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ABSTRACT

Global software development has become a common reality with the advent of off-shore development and the need to be close to markets. This type of development has posed some challenges faced by software development personals. In this research, we report a software development project that involves the collaboration of students from USA and China.

Keywords

Global software development, distributed software development, teaching, education, learning.

INTRODUCTION

Global software development distributes various development activities across global locations. Software development organizations have begun to increasingly adopt this type of development because of benefits such as cost reduction and around-the-clock development (Komi-Sirvio, Abrahamsson and Huomo, 2006). Global software development usually results in time, geographic, cultural, organizational, and identity differences (Espinosa, DeLone and Lee, 2006), requiring effective coordination among teams (Kotlarsky, Van Fenema and Willcocks, 2008; Oshri, Kotlarsky and Willcocks, 2008). Traditional communication channels such as face-to-face meetings are no longer common, making communication and coordination more complex (Oshri, et al., 2008).

Therefore, software engineers must acquire the skills to address the challenges that are present in global software development. It is important to prepare our students for these environments. However, teaching global development is challenging for the conventional university curriculum because it is difficult for students to learn about global development without hands-on projects that provide real experience in a global setting (Damian, Hadwin and Al-Ani, 2006). Preparing students in this field requires new teaching approach, theoretical contents and tools (Monasor, Vizcaíno, Piattini and Caballero, 2010). Thus, the objective of this study is to investigate the effective way for students to learn about global software development through real experience.

This objective entails examining how students from different countries form global teams and collaborate with each other developing a software system. Specifically, in this paper, we report a research on global software development project that involves the collaboration of students from the United States and China.

The paper is organized as follows: First we discuss the challenges in global software development. Then we present our research design and implementation. After that we present our findings, and finally we discuss the results and our contributions to theory and practice.

CHANLLEGES IN GLOBAL SOFTWARE DEVELOPMENT

Global software development faced many challenges. First, effective communication across countries becomes challenging. Communication frequency is dramatically decreased when projects are distributed among multiple sites (Herbsleb and Mockus, 2003; Matloff, 2005; Meadows, 1996b). Communication cost (time, money and staff) is increased (Herbsleb and Mockus, 2003; Matloff, 2005) because of the complexity of connecting people across sites, including channeling of communications (Meadows, 1996b). Team members rarely meet in person. Most of their interactions rely on the use of communication technology (Maznevski and Chudoba, 2000). As a result, there is lack of informal, direct communications that are more common in collocated work settings (Meadows, 1996b).

Collaboration complexity is another issue faced in distributed projects. Difficulties to divide work, and manage interdependencies in distributed projects (Meadows, 1996a) cause problems such as repetition of work (Matloff, 2005) and

affective and task conflicts (Hinds and Bailey, 2000). Less frequent and predictable collaboration and loss of social contact between the teams (Kumar and Willcocks, 1996) causes delays in distributed collaborative work processes (Herbsleb and Mockus, 2003; Jarvenpaa and Leidner, 1998) and increased response times and coordination costs (Hinds and Bailey, 2000).

Another challenge in global software development is lack of control. Quality issues (Matloff, 2005; Ropponen and Lyytinen, 2000) and staffing issues (e.g., hiring inexperienced developers) (Matloff, 2005) are reported in global projects as a result of loss of process control. The direct supervision between the manager and the subordinate on the remote sites is missing (Cramton, 1997). There are information asymmetries and limited contact between the manager and the subordinate. The manager has less insight in subordinate's context, experiences and communication intentions. As a result, it is more difficult to build rapport and trust(Kurland and Egan, 1999; Wiesenfeld, Raghuram and Garud, 1999).

Distributed development also suffers from lack of cohesion. People at different sites are less likely to perceive themselves as part of the same team than are people at the same site. Lack of cohesion threatens motivation and morale of the team which may adversely impact performance (Herbsleb and Mockus, 2003). Lack of understanding of counterpart's context (Cramton, 1997) is another problem. Global development may involve different languages/expressions as well as different cultures (business culture, team culture, and country culture). This causes the lack of common understanding and reciprocal knowledge across sites, particularly when members use nonnative languages and employ terms that may be misinterpreted (Lutz, 2009).

