GROUP-BASED LEARNING IN INTERNATIONALLY DISTRIBUTED TEAMS:
AN EVALUATION OF A CROSS-ATLANTIC EXPERIMENT

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Abstract - Students from the Netherlands and the USA have collaborated in teams on engineering design formulation. We evaluated how the students, divided into mixed groups, communicated, learned and collaborated. We found that some groups had made explicit arrangements regarding times and means of synchronous and asynchronous communication, complicated by the 6 hour time difference. Simple but highly accessible tools (email and chat) were used most often. We conducted a detailed individual group assessment in which each student evaluated each group member regarding quality of contributions and commitment. We found that local group members were rated significantly higher than non-local ones. Although students felt at ease in their international group, and indicated that they were able to express their opinions, not every group functioned well, as illustrated by the free-riding behavior of non-local group members. Overall, the students recommended that the international collaboration be continued.

Index Terms – Collaborative work, Distributed teams, Engineering design, Group-based learning.

INTRODUCTION

The availability of various information and communication technology tools (ICT) has prompted many experiments that are aimed at using and evaluating ICT tools in university courses. Likewise, the Faculty of Technology, Policy and Management at the Delft University of Technology (DUT) has conducted a major program called IMAGO (ICT-Modelled and Globally Oriented) [1], which is aimed at giving ICT a more central role in the education provided [2]. Courses that are part of the IMAGO program are designed and improved in a number of consecutive design cycles.

The course that is described in this paper, i.e. an elective engineering design course taught simultaneously at Carnegie Mellon University (CMU), USA, and at Delft University of Technology (DUT), the Netherlands, has been developed and taught in the framework of the aforementioned IMAGO program. In two previous development cycles we focused on communication, complicated by the 6 hour time difference. Simple but highly accessible tools (email and chat) were used most often. We conducted a detailed individual group assessment in which each student evaluated each group member regarding quality of contributions and commitment. We found that local group members were rated significantly higher than non-local ones. Although students felt at ease in their international group, and indicated that they were able to express their opinions, not every group functioned well, as illustrated by the free-riding behavior of non-local group members. Overall, the students recommended that the international collaboration be continued.

This year (fall 2002), 39 MSc students participated in the course in mixed groups: 21 students at the Delft University of Technology, and 18 students at Carnegie Mellon University in the USA, from various engineering disciplines. The goal of this year's experiment was to take a closer look at the group process and focus on the students’ perceptions on local and non-local group members. An additional challenge, compared to other international teamwork initiatives, is the considerable time difference between the universities involved.

The next section describes the theoretical framework that we used to formulate our research questions. The results section describes the outcomes of the survey we conducted among the students after the course. In the final section we will draw conclusions with regard to communicating, working and learning in distributed cross-Atlantic groups.

RESEARCH DESIGN

Theoretical Background

We investigated some of the well-known problems in group-based learning, especially in distributed group work in international teams [7]. Those problems concern the
scheduling of group tasks, the division of tasks, the cohesion of the group and communication.

Task schedule. One aspect of the management of group-based learning concerns the scheduling of tasks. Groups often experience problems when planning their work and in the operationalisation of the task schedule. As a result the group work may not be completed in time. The challenge of the cross-Atlantic experiment was to schedule the activities in such a way that overseas group members could continue the work, while the local members were asleep, known as “leapfrogging”.

Division of tasks. One well-known problem in group work is the ‘free rider’. It can be highly frustrating when some group members have to do extra work because other group members contribute too little. The distributed locations make it difficult to be aware of what is actually happening on the other side and to exert influence on the non-local group member(s).

Cohesion. Even when the technical support tools are available, students tend to focus on their local colleagues first. Whether students are willing to make an effort to collaborate with non-local group members depends on the perceived (virtual) presence of these non-local group members. The fact that the groups are quite homogeneous in age, motivation and skills, and are balanced in number (2-3 local students are teamed with 2-3 non-local students) could be helpful in the collaboration. In a former experiment we organized a video-conferencing session before starting the work, which was meant to support the socializing process. Due to high costs it was replaced by a webcam. A lack of awareness often caused a lack of engagement to the group work and problems with, for instance, negotiating and decision making [7].

