

Virtual, Distributed Courses to Teach Global Software Engineering: A Cultural Contrast of Germany, Japan, Mexico, and Mongolia

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Abstract

In addition to knowledge of distributed project management techniques, software engineering courses need to teach students the intercultural communication skills necessary to cooperate effectively with team members from different cultural backgrounds. Because many students do not have the time or financial resources to spend a semester in a foreign country, participation in virtual, distributed courses at their home universities can provide opportunities to gain international experiences for a larger group of students. Experiences, results and lessons learned from several iterations of distributed, virtual courses conducted between universities in Mongolia, Mexico, Japan and Germany are presented. Instead of classic, instructor-based lectures, a project-based learning approach was implemented to simulate a real-world, global software engineering project.

1. Introduction

Software engineering education has expanded from the instruction of technical methods for small teams at a single site. After graduation, our students are often faced with the additional challenges posed when working in distributed teams spread across a number of countries. In addition to international project management methods, they also need to learn the soft skills necessary to collaborate with people they have never met, who work in different time zones, speak different languages and have different cultural perspectives.

Initial experiences from the individual teaching experiments between two countries have been described in previous publications [1, 2, 3, 4, 5]. This work

integrates results from these previous publications in order to draw new cultural comparisons between virtual, distributed courses held by universities in four countries, Germany, Japan, Mexico and Mongolia. The goal is to find answers to three research questions:

1. Can virtual, cooperative courses help students learn the distributed project management and cultural skills necessary to work on global software development without leaving their home universities?
2. Can project-based learning help students understand problems and find their own solutions to cultural misunderstandings?
3. Can the utilization of cross-site teams prevent the formation of in-group vs. out-group dynamics between students of different universities?

First, in Section 2, the challenges to teaching global software engineering are described. In Section 3, the methods and organization of the courses are described. Next, in Section 4, the experiences and observations from the courses are recounted. Section 5 presents the results from project retrospectives and questionnaires filled out by the students. Finally, in Sections 6 and 7, conclusions and plans for future work are discussed.

2. Teaching Global Software Engineering

2.1. Identification of Learning Challenges and Goals

A number of researchers have conducted systematic reviews of the literature in order to identify the main problems which global software engineering courses should address. Beecham et al. [6] and Clear et al. [7] identified the following difficulties: global distance,

teamwork, soft skills, stakeholders, infrastructure, development process and curriculum. Hoda, Babar, and Shastri [8] focused on the socio-cultural challenges in global software engineering education. They identified six dimensions: language, concept of time, attitude towards grades, assumptions about national culture, autonomy, and influence of the lecturer.

The learning goals for the courses described in this work are to help students to recognize these socio-cultural dimensions and to develop strategies to overcome these difficulties inherent to global software development.

2.2. Cultural Differences

Hofstede applied statistical methods to analyze data collected from thousands of IT employees worldwide [9]. He classified differences in cultural perspectives according to six dimensions:

- Power distance (PDI): The attitude of a society to inequalities among individuals in a society
- Collectivism vs. individualism (IDV): The degree of interdependence among members in a society
- Assertiveness (ASR): Assertiveness and success vs. harmony and cooperation
- Uncertainty avoidance (UAI): Feeling threatened by unknown or ambiguous situations
- Long-term vs. short-term orientation (LTO): Planning for the future vs. living in the present
- Indulgence vs. restraint (IND): The extent to which life is to be enjoyed vs. showing restraint

Note: Hofstede's original dimension (MAS): masculinity vs. femininity has been renamed (ASR): assertiveness vs. cooperation here.

Another researcher, Hall [10] described two different ways of viewing time:

- M-time: time as a series of distinct, monochromatic units
- P-time: time is fluid, polychromatic

Monochromatic cultures, such as Germany, would tend to start and end a meeting at a precisely scheduled time. Polychromatic cultures, such as Mongolia, may show up for a meeting a bit later. Without the chance to establish rapport, they may feel they are being rushed through and then cut off abruptly, before they have had a chance to adequately express their views.

