back and becomes an observer as the team expresses ideas and clarifies design concepts with one another.

3.3 Conflict Resolution & Leadership

As the team shares ideas during task planning about various approaches to solving their problem, difference of opinions may emerge. This is often related to misunderstanding of the problem statement or preliminary requirements defined by the sponsor, disagreement about the most effective design pattern or tools to use, or issues of time management within the team. The team specialist must coach the students through such conflicts until they are resolved; facilitation occurs, for example, so that a plan is devised for clarification of problem definition, pros/cons are evaluated, and time estimation is revisited and agreed upon by all.
When conflicts arise during task planning, it is interesting to note the leadership styles that are revealed. The team specialist needs to recognize and acknowledge the responses of each team member; for example, some students may monopolize the meeting, others may seemingly attempt to hide. Usually these behaviors are indicators of future team interaction, so it is best if the team specialist takes advantage of the opportunity to take immediate action and model ways to handle such scenarios. Some students have an easier time than others to be outwardly proactive and confident, while others who may seem to be uninterested, may actually be intently listening and observing before jumping in with an opinion. It is important for the team specialist to listen carefully, clarify students' ideas and then encourage quiet team members to offer their thoughts; such mentoring serves to facilitate the group and to model appropriate actions.

3.4 Illumination of Project Deliverables

In CSC 492, each student is required to deliver an individual formal presentation, an Oral Progress Report (OPR), and each student team submits formal written reports, an Interim Progress Report (IPR) and a Final Report. In general, computer science students define writing and speaking assignments as "overhead" to their work. As a result of tasking, the team specialist and students fill up a large whiteboard with system requirement lists, various design approaches to the problem, and tasks per team member including implementation decision-making points and schedules for testing pieces of the developing application. To summarize the task planning session, the team specialist asks the presenter of the team's upcoming OPR to outline their presentation. In most cases, that team member tends to process before speaking, looks at the whiteboard and seems to suddenly realize that the outline is right there in front of them all! The task planning itself has created a framework for the presentation: the requirements, design, implementation and testing of the team's defined iterations. Similarly, when the team specialist asks the team to outline their written IPR, the students recognize the structure in front of them. A discussion ensues as the team specialist easily convinces the team that the oral and written reports are the work of the team. It is not only the code of the system that defines the "work" of a computer scientist, but it is also the recording of the planning and testing processes (requirements, design and test plans/results) that completes that work.

3.5 Follow Through

At the conclusion of the task planning sessions, the team specialist and team discuss the dynamic nature of task plans: if they change, rationale for the change must be provided either informally to technical advisors and team specialist or formally documented, as appropriate. Students nearly always express an appreciation for these sessions; they comment on their usefulness and often ask if another session can be conducted during the semester. One session is required, additional sessions are optional; if students request another task planning session, the team specialist usually plays a lesser role in any subsequent session and the students are encouraged to facilitate the session on their own.

4 RESULTS

Students are usually surprised after task planning sessions – many of them have never communicated in this way: breaking down tasks into subtasks, considering dependencies of one task on another, planning to learn from one another as they develop a piece of a project, or estimating the amount of time it will take them to complete a defined task.

4.1 Planning is Work

The instructors (i.e., technical advisors and team specialist) of this computer science senior design course have noticed over the years that students tend to struggle with the planning phase of the capstone experience. The first and second years of many undergraduate computer science curricula focus mainly on the programming aspects of the discipline (that is, how to write code). Requirements and design development is not the focus of the expectations for the students (much less the expression of that development) until their senior year. The facilitation of simple, straightforward planning moments that occur during tasking, therefore, tends to build confidence in fledgling computer scientists.
4.2 Professional Communication is Not Overhead

Changing the computer science culture where professional communication components (that is, writing, speaking and teaming) prevail as “overhead” has been a goal of the Center since its inception. Task planning has proven to provide the most effective environment where this concept can be demonstrated to novice computer scientists. During the task planning sessions, students recognize that their oral and written reports are repositories for their work and tradeoff decisions (for example, results of requirements exploration and evolution of various design ideas), rather than an afterthought or unnecessary busywork.

The dynamic nature of task plans also helps instructors (technical advisors and team specialist) to facilitate discussions with teams, emphasizing to students the importance of professional communication for project success. Students are expected to include formalized task plans in their written progress reports and to have their plans electronically available for updating and viewing. On team work days during the semester, instructors visit each team and ask them to provide a project update based on the developed task plan. To monitor whether or not individual students are keeping up with their assigned tasks, each student is required to record time spent on the project using a web-based logging system. Instructors read these logs and intervene if problems are detected. As a result of these inspections, guidance is provided to students who may need assistance with issues related to, for example, time management, team conflict, and technical bottlenecks.

4.3 Task Planning As a Model for Team Interactions

Task planning sessions are pivotal to the computer science undergraduate senior design experience. The session provides an opportunity for the team specialist to work with individual teams at an essential time of team formation and product development. Facilitation and modeling occurs so that student teams are able to scope a project for success, explore design tradeoffs, and turn conflict into a positive decision-making event. All team members participate in task planning, leading to the definition of expectations and ownership of project responsibilities. Communication components are revisited: students are encouraged to speak aloud as they convey and clarify ideas for one another, and a deeper appreciation for course deliverables is revealed. Additionally, the session continues in the form of an electronic task plan, thus serving as a checkpoint for team monitoring and future discussion points between instructors and students. It is during and after these sessions that students begin to more completely understand and embrace the power of teaming.

5 CONCLUSIONS

The professional world relies on effective teaming to increase productivity and profit margins. Teachers in most educational settings and disciplines understand and respect the value of teamwork – many establish teams and expect students to collaborate while working on project assignments. The challenge can occur when instructors must teach and model interactions that encourage effective teaming. One way to facilitate such interactions is through task planning which can be applied to team-based projects in any discipline.

Communication is the force behind effective teaming and tasking allows students to take control of their work approach by communicating in a different way. Overall goals are explored and then broken down into smaller milestones. Team members decide on their overarching approach to solving a problem and then they identify who will do what by when; this decision making is often challenging and time consuming because team member perspectives on these topics are unique. With the facilitation provided by an instructor, the team is required to proactively work through these differences and agree on detailed steps. Task plans are recorded, every member is held accountable to tasks assigned to them, and plans are flexible enough to accommodate obstacles and subsequent resolution of those challenges.

Students learn that planning is worth their time and that it is an integral work component of projects. Effective communication skills are modelled, facilitated and expected. Each team member buys into the overall purpose and work approach which helps lead them to being proactively committed to creating a quality product. Task planning is a rich teaming activity that allows students to grow professionally as it prepares them for the next chapter ahead of them.
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REFERENCES