Communication. Physical group meetings are not possible on a cross-Atlantic distance education course. For that reason, this experiment investigated the use and usefulness of the available communication tools for communicating with the non-local group members: e-mail, chat, telephone, and webcam. Furthermore, an electronic learning environment (ELE) was used to ensure access to (group) documents and resources. The ELE will not be discussed further in this paper.

Literature indicates that shared time slots are beneficial for distributed group work, as synchronous communication allows groups to update each other on the progress they have made. If no time slots are arranged, groups have to rely on a slower cycle of asynchronous communication and run the risk of delays in their schedule and decision making [7]. This is a source of frustration to students. Working with students in different time zones – there is a 6-hour time difference between Delft and Pittsburgh - makes it even more difficult to communicate. Therefore, the students were strongly advised to make arrangements regarding the time of synchronous communications and the response time of asynchronous communications.

Research Questions

The main research questions that are dealt with in this paper are:

- To what extent do students experience problems with group work in cross-Atlantic distributed teams, in particular with planning, division of tasks, cohesion of the group and communication?
- To what extent are the students satisfied with the learning effects of the course?

Survey Design and Implementation

To investigate whether the problems described occurred in our experiment, the course was evaluated by means of a survey. The survey was divided into separate themes concerning distributed group work and learning.

Students indicated whether or not they agreed with 28 statements on a scale of 1 (disagree) to 4 (agree). Second, they had to indicate how many hours they had put into using the various ICT tools and indicate their usefulness on a 5-point scale. Third, the students were asked (i) to select from a list of possible problems, extracted from [7], those which occurred in their group, (ii) to indicate what the exact problem was and (iii) to make a suggestion for improvement. Finally, the students filled out a table in which they assessed themselves and each individual group member on the following aspects on a 5-point scale:

- quality of contributions
- quality of feedback
- commitment
- inspiration to me.

We asked the students to fill out the survey during the final class of the course in order to ensure sufficient feedback. The overall response rate of the survey was 85%. The distribution of responses among DUT and CMU students is shown in Table I.

<table>
<thead>
<tr>
<th>TABLE I</th>
<th>CLASS PARTICIPATION AND SURVEY RESPONSE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>DUT</td>
</tr>
<tr>
<td>Number of students</td>
<td>21</td>
</tr>
<tr>
<td>Survey respondents</td>
<td>19</td>
</tr>
<tr>
<td>Response rate</td>
<td>90%</td>
</tr>
</tbody>
</table>

RESULTS

Task schedule

Students had to make a schedule in advance, assisted by the instructors, who had set a number of intermediate deadlines. It is important to note that all students involved were familiar with schedules such as these. The groups were
specifically made aware of the advantages and problems of leapfrogging.

Students were asked whether they had made such a schedule, whether the working arrangements with the non-local members were easy to agree upon and whether the group worked according to the schedule. The students indicated on a 4-point scale that a schedule had been made (mean 2.6, s.d. 0.8), but the statement “agreement was easily reached” scored lower (mean 2.2, s.d. 0.9). Moreover, the students mentioned on an average of 2.4 (s.d. 0.9) that the group worked according to the schedule. Given this outcome, there are likely to be efficiency problems when working according to the leapfrogging principle. As depicted in Figure 1, students pointed out that the continuation of the work by overseas group members while you sleep did not work as well as expected. There was a difference in perception between CMU students and DUT students.

The different effects of the time difference on both groups may have contributed to these outcomes. When DUT students decide to finish at 6 pm, it is already noon in Pittsburgh. When CMU students decide to stop, however, the DUT students will find the CMU contribution when they start working at 9 am the next day.