Hall [10] also differentiated between high and low context cultures. The personal relationships between people are often an intrinsic part of communication. Facial expressions, gestures and pauses can convey more meaning than the actual words spoken. Collectivist societies, such as East Asian countries, also tend to be classified as high context cultures. Western countries such as Germany tend to be more individualistic and lower context cultures. Because written and spoken words convey meaning, communication can often seem verbose.

2.3. Project-Based Learning

Instead of traditional, instructor-based lectures, the courses described in this work implemented a student-centered method called Project-Based Learning [11]. Students are assigned "a messy project," without any detailed instructions exactly on how to solve it. Students work together in groups and inevitably encounter a number of problems. Each of these problems can be expanded on as "teachable moments." The instructor's role is to coach the students to help them discover their own solutions to the problems encountered.

Richardson and Delaney [12] used a hybrid, project-based learning approach to teach a software engineering class for bachelor's degree students. They found this method to be quite helpful in teaching soft skills. Woodward et al. [13] taught information systems using teaching units based on project-based learning. They found that a combination of discovery-based learning, cooperative learning strategies and an analysis of case studies was beneficial to improving students' soft skills. Mendes Silva et al. [14] found that an adapted version of project-based learning gave more realism to teaching software engineering. By working on concrete projects, students were able to apply their skills in a meaningful way.

3. Research Methods

3.1. Organization of the courses

Since 2012, virtual, distributed global software engineering courses have been conducted at the Nuremberg Institute of Technology in Germany. Each course was conducted as a team-teaching course with a partner university in a different country:

1. Mongolian University of Science and Technology in Mongolia (2012, 2013)
2. National Polytechnic Institute in Mexico (2014, 2015, 2016)

3. Ritsumeikan University in Japan (2017).

Most of these courses were taught as seminars at the master's degree level. Class sizes were relatively small, with fewer than 20 students taking part at each university.

Before starting the project phase, students were given introductory lectures about different aspects of global software engineering, such as agile software development, international project management, distributed collaboration tools and intercultural communication according to Hofstede and Hall. Following this phase of introductory lectures, students started on the project phase of the seminar. In keeping with the project-based learning method, the goal was to simulate a realistic, multinational software development project. Each semester, one of two course formats was chosen:

- an intensive, all-day block seminar, which ran continuously for two weeks (except Sundays)
- a weekly course that ran for 12 weeks during one semester.

Students were assigned a practically-oriented software engineering project. For example, one project was to design and build a prototype app for international exchange students. Students going abroad needed be able to connect with student mentors from partner universities before, during and after their semester abroad. The app had to be multi-lingual and satisfy the needs of students from both universities. Another project was to build a customer loyalty system for an Irish pub. Students needed to take into account the needs of the owner, the employees and the customers. Speed, ease of use, data privacy and the noise level in the pub had to be taken into account.

Students were provided with a brief, initial project description, but were not given detailed instructions on how to complete the assignment. They performed their own requirements elicitation with a customer and other end users. They analyzed these stakeholder needs to design and implement a prototype of their software. Each group held a final presentation of their results and handed in written documentation of their projects.

During the first five courses (2012–2016), students were grouped into homogeneous, single-site sub-teams. For example, 20 students in Germany and 20 students in Mexico worked together to develop one common software project. For the first time in 2017, heterogeneous cross-site teams were formed. Each team was made up of four students in Japan and four students in Germany. These mixed teams then competed against

other cross-site teams to see who could develop the best project for a real customer.

There was no face-to-face communication between the two groups. Due to the relatively large time differences between Germany and Mexico (seven hours), Mongolia (seven hours) and Japan (seven/eight hours) students only had about a one hour time window each day when they could communicate in real-time via video conference. All other communication was conducted asynchronously via cloud-based project management and collaboration platforms, messaging and e-mail.