We need to prepare our students to face and address the above challenges. This motivates our study on training in global software development by exposing the students to the challenges and learning from the real experience in addressing these challenges.

PROJECT DESIGN AND IMPLIMENTATION

To enhance the experience of students on global software development, we designed a collaborative project between students at Old Dominion University, USA (ODU) and students at Shanghai Jiao Tong University, China (SJTU).

System Design is one of the core courses in the IT curriculum at Old Dominion University. Students taking the course are usually seniors majoring in IT or Computer Science. They have taken one prerequisite programming course in C++ and a course on system analysis. Many have taken several other programming courses such as Java and C#.

The course covers basic system design concepts and techniques. Emphasis is placed on object-oriented development paradigms for the design of business information systems. The course involves the development of UML models of problems that are related to business applications.

The students from China are juniors in the Department of Information Security taking *Software Engineering* course. This course covers all activities of software development lifecycle, including system analysis, design and implementation. Students have taken programming classes before and are taking database class concurrently.

Design of the Global Software Development Project

Students from both sites were asked to work on a 12-week software project that included several phases and deliverables. The project included several tasks: 1) identify an information system to design, 2) conduct system analysis and specify the requirements, 3) conduct system design, 4) implement the system, and 5) deliver the documentation of the system.

These tasks were collaborated between the students from the two universities. ODU students had learned system analysis before and were focusing on design only in this semester, so they were required to lead task 3 which is the design of the system. SJTU students, on the other hand, were learning all the activities in software development lifecycle, including implementation. So they were asked to lead task 4 which is the implementation of the system. Students from both sites collaborated on task 1, 2 and 5. Each team could decide how to allocate work loads among the team members.

Team Formation

It was voluntary to participate in the project for students at both sites. The instructors first provide information about the project and the students at the other university. Then the students who showed interests to participate were given the instructions on how to proceed. At SJTU, 30 students first formed 7 teams with 4 or 5 students per team. A team leader was elected and the team leader posted the information of the other SJTU team members, and their interests in topics or projects on the group website (a yahoo group created by the instructor). Eight students at ODU who decided to participate also posted their information on the website. The 7 team leaders at SJTU and 8 students at ODU contacted each other and formed 7 global software development teams (6 teams had one ODU student, one had two ODU students). They used English as the language in communication.

Data collection

The 12-week project required several deliverables (Table 1). In addition to the deliverables, we collected students' demographic data and their previous experiences on software development. The teams were required to submit all the communication documents including emails and records of online chat between ODU members and SJTU members. Other communication data such as the postings on the group website and group meeting records were also collected.

Week	Deliverables
1	Team information (team leader and members name)
2	Initial project topic for instructor's approval. Description of the project scope and major functionality Project plan
4	Detailed requirements specification
6	Status report
8	Initial design
10	Detailed design
12	Full project (with documentation)

Table 1. Deliverables

Students were interviewed after the project was due and filled out a questionnaire (Table 2).

1. In your opinion, what were the most important benefits for working on this project?
2. Did you learn from your team members?
3. Did you learn the knowledge of design from working on this project?
4. Did working on the project improve your understanding on team collaboration (in an outsourcing environment?) Please give examples.
5. Other benefits?
6. What were the major challenges in working on this project?
7. Was communication with your team members difficult? What were the channels (such as email, msn) did you use for communication?
8. Were there any culture differences that have impacts on project process?
9. In the beginning, did you trust your team members on their competence and attitude since you have never met them in person? Did your feeling changed overtime?
10. Please evaluate your team members, their strength and weakness.
11. What is your overall experience on the project?
12. If let you choose, will you do it again?
13. How should the professor improve the process?

Table 2. Questionnaire for the global project participants

RESULT

The global software development processes for this project were beneficial to students in different ways. The students learned about global distributed environment with real experience. They were challenged by issues in cultural differences, communication, project planning and control, and other aspects in the process. In addition to these benefits, our study reveals several interesting findings that were not expected before the project.

Asymmetry in Perceived Benefits

First of all, it is interesting to notice that the perceived benefits of the project to students in the two countries were significantly different.