<table>
<thead>
<tr>
<th>Frequencies</th>
<th>CMU</th>
<th>DUT</th>
</tr>
</thead>
<tbody>
<tr>
<td>disagree</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>slightly disagree</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>slightly agree</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>agree</td>
<td>5</td>
<td>7</td>
</tr>
</tbody>
</table>

FIGURE 1
LEAPFROGGING WORKED WELL IN MY GROUP (N=33)
(Mean DUT 2.4 (1.1); Mean CMU (1.6 (0.7); Sign. 4.3%)

Division of tasks

Group members may become discouraged if other members do not take a fair share of the work. At a distance, it becomes hard to monitor the work of overseas group members and to detect free riders at an early stage.

In this experiment, students had the impression that they did more work than the other group members (mean 2.8, s.d.1.0, 4-point scale). The work of the (overseas) colleagues was obviously not visible enough to all the group members. When asked to compare the contribution of local and non-local group members (“the non-local group members put more effort into the project than we did”), the students disagree (mean 1.8, s.d. 0.8).

The contribution of each individual group member has been evaluated in more detail in a group assessment (see next section). From this assessment we found that freeriding behavior occurred, indicated by consistently low scores for some group members. An additional comment on the survey made this very clear in one particular case: “[Non-local] students in our group did nothing, no interest, no knowledge, no nothing”.

Cohesion

The lack of visibility of the work of non-local group members could point to a lack of cohesion in the group. Students tend to focus on local group members when working in distributed teams, and are less aware of their non-local group members. We investigated the cohesion in the group through a number of statements and a group assessment.

Firstly, we found, on a 4-point scale, that the students felt at ease in the groups, but that there was a significant difference between the local group setting (mean 3.6, s.d. 0.6) and the international group setting (mean 3.1, s.d. 0.8). Also, the DUT students felt significantly more at ease in the international group compared to the CMU students, as tabulated in Table II.

<table>
<thead>
<tr>
<th>Statement</th>
<th>Mean DUT</th>
<th>Mean CMU</th>
<th>Significance (conf. 95%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I felt at ease in my local group</td>
<td>3.7 st.d. 0.5</td>
<td>3.5 st.d. 0.7</td>
<td>39.0 %</td>
</tr>
<tr>
<td>I felt at ease in my group</td>
<td>3.4 st.d. 0.6</td>
<td>2.7 st.d. 1.0</td>
<td>2.5 %</td>
</tr>
</tbody>
</table>

Secondly, problems with negotiating and decision-making may also point to a lack of awareness. We asked the students how they perceived the negotiating processes with their local and non-local group members. It was found that they were able to express their opinion to all group members and that their opinion was taken into account. There was a significant difference between the perceived impact of personal opinions in the local and non-local negotiating processes.

Finally, a lack of engagement in the group work may also indicate a lack of awareness and cohesion. A separate part of the survey was, therefore, aimed at explicitly assessing the local versus the non-local group members on a number of keywords: quality of contributions, quality of feedback, commitment and inspiration to me. We asked the students to indicate to what extent they and their group members had contributed to these particular keywords on a 5-point scale. A typical example of such an assessment is

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shown in Table III. Italics indicate what a (hypothetical) student called Jim could have written in the table.

**TABLE III**

**EXAMPLE OF A GROUP ASSESSMENT**

(1=poor, 2=mediocre, 3=satisfactory, 4=good, 5=excellent)

<table>
<thead>
<tr>
<th>Name</th>
<th>You</th>
<th>Local member</th>
<th>Non-local member</th>
<th>Non-local member</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quality of contributions</td>
<td>Jim 4</td>
<td>Sarah 3</td>
<td>Jan 3</td>
<td>Marie 2</td>
</tr>
<tr>
<td>Quality of feedback</td>
<td>4</td>
<td>4</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>Commitment</td>
<td>4</td>
<td>4</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>Inspiration to me</td>
<td>N.A.</td>
<td>4</td>
<td>2</td>
<td>2</td>
</tr>
</tbody>
</table>

Although the tables were not anonymous, we expected the tables to be filled out truthfully as the students had already received their grades for the course, and the instructors had ensured that the data would be processed anonymously.