3.2. Gathering of Qualitative Data

Gathering an adequate amount of data for meaningful comparisons was difficult for this study. The sample sizes of each class were quite small, ranging from 7 to 20 students at each university. The cooperating universities and participating professors varied over the years. The format of the class also changed from a block seminar (2012–2016) to a weekly seminar (2017).

Due to these variations in course parameters, which are inherent in an academic environment, randomized, controlled, double-blind studies are not practical. Quantitative statistical evaluations would not have led to meaningful results, due to confounding factors. Observed effects may have been influenced by changes in course parameters from one year to another. For these reasons, this study implements qualitative evaluation techniques: experience reports, questionnaires and project retrospectives.

At the end of the semester, project retrospectives were conducted with the 4Ls Method developed by Gottesdiener [15].

- Like: What did you like about this project? What went well?
- Lack: What was missing? What went wrong?
- Learn: What did you learn during this project?
- Long for: What will you do differently next time, based on these experiences?

Questionnaires asked students about their experiences working with project members from other countries. Student evaluations on course organization, teaching methods, the workload and their learning success were conducted.

Experiences of the participants in the different courses are presented in *Section 4 Experience Reports*. The summarized results from the questionnaires and retrospectives are presented in *Section 5 Results*.

4. Experience Reports

This section describes experiences encountered during the different courses, grouped by countries.

4.1. Experiences from the Mongolia - Germany Experiments

Virtual, team-teaching courses with two universities in Germany and Mongolia were conducted in 2012 and 2013 and are described in detail by Beier, et al. [1] and by Ende, et al. [2].

During the first course, four professors from the Mongolian University of Science and Technology flew to Germany for one week. This initial meeting greatly helped to establish a sense of trust between the cooperating professors. Because the language barrier was so high, a student who was originally from Mongolia and who was currently studying in Germany served as an intercultural coordinator. Without this “intercultural bridge builder,” communication would have been impossible, even between the professors.

Although the geographical and temporal differences were expected, the enormous language and cultural barriers presented huge obstacles for the students on both sides. Problems which could be anticipated in advance, such as geographical distance and the eight-hour time difference, could be solved in advance. Real-time video conferences were scheduled at a time when it was afternoon in Mongolia and morning in Germany. Irregularly occurring problems, such as unstable internet connections, could not be planned for in advance. Drop outs in the internet connection made video conferences impossible on some days and even slowed down asynchronous communication via e-mail.

Although the language barrier could be somewhat alleviated by the aid of a bilingual student and translation software, the cultural barrier proved to be almost insurmountable. The Mongolian students were used to a traditional lecture format, where the professor is seen as a person of authority. German students felt comfortable asking questions and participating in lively, heated discussions. This behavior was sometimes viewed as rude by the Mongolian students. At the end of a presentation, German students knocked on their desks to show their approval. The Mongolian students were shocked by what they interpreted as threatening behavior. To ease their feelings of uncertainty, German students developed detailed specifications and project plans. The Mongolian students' preference for flexible improvisations reflected their heritage as a nomadic culture.

Although the students on both sides appreciated the opportunity to work together with other students from

a very different culture, they felt this proved to be too much of a challenge, even for master's degree students.

4.2. Experiences from the Mexico - Germany Experiments

The results of the Mexico - Germany Experiments from 2014–2016 are described in detail by Harrer, et al. [3] and Olivares-Ceja, et al. [4].

Germans tend to value direct communication and situations which are clearly defined, according to Hofstede [9]. They feel uncomfortable in ambiguous situations and avoid uncertainty. German students usually expect detailed specifications and clear instructions of what is expected of them. The unfamiliar ambiguity of a loosely described project without detailed specifications proved unsettling for the German students. The Mexican students seemed more comfortable with ambiguity. The opportunity to flexibly adapt project specifications was viewed more positively.

The primary motivator for the German students was to achieve good grades. This is in keeping with Hofstede's [9] characterization of Germany as an assertive society, which values achievement and success over harmony and cooperation. The German students also showed more concern about their individual grades, rather than the success of the group as a whole. This goal contradicts with the principles of agile software development, which values the team over the individual. This behavior is typical for an individualistic as opposed to a collectivist society [9].

