A CASE STUDY OF TWO ENGINEERING STUDENT DESIGN TEAMS

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Background

This paper analyzes the structure and group dynamics of two engineering student design teams with contrasting organizations. The two teams formed themselves for a third year course, Transducers and Embedded Systems, offered by the School of Engineering Science at Simon Fraser University. The course involves the students in forming design teams and completing a project which involves the use of transducers and microprocessor systems.

Both teams studied in this paper were evaluated highly by faculty**. Subsea Engineering** (Darren, Tracy, Teresa, and Amy), designed a thermocline sensing device to detect underwater temperature boundaries, and **SOS Engineering** (Trevor, Greg, Todd, and Vien) designed a submersible oxygen sensor to measure underwater oxygen levels. I studied the two groups by observing them in the lab, discussing their progress throughout the term, and interviewing some of the team members--Tracy and Darren from SubSea, and Todd and Greg form SOS--at the end of the term.

Introduction

Two common methods of organizing engineering design teams are

1. clearly assigning task responsibilities, and
2. clearly defining individual roles.

Each method has its advantages and disadvantages. An organization in which the tasks are clearly identified and then divided among the individuals or small groups of individuals is quite time efficient. However, if strong communication is lacking between the individuals or groups, problems can occur during integration of the different parts. An organization, in which the individuals have defined roles (such as leader, troubleshooter, theoretical analyzer, etc), can be time inefficient because each member must become familiar with various aspects of the project instead of just a narrow portion. However, with the members more aware of the different areas of the project, it tends to lead to smoother system integration and a more rewarding learning experience. Of the two groups in this study, SubSea chose an organization with defined individual roles, while SOS chose an organization with defined task responsibilities.

Role Definitions

In SubSea Engineering, the members had well defined roles. Amy was the leader. From the beginning she displayed a high degree of interest, and exhibited a high level of effort and organization. The group recognized her natural leadership qualities and formally designated her as the project manager. As the project progressed, the other members started to assume well defined roles. Darren became the "devil's advocate", questioning the other members' ideas and decisions. As the project work began, Teresa exhibited a high level of troubleshooting ability. Wherever there were problems, Teresa would start working with the person, questioning the technical decisions, and working unrelentingly until the problem and solution were discovered. Tracy was the group's positive reinforcer, helping to keep the group highly motivated. This role was important in counterbalancing some of the members' high degree of self-criticism.

In contrast, SOS did not have highly defined roles. There was no strong leader. Trevor was the closest to acting as a leader, since the project was his idea and since he had the external contacts that were required. Vien was the only person who evolved into a role, always laughing at himself and at the group, even though he actually worked as hard as the other members. This ability to make light of the group's mistakes was very important in reducing the group's stress level. A main reason the members in SOS did not evolve into group roles was that the group split up into smaller groups of two--one for hardware and the other for software--which did not seem to require well defined group roles.

Thus, the members of SubSea had well defined roles of leader, troubleshooter, "devil's advocate", and positive reinforcer, while the SOS members in their smaller task oriented groups did not have strong group roles.

Decision Making

SubSea made functional and high-level design decisions as a group. The group met constantly during the initial phase of the project to define the functional and design specifications. Although in many instances an individual disagreed with the group, the members generally avoided getting deadlocked over an issue The individuals expressed their disagreement in different ways. Tracy stated that she disagreed, and gave reasons for her disagreement. Teresa rarely disagreed openly, but voiced her concerns. If the group ignored her concerns, Teresa kept repeating them until they were dealt with. Amy generally remained calm and thoughtful. Tracy stated that she appreciated Amy's calmness and her willingness to remain quiet and consider the matter. (However, Tracy also stated that sometimes she had to work hard to draw Amy out). Amy's unwillingness to take an explicit stance prevented the group from becoming evenly deadlocked--without Amy taking an explicit stance, it left three people to discuss an issue. On the whole, the group was successful and effective in making major decisions. With the major requirements decided, the individuals working on a

given task decided upon the specific design and operational issues. In general, the group had no trouble reaching decisions, and disagreements caused no hard feelings.