An analysis of the scores of the DUT students and the CMU students demonstrated that there were no significant differences between the scores of the two universities that would influence the combined results discussed below. We therefore combined the local group members (regardless of whether they were DUT or CMU students) and the non-local group members per keyword as well as totaling them for all keywords. The results tabulated in Table IV show that there is a significant difference between the scores given to local group members and the scores given to non-local group members: local group members tend to receive higher grades than non-local group members.

**TABLE IV**

**RESULTS OF GROUP ASSESSMENT: MEANS AND T-TEST**

<table>
<thead>
<tr>
<th>Keyword</th>
<th>Local members mean</th>
<th>Non-local members mean</th>
<th>Significance (conf. 95%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quality of contributions</td>
<td>4.0</td>
<td>3.0</td>
<td>0.0 %</td>
</tr>
<tr>
<td>Quality of feedback</td>
<td>st. d. 0.7</td>
<td>st. d. 1.0</td>
<td>0.0 %</td>
</tr>
<tr>
<td>Commitment</td>
<td>4.2</td>
<td>2.8</td>
<td>0.0 %</td>
</tr>
<tr>
<td>Inspiration to me</td>
<td>st. d. 0.8</td>
<td>st. d. 1.1</td>
<td>0.0 %</td>
</tr>
<tr>
<td>Keywords combined</td>
<td>4.0</td>
<td>2.7</td>
<td>0.0 %</td>
</tr>
<tr>
<td></td>
<td>st. d. 0.7</td>
<td>st. d. 1.0</td>
<td></td>
</tr>
</tbody>
</table>

Students considered email to be the most useful tool and used it on average for 1.2 hours/week to make arrangements and for reaching all group members at the same time. However, when students were asked whether arrangements concerning the response time had been made, they answered 2.5 (st.d. 0.8) on average. This result was corroborated by 15 students mentioning delayed responses as a drawback of email.

Chat was considered to be the most useful synchronous tool, and session time slots were often arranged beforehand (mean 2.9, st.d. 0.8). Chat was used for an average of 1.2 hours/week for the exchange of ideas in brainstorming sessions and for quick corrections to each other’s work. Drawbacks were that it was hard to communicate with several people in parallel. Telephone and webcam were hardly used (0.3 and 0.2 hours/week respectively) for reasons of high cost and difficulty of access.

As expected, given the problems that emerged in previous sections concerning the schedule, the division of tasks, and group cohesion, students indicated that communication with the non-local group members was not satisfactory. Students slightly disagreed with the statement “Getting in touch with the non-local group members was easy” (mean 2.0, st.d. 0.9), and also with “The communication between group members on an international level was sufficient” (mean 2.2, st.d. 0.8).

**Communication**

Many of the aforementioned problems are a result of poor communication processes. In previous years we investigated how to stimulate the students to use appropriate ICT tools for communication purposes. In [4] we reported on the effectiveness and usefulness of tools such as video conferencing, email, online chat and web-based document management systems. This year we decided to leave the choice of tools to the students after we advised them of the various options. Figure 2 shows the perceived usefulness of the various tools.

![Figure 2: Usefulness of communication tools](image-url)
The second research question discussed in this paper focuses on the learning objectives of the course. The course centered on two learning objectives, stated briefly as:

- to learn engineering design problem formulation (content)
- to experience working in distributed teams (process).

We did not measure whether learning actually occurred, but only used the survey to acquire the students’ opinions on the learning outcomes. The results of the survey indicated that students felt that both learning objectives had been achieved, as depicted in Figure 3 (4-point scale; 1=disagree, 4=agree).