Perceived learning of different cultures

One of the purposes of this global project is to learn the impact of cultural differences on team collaboration. As expected, ODU students consider learning a different culture from their Chinese partners was an important benefit. One ODU student commented: "*The most important benefit I believe is learning from other students across the world. My teammates and I discussed not only the project but also life being students and the similarities and differences of being students in different cultures."* Another ODU student commented: "*Some of the great benefits of this project were being exposed to other students [in another culture]. It's one thing to be in a group with people within your own class however the element of having students from another school, another country even just shows how business is turning global. It really opened my eyes to the nature of the business world today."*

Almost every ODU student believed that it was very beneficial "*being able to successfully work with students internationally; overcoming all cultural and language barriers, and working with the time difference."* To be exposed to the Chinese culture was perceived as a valuable experience. One ODU student stated: "*The most important benefit in working on this project is the team work across cultural boundaries. I learned more about the Chinese culture than about IT."*

On the other side, the students at SJTU did not perceive exposing to American culture as a benefit. The Chinese students were very confident about their understanding of western culture. As one SJTU student stated: "*The reform and opening policy [in China since 1978] has made us to be used to the western culture."* The student had a strong belief that cultural difference was not an issue in collaboration between team members.

It is obvious that there is a severe asymmetry of the students' perceived knowledge about each other. While the Chinese students were confident that they were very familiar and comfortable with western culture and they didn't learn much from their US partners on the culture aspect, the US students found that Chinese culture was very different and they learned a lot about it from working on this project.

Perceived learning of global collaboration process

ODU students focused on utilizing this opportunity to learn about skills of team collaboration in global development environment. As one student believed that the project was a learning experience on collaboration: "*All project/team collaboration provides a learning experience. When that team also has a global element that teaches even more."* Another student learned about the importance of intensive communication: "*Designers and the team that will build the design have to work closely together. My team had some miscommunications in what was expected and I believe it had to do with not having any face- to- face time with each other to really go over our expectations."* Another student mentioned that "s*eeing different approaches to projects helped me learn another aspect of collaboration."*

On the other side, most SJTU students focused on learning from teamwork in general. The collaboration across country boundaries was not much considered as different. The focus was on task division and project planning and control in general: *"We have to divide our task clearly and try our best to assign responsibilities. For example, we have to set a due date for each part in order to meet the final deadline. This kind of collaboration will provide a higher efficiency [than not to collaborate]. You know, this project is a bit like a kind of software outsourcing which is common in China. For instance, once we came up with an idea about changing something in the requirement and sent an email to the ODU member to ask for his comments. Then, we discussed the new idea and finally accepted it. From team work, we got much help and enhanced the efficiency."* The Chinese students, while realized that the project mimics offshore outsourcing in some way, were more task-oriented and focused more on collaboration among team members.

Asymmetry in Perceived Challenges

The perceived challenges of the projects to students from the two countries were also different.

Perceived challenge in communication

Communication between team members turned out to be more difficult than we expected. Students from both countries considered communication the major problem of the development process. However, some of their perceptions on this challenge were different even though they all mentioned the physical distance and time zone differences as major communication barriers.

One issue was the 13 hours time zone difference among team members in the two countries. This challenge was perceived the same way by the students from both sites. An ODU student mentioned that it was challenging to talk to her team members because of this problem. "*Timing was the biggest challenge for me. Having to stay up late to actually chat with my group member got challenging."* The students at SJTU had the same difficulty: "*It is really tough for us to communicate because in our school, after 11 P.M., there is no electricity at all and for sure, no net connection [in dorms]. The time difference has*

become a big obstacle. We can only communicate via email. …. Actually, I assigned several tasks but eventually those were done by me due to the time limitation."

The communication challenge of languages, however, was perceived differently. For ODU students, language barrier coupled with the lack of face-to-face communication caused issues in communication. "*The language barrier made some things difficult …Even making sure that he [the STJU team leader] got what he needed from me was a challenge as well."* It was clear that the ODU students were cognitive of this problem and tried to be flexible in handling the language issues. "S*ometimes I would think a comment was rude but it was only his lack knowing English I believe."*

However, the SJTU students didn't realize that language could be a source of misunderstanding. They were confident about their English and communication skills. One student commented: "*Language was not necessarily a barrier. But I have to say communication between SJTU and ODU was not easy.*" Another student agreed: "*Language barrier is not a problem, but the time difference is. I think we don't encounter many language problems*."