SOS also made functional and high-level design decisions as a group. None of the members were especially stubborn or rigid about their ideas. The group dealt with decisional impasses by contacting external authorities. For instance, Trevor would contact engineering companies around town, while Greg would contact his older brother (a fifth year engineering student with more experience) or a friend working in a related engineering company. With the high-level decisions made, the individuals working on given tasks could make specific design decisions themselves.

In both groups all the members participated in the functional and high-level design decisions, while specific decisions were made by the individual working on the specific task.

Project Management

Subsea began with a formal project management structure. Amy was the project manager, responsible for scheduling the project and coordinating the different major tasks. Tracy was the hardware coordinator, Darren the software coordinator, and Teresa the documentation coordinator. The coordinator was not responsible for doing all the work, but rather for ensuring the associated tasks remained on schedule. However, as the project progressed, the individuals slipped into their preferred group roles: for instance, Teresa became the troubleshooter for all areas of the project, while Amy took over all the coordinating responsibilities. Amy had to work very hard to keep the whole project coordinated. The other members also had to spend considerable time learning about different areas of the project as they went from task to task. Even though they realized their method was quite time inefficient, the members felt rewarded because they became knowledgeable in all areas of the project.

SOS managed their project by clearly defining their software and hardware requirements as a group, and then allocating the different tasks to smaller groups. Todd and Greg were responsible for the hardware, and Trevor and Vien for the software. The two groups worked almost completely independent of each other. The group as a whole stopped having formal meetings. They communicated informally between classes, informing the other members of issues they thought were relevant for the others. Trevor handled external communication and informally relayed the information to the other members.

Thus, SubSea had a structured project management format to coordinate the individuals as they went from task to task. In contrast, SOS had a loose management structure, relying on dividing task responsibilities to ensure project completion.

System Integration

SubSea had no problems integrating the different hardware and software components. Throughout the project Amy kept all the individuals informed of changes in the project that would affect their specific area, so everything meshed very well.

In contrast, SOS discovered various problems during integration, mainly due to inadequate coordination. First, the hardware group discovered, that due to software requirements, the system had more power supply voltages than they thought. If they had known this earlier, the hardware circuit could have been a little simpler. Secondly, the group discovered that their motor's rated voltage was actually 24 "volts rms" (equivalent to 68 "volts peak-to-peak") instead of 24 volts peak-to-peak. They initially thought the rating was 24 peak-to-peak because of a conversation Trevor had with a chemical engineer supplying their motor. Perhaps if Trevor had been more involved with the hardware he would have been more skeptical of the engineer since motors are normally rated in volts rms. Or, perhaps if Greg or Todd had contacted the engineer, they would have discovered the problem sooner.

This major problem was averted by Greg, who found a power conversion circuit from a friend working at an engineering company. After discovering a solution, the group ran into another communication problem. While helping Greg build the new circuit, Vien soldered a component without removing the heat sensitive IC's. Greg forgot to tell him. This error cost the group a trip across town to get more IC's with the demonstration scheduled in a few hours. However, the group solved all the problems, and completed the project.

Thus, SubSea, with its members more aware of different areas of the project, and with its structured management style to stay coordinated, had an easy time with system integration. In contrast, SOS with its members less aware of all the different areas of the project and less communication, had a harder time with system integration. Perhaps, SOS could have improved their communication by continuing their formal meetings and, thus, avoided their system integration problems.

Conclusions

In conclusion, SOS's organization, which involved dividing task responsibilities, was advantageous because it was time efficient, equitable (in regard to workload), and safe regarding personal conflicts. However, this organization was disadvantageous because it required a greater degree of communication to ensure successful system integration.

SubSea's organization, on the other hand, which involved defining individual roles, was time inefficient, and had more potential for personal conflicts--although in SubSea's case conflicts were generally avoided. However, SubSea's organization led to more effective system integration and a more rewarding learning experience.

References

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