During the first video-call with the Mexican students, the German students tried to establish a sense of order by concentrating on a task-oriented organization. They did not realize that this “business first” approach could seem intimidating in other cultures, where an initial phase of informal social contact to ease team-building would be expected. The Mexican students tried to establish a sense of rapport by asking personal questions rather than project-related inquiries. German students were confused why the Mexican students were wasting time. The Mexican students felt disappointed that the German students were not interested in them as people. This is in keeping with Hofstede's classification of Mexico as a culture which values the welfare of the entire group over that of the individual [9].

According to Hall [10], people in Germany tend to view time as monochromatic. They expect meetings to start and end punctually. The Mexican students view time as polychromatic. They considered the meeting times to be approximate, rather than strict. The German students were upset when meetings started late and left

immediately once the scheduled meeting time was over, whereas the Mexican students felt they had just gotten started.

As the project progressed, the two teams identified some of the difficulties in this intercultural collaboration and tried different approaches to alleviate these problems. Meetings were conducted based on a written discussion agenda, which each group received ahead of time. Because e-mail was often not read or answered, the students agreed that any binding agreements had to be made during video conferences.

The German students were used to adhering to an established plan and were thus alarmed by requests for new requirements during the project. They saw these changes as a violation of the initial project specifications. They had to learn to abandon their strict schedule and to adapt to the agility of their Mexican group members. As the project progressed, they realized that the new ideas from the Mexican group members were often better than the initial project specifications.

Finally, at the end of the semester, after the pressure of grades had abated, the German students finally relaxed enough to take time to communicate informally with the Mexican students. They asked themselves why they did not even know the names of most of their Mexican partners. The Mexican students hoped to keep in touch informally after the course was over and were disappointed when the contact ebbed. Students on both sides realized that they could have saved a lot of time and prevented misunderstandings by first investing more effort building trust between group members.

4.3. Experiences from the Japan - Germany Experiment

The results of the first Japan - Germany Experiment are presented in detail in Marutschke et.al [5].

One goal in this class was to prevent students from clustering together with other students from their own country. Students were assigned to heterogeneous groups, made up of four students from Japan and four students from Germany. The intention was to test whether mixed teams could lessen the building of “in-group vs. out-group” sentiments. Students found these mixed, cross-site teams much more challenging. They were also quite surprised that the students from the Japanese university were not originally from Japan. As part of an English language master’s degree program, students were from a number of East Asian countries, such as China, Korea and Vietnam. Having to adapt to a number of different Asian cultures proved even more difficult than planned.

The minimum set of activities to be completed by

the end of the 15 week semester on the Japanese side were—requirements elicitation and interaction with a real client, brain storming activities and conceptual design together with rapid prototyping.

One of the main purposes of project-based learning is to let students work out a solution by themselves and let them experience an actual industrial setting in the early stages of the product life cycle. This naturally can lead to unclear requirements at the beginning of the project, which was unsettling to the students in Germany, who feared the ambiguity and were intent on getting good grades. The students in Japan seemed less focused on their grades and more concerned about group harmony. Even with keeping the teams as heterogeneous as possible, the communication within teams, especially on the Japanese side, had initial difficulties. Some team members switched to their common, native language and seemed to come to conclusions that the rest of the team could not follow. From experience, students tend to rank the English abilities of people from other non-native countries subjectively lower than their own. This often leads to different sides complaining about communication difficulties.

The actual project requirements were elicited in collaboration with a bona fide business owner in Japan and complemented by introspection on customer-business interaction in Germany, although in different cultural settings.

As the semester progressed, both sides looked for ways to communicate better. They also learned to take minutes of every meeting, to set deadlines for each individual activity and to assign one person as responsible for each task. When one half of a group noticed that their other half did not understand a certain technology, they made tutorial videos for each other.