As a result, the SJTU students didn't take any actions in addressing the issue, even though the language issue, together with cultural differences, hindered the effective communication. For example, in forming a team, one SJTU team leader started to contact every ODU student privately to ask if s/he was interested. He got positive answers from several ODU students. The SJTU team picked their partners without informing the other ODU students who had agreed to form a team with them. As a result, one ODU student found out that she had no team after the project started and deadline of team formation passed.

She was very upset and emailed the team: "*This did come as a surprise being that I confirmed that I would like to be your group a week ago.*" The SJTU student explained to the instructor: "*I didn't know after they replied us [with yes] they wouldn't make further communication with other teams*."

Perceived challenge in project process

Another challenge the teams faced was that students had different focuses on the project development process. ODU students focused on project planning at the initial stage, trying to collect and understand the system requirements first. SJTU students, on the other hand, focused building a working software product. As a result, the perceived challenges of the software development process were different.

For example, one team's project was a Crime Tracking system for ODU police department. The ODU student proposed this project and was responsible to contact the campus police department and collect requirements. As a class project, the system will not be implemented in ODU police department. She set up appointments with the police department, talked to the officers, studied the current systems and read relevant literature in this domain. In the second week of the project, her SJTU partners requested her to provide the complete requirements as they were eager to start programming (without design). The ODU student responded that she needed to be careful in approaching the police department to get their support in collecting the information. However, the SJTU members didn't understand the effort and time needed in requirements analysis. The team leader told her: "*We don't need to care whether the police station will grant us the project. Since [what] we will build is for the service of them."* They asked her to provide requirements as they have started implementation phase without fully understanding the requirements (and no design) in the 3rd week of the project. They told her: "*We do [have done] some preparation already. We can start the analysis [of] their possible requirement[s]. …And we already began to do some programming preparation here."* As a result, the ODU member felt that she couldn't catch up with the team. She told the instructor, "*I am getting a little confused and overwhelmed with this project."*

The ODU students and SJTU students have different views toward the challenge of the project process. The ODU students found that understanding the business rules and values of the system to be built were challenging while the SJTU students thought that learning a new programming language and using it to build a system by a team was more difficult. A SJTU team leader commented: *"The major challenges include difficulties confronted in coding, difficulties as a team leader in motivating every team member to work efficiently and difficulties in making a schedule that includes all the required work, demands and dates."* Another SJTU team leader talked about how they overcome the difficulty of learning a new language and a new tool. *"I am a lot more familiar with the software Expression Blend. I found it is a really amazing tool. Using this tool, our software is done a lot easier. We learnt C# language by ourselves and got familiar with the WPF project."* This difference was viewed by an ODU student as a nice balance. "*They (SJTU students) seem very well versed in programming, where as we [ODU student] seem more versed in the business aspects. It provided an excellent balance."*

Strategies in Global Development Approach

In addition to the asymmetry in perceived benefits and challenges, we also learned some strategies in designing global software development projects from the study.

Self-organizing team with sufficient control

The teams were initially set up with minimal control by the instructors on both sites. The students were given the freedom to pick a project to work on, to decide the communication media and communication frequency, and to enact their project plans. The instructors set up a few milestones (Table 1) and helped solving issues raised by students. In the self-organizing team, the team members from both countries shared a goal and a common belief that their work was interdependent and collaboration was the best way to accomplish their goal. The team members were empowered with the responsibility for planning, managing and controlling the work. They also shared responsibility for problem-solving and continuous improvement of their work processes. However, the appropriate level of management and control were still needed in the global environment. One ODU student commented on the instruction provided by the instructor, "*I wish the project had more structure [defined by the instructor]…had the individual diagrams due the same time … so the students can provide information to their team members on a more consistent basis."* A SJTU student mentioned the need to have certain control over the process: "*Maybe the most needed to be done is to ask every team to hand in a report or product produced (beta release) at the end of each phase instead of requiring submitting the final product only before the deadline. This will get team members motivated and ensures a team to submit a good product instead of a product that is produced in the last few days before the end."*