We also asked the students whether working in an international group had contributed significantly to the first, content-related, learning objective. The students indicated that working in an international group had contributed to the engineering design learning objective on an average of 2.4 (st.d. 1.0) on a 4-point scale. The answers of the DUT students to this question did not differ significantly from those of the CMU students.

These results confirm the findings and recommendations from literature, which state that the deployment of distributed, international teams in learning environments has an added value if the different parties have different expertise, knowledge or methods. Furthermore, the assignments should contain incentives to consult each other’s expertise [8].

We finally asked the students whether the international collaboration should be part of the course in future years. Figure 4 shows that 80% of the students recommended that the international collaboration be continued. There was a significant difference, however, between the DUT and CMU students in the sense that only CMU students (6 out of 14 CMU students) advised against the continuation of the international collaboration. This is also shown in Figure 4.

Comments given by the students regarding discontinuation of the collaboration were:

- “Difficult to coordinate meeting times. Often left one [CMU group member] collaborating with Delft members.”
- “Perhaps on a more limited basis: 2 projects with CMU only and 1 project with Delft. […]”

Comments given in support of the continuation of international collaboration were:

- “Even though we had problems and it made life more difficult, it was a good learning experience and it was good to hear their differing ideas.”
- “This collaboration allows students on both sides to understand how each place works and it provides insights seldom seen or heard if just held in one country.”
- “It is fun and educational, a good experience.”

**CONCLUSIONS AND RECOMMENDATIONS**

In this cross-Atlantic experiment students from the Delft University of Technology (DUT) in Delft, The Netherlands, and Carnegie Mellon University (CMU) in Pittsburgh, USA, collaborated in mixed groups on a course called “Engineering Design Problem Formulation”. We studied the group process and the students’ perceptions of local and non-local group members. More specifically, we focused on task scheduling, the division of tasks, group cohesion and communication.

All students have experience of working in local groups and making work schedules. Making and following a schedule in an international setting, however, is not self-evident. The lack of detailed structure in the set-up of the course may have contributed to these outcomes, illustrated by the following comment by a student: “One major thing
that would help is a clear, easily accessible list of assignments for the class and the due dates for both sides.” Students wanted the instructors to provide more structure in the set-up of the course. In a more pre-structured set-up such as this, ICT support on workflow may help the students keep to the schedule [7]. The recommended workflow support could also bring about improvements in the leapfrog style of working, i.e. overseas colleagues continue the work while you sleep, which did not get off the ground very well in this experiment.

More than half of the number of students indicated that they did more work than their colleagues. This was confirmed by the results of the group assessment in which students assessed each group member individually. Students identified free-riding behavior, especially of non-local group members, and this perceived unequal division of tasks hindered the group processes. Using the group assessment instrument during the course could reveal the perception of the efforts of the individual group members and could initiate a discussion about the responsibilities of group members towards the group.

With respect to the functioning of the group, we also found that students were able to express their opinion to all group members and that their opinion was taken into account. Also, the students felt at ease in their international group. A notable difference was found in the perception of DUT students as opposed to CMU students: DUT students felt more at ease in the international group. In addition, the DUT students were more positive about leapfrogging. These perceptions may have contributed to the unanimous recommendation of DUT students to continue the international collaboration, whereas some CMU students advised against it.

Finally, with regard to the communication processes, the most useful ICT tools were email and chat; both were used 1.2 hours per week. Communication between the students could still be improved, and in doing so, cost and ease of access of the tools should be taken into account, as the telephone and webcam were not used for those reasons.

Our second research question addressed the extent to which the students were satisfied with achieving the learning objectives of the course, namely “to learn engineering design problem formulation” and “to experience working in distributed teams.” Students indicated that both learning objectives had been achieved.

The extent to which working in an international group contributed to the content-related insights (i.e. engineering design problem formulation) could be improved. One way to accomplish this was suggested by a student in the following comment on the survey: “[…] I liked the fact that we had to create something with overseas cooperation. I would have liked it even more if we had to make a report in which differences between us were subject.”

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