There was a “working strategy,” where all cross site teams quickly converged to the leading-by-example team management style. Specific team leaders emerged, who contributed significantly to the work and also took responsibility for team organization and started demanding accountability from other team members. For the Asian students, the latter was not a surprising outcome, as most of the participants in Japan learned to position themselves as social leaders. This reflects findings by Jarvenpaa and Leidner [16]. In the early stages of a project, trust can be facilitated by not blaming technology for problems. Team members should take the initiative to deal with confusion and provide suggestions, without waiting for others to come up with instructions. To maintain trust, the group should shift the focus to task-orientation to move the project forward, avoid negative or ineffective leadership styles and try to react calmly to crisis. As all of the students

were non-Japanese, they were also used to studying in a multicultural environment.

Students from both countries reported extreme difficulty in communicating with the remote half of their teams. Some team members reported a lack of trust in team members in the other country, since they did not have the opportunity to meet them personally. Next time, they vowed to spend more time getting to know each other at the beginning of the project.

5. Results

5.1. Perceived Cultural Differences

Based on the opinions gathered during the retrospectives and from the student questionnaires, the team members' behavior was rated according to Hofstede et al.'s [9] and Hall's [10] cultural dimensions:

- PDI: Power Distance
- INV: Individualism vs. Collectivism
- ASR: Assertiveness vs. Cooperation
- UAI: Uncertainty Avoidance
- LTO: Long Term Orientation
- IND: Indulgence vs. Restraint
- MPT: Monochromatic vs. Polychromatic Time
- LHC: Low vs. High Context

Dimensions	Germany	Japan	Mexico	Mongolia
PDI	low	high	high	high
INV	high	low	low	low
ASR	high	low	high	high
UAI	high	low	low	high
LTO	high	high	low	low
IND	low	low	high	high
MPT	mono	mono	poly	poly
LHC	low	high	high	high

Table 1. Comparison of Cultural Dimensions based on Hofstede et al. [9] and Hall [10]

As evident from Table 1, students from Germany, Japan, Mexico and Mongolia differ considerably on the cultural dimensions of power distance, individualism, long-term orientation, indulgence and time perception. Assertiveness scores high for three countries. Team members from Germany were the only ones who valued a low power distance, high individualism and low context communication. Japan-based and Mexican

team members showed low uncertainty avoidance, a known trait that students try to keep a certain level of uncertainty at the beginning of a project. This contrasts with Hofstede's results [9] and explains some of the initial difficulties in the communication between the teams.

The teams of students noticed quite rapidly that they had different views on the power distance between students and professors. Although German students were used to self-organizing and asking professors direct questions, this behavior was considered rude in the other three countries. Other students from cultures with a high power distance hesitated to take the initiative out of respect for their instructors. German students needed to recognize that their ambition to maximize their individual grades might not have been as important as the success of the entire group. Although from collectivist cultures, some of the East Asian students in Japan had a similar problem during the initial stage of the project. The dynamic, short-term flexibility of the Mexican and Mongolian teams was unsettling for the Germans, who are used to long-term planning to minimize uncertainty. The polychromatic time perception of some teams conflicted with the monochromatic German view of time. As the only low context culture, German students were often confused by what they perceived as vague answers from the East Asian students, while the East Asian students sometimes found the directness of the Germans rather rude. From a high indulgence and collective culture, Mexican students thought the German students focused solely on the tasks, neglecting the social aspects of the group.

At the beginning of the courses, students ranked differences in time zones and languages as the most important factors for global software engineering. At the end of the courses, students ranked cultural differences and trust between teams as the most important factors.

5.2. Project-Based Learning

Project-based learning was especially effective in helping students learn to understand the problems inherent to working with people from different cultures. Although they had been prepared for the coming experience during the lecture phase, at the beginning of the project phase, many students reported experiencing a mild culture shock. They were surprised that the students from the partner university did not understand the way they expressed their ideas and had different styles of cooperation and communication.