Communication channels

Another finding of this study is to facilitate students' communication by setting up initial meetings and providing guidelines on choosing communication channels. A ODU student expressed the need for initial communication and direction provided by the instructor, "*I think somehow [needed is] creating a way to get us more time with each other, maybe devoting class time or setting up some type of network where we can speak with each other face-to-face. Giving us better communications on directions so that if things aren't going in the right direction we can catch that sooner in the design process."*

Students were told to choose whatever communication channels they preferred. They all initially used email, but quickly found that email was not an effective way of communication. One team member at ODU didn't check email regularly. Instead, she uses Facebook as her major communication tool. However, Facebook was not used in China. She only checked email once a while and delayed responses to her Chinese team members. Her teammates in China complained: "*Most communication was done via email, and I have to say when I wrote an email, the ODU members did not respond quickly.*"

Another communication channel was the use of instant message such as MSN. Interestingly, the students in China proposed to use QQ which was the most popular chatting tool in China, but the students in the U.S. never heard of it. One team decided to chat in MSN, but their plan never worked as it was difficult to have all the team members available at a specific time, due to the 13 hours time zone difference and holidays. In one email from a SJTU team leader, *"I am afraid that we fail to meet on MSN again. Currently I will have a seven day holiday again due to the Shanghai Expo. So I will not be online quite often. I think both of us need to check email quite often. Or which account do you use instead of your school's account?"*

Skype was tried in some teams and due to time difference, never worked. As one SJTU students commented: "*I tried to establish a stable communication channel via MSN or Skype---not the email because email can not be called a stable communication channel when you do not know when the other side will read this mail---but failed. Finally I found out [ODU member]'s Facebook account and made some contact via Facebook."*

DISCUSSION AND CONCLUSION

The global project was initially designed to enhance students' understanding and learning on global software development. The findings of the study highlight some novel and significant issues in preparing the future IT professionals in the global environment.

First, the asymmetry of perceived benefits and challenges from the project reveals the mindset gap between the students from the two countries. We believe that with globalization as a major trend, the knowledge and culture gap between members from different countries might be shrinking. The students in the US have increasing knowledge about China and other countries. They understand that China has growing impacts on the world economy. On the other side, Chinese students in this generation grow up watching Hollywood movies, listening to US pop music and following the high technologies invented in the US. Many college students are fluent in English. So it was assumed that Chinese students were more ready to work on global projects than their US partners. Our findings do not support this assumption. We found that the US students were eager to learn about other cultures and would consider culture as a factor that had impact on their project. The Chinese students perceived that they had known well about the western culture and denied the impact of cultural differences, even though it was obvious in the project process. The different perceptions towards learning led to different collaboration

strategies. The US students were more flexible in adjusting actions to accommodate cultural differences than their Chinese partners.

We also found that Chinese students focused more on the technical side than on business side of a project, while US students spent more time on understanding a system's business value but not enough on the technical aspects. The ODU students did not take into account the technical details of implementation when they design the system. There was a gap between design which was done by ODU students, and implementation which was the focus of SJTU students. Most of ODU students were not involved in any implementation decision. As a result, the designs delivered by the ODU students were considered not matching the implementation and were ignored by some SJTU teams during the coding process. The designs were only used for documentation purpose.

The topics proposed by ODU students were more business oriented such as a restaurant system and a crime tracking system. The topics proposed by SJTU students were more technology oriented such as a computer game. One reason for this difference might be that the ODU students were from business school and SJTU students were from engineering school. This difference led to some conflicts but also was viewed as a nice balance by some teams.

There are certain limitations of the study. One major limitation is the size of the project. The small size of the project made design a phase that could be skipped by the teams. This research contributes GSD education by exploring the challenges and the dynamics in the global collaboration. The findings may assist researchers, instructors and practitioners in providing an educational environment that prepare our students and workforces for the global environment.

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