Based on the retrospectives and questionnaires filled out by the students at the end of the semester,

project-based learning had quite a positive effect in helping them to internalize theoretical concepts. During the lecture portions of the course, they initially thought that they had understood the principles of distributed project management and cultural dimensions. It was not until the project phase of the course when students realized the difference between passively consuming lectures and actively solving problems on their own. Students did quite well finding solutions to practical problems with appropriate schedule planning and the use of collaborative tools. In contrast, establishing rapport and trust between remote group members proved to be one of the largest hurdles in each course.

5.3. Course Organization

The two different course formats were rated differently: block seminar vs. weekly classes over an entire semester. The students who took part in the block seminar rated it as an extremely intense experience. At the end of the seminar, a number of students complained of exhaustion. They did, however, express the opinion that the block seminar was a very realistic simulation of a global software project, because they worked together all day solely focused on one subject. The students who took part in the weekly course over an entire semester also felt pressed for time, but because they had other classes to study for in parallel. Although they reported lower stress levels, they thought that a block seminar would have been “easier,” because they could have concentrated on one subject.

During the first five courses (2012–2017), students were allowed to form homogeneous, same-site sub-teams. Students at each site rapidly formed sub-teams which were cohesive at each site. Work was divided up between the sites to minimize interdependent interfaces. Each group designated a communication manager, who was primarily responsible for leading the real-time video conferences. The development of an “in-group vs. out-group” mentality was observed. Problems encountered were readily blamed on the other team at the remote site.

For the course held in 2017, students were assigned to work in heterogeneous, cross-site teams, which competed against each other. This increased the amount of communication necessary between team members at different sites. Students reported higher levels of frustration and the impression that they got less work done than if they had worked alone. At the end of the semester, students did not report a higher level of cross-site group cohesion with the partner university than the homogeneous, single site groups from the previous courses.

6. Conclusions

After six years of team-teaching experiments in global software engineering, a number of conclusions are possible. First of all, cooperative, virtual courses have proven effective to teach students global software engineering. The simulation of a geographically distributed software project helped students gain experience in international project management and intercultural communication, without leaving their home universities. This type of experience can prove especially valuable for the large majority of students who do not have the opportunity go abroad during their university studies.

Secondly, students reported that project-based learning was much more challenging than traditional, instructor-based lectures. These experiments were conducted with students at the master’s degree level. Although project-based learning could theoretically be used with bachelor’s degree students, they should have the requisite software engineering competence. Kirschner et al. [17] warn that discovery-based teaching methods can lead to cognitive overload for students who lack the basic skills necessary to solve problems on their own. Because these master’s degree students in this study already had an adequate background in software engineering, they said that they had learned more by making their own mistakes than they would have learned by listening to theoretical lectures. The simulation of a global software project helped them to acquire new skills in distributed project management and intercultural communication in a safe environment.

Thirdly, the requirement to form cross-site teams made up of members from two universities required more effort on the part of the students. Although the potential for conflicts between group members increased, students felt that in the end they learned more than they would have with single-site teams. This experience contrasts with the results observed by Paasivaara et al. [18], who reported no difference between single-site and cross-site teams.

Finally, from the point of view of the instructors, organization, informal communication and trust were judged to be the most important factors for conducting a virtual, distributed course. Although the students never got the chance to meet each other “in real life,” the instructors were able to meet personally for one week. These personal meetings were essential, not only to discuss class organization. More importantly, these meetings gave instructors the opportunity to get to know each other on an informal basis. This informal communication formed the basis for a level of trust, which is vital for the success of a virtual, cooperative

course. Other researchers also confirm that trust and a good relationship are vital for collaborations [19].

7. Future Work

Plans for future work include the exploration of methods to increase trust and group cohesion. Factors which were found by other researchers to influence trust [16] and group resilience [20] will be studied to see whether these results are also valid for this test environment. Further plans also include the attempt to form distributed virtual courses with three different universities in one semester. The amount of necessary communication between group members is expected to increase significantly.

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