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Categorizing How Students Use Collaborative Technologies in a Globally Distributed Project

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Abstract—Possibilities for collaboration in globally distributed projects have radically changed with the introduction of new Collaborative Technologies (CTs) in the Web 2.0 era. The use of such technologies in the context of students collaborating in a globally distributed project is little explored in research. A better understanding would provide opportunities for improving the collaboration, and more importantly is that a better understanding would improve the possibility of scaffolding, and student learning in general. In this paper we present results from a study of students' use of CTs in a globally distributed project with a focus on the challenges encountered in trying to collaborate using this technology. The study is focused on a few aspects of how a combination of CTs could be utilized and issues associated with their set up and adaptation for use. We discuss potential reasons for the observed patterns of technology use and how they influenced the collaboration environment around a globally distributed student project.

Keywords—component; survey; reflections; Open-Ended Group Projects; global collaboration; collaborative technologies

I. INTRODUCTION

Use of Collaborative Technologies (CTs) in globally distributed projects is the theme of this paper and we look at it from an instance of student collaboration. The educational setting is a semester long collaboration between Computer Science students at Rose-Hulman Institute of Technology in USA and IT engineering students at Uppsala University in Sweden. The learning environment is based on the Open-Ended Group Project (OEGP) concept [1, 2] in which the students gather and expand knowledge about a complex real-world issue in the health care area on behalf of an external client. Close and genuine collaboration is essential for the success of this project and use of CTs is a necessary component in achieving this due to the geographical distance between the two cohorts. One of the students depicts the importance of CT in this colorful quotation:

"I don't think this project would exist without the communication tools available to us"

Use of CTs has become an everyday activity and is today more or less taken for granted in the workplace and in education. It has certainly made communication both easier and richer since we first started our student collaboration in 2005. The students' collaboration has nevertheless not been without problems and difficulties, and an attempt to improve

communication by giving the Swedish students access to a high tech laboratory classroom was made during the 2011 instance. This attempt has been studied and some observations from this study are reported in this paper and in companion paper [3] looking into how the students reflected on CT.

A result of our study is an increased understanding of the challenges students encounter in trying to collaborate with the use of CTs. This is done with the broader aim to improve scaffolding and learning with regards to collaboration and communication in globally distributed projects. Data in the study was gathered using two surveys and two written reflection assignments during one semester in a course with computer science and IT students from two countries six time zones apart. The study also included direct observations of the collaboration made by the teaching faculty and staff at a collaboration room at one of the Universities. Results show that students use numerous technologies in their collaboration, and that their perception of the usefulness of the different technologies depended on factors such as the possibility of using the technology on a smart phone, their previous experience with using the technology, and the possibility of combining asynchronous and synchronous communication. Surprising results revealed that email was much less frequently used than expected and had to a large extent been replaced by asynchronous use of chat through Skype. Moreover, many students considered the collaborative project platform useless despite its advanced technology, which included possibilities for different forums, milestones and shared folders. It appears that the demands of technology use mediation imposed by collaborative technologies were not appreciated by students with prior experience of more personalized technology use.

We will first present the local setting in some detail in order to provide the reader with an understanding of the context of the study. This is followed by giving a general theoretical framework for the study and presenting the data collection methods used. Some results of the study are then presented and discussed.

II. BACKGROUND

A. The Student Collaboration

The local context for this study is a globally collaboration between students at the Swedish university taking the IT in Society course and students at the American university taking

the Computing in a Global Society course, where the two cohorts are almost 7,000 km and six time zones apart. This setting and different aspects of it have been described elsewhere [4 - 8], but a short summary is given here to provide the reader with a quick update.

The educational setting is aimed at developing professional competencies that are essential in relation to working in a global collaboration setting. This setting is based on the Open-Ended Group Project (OEGP) concept, where complexity and many options for how to approach a problem are central issues. OEGP is a suitable concept for preparing our students for working on a global arena. An important aspect of the educational setting is that the project is placed in a real environment with a real client, which adds to the complexity and also is shown to increase motivation for the students [9]. An issue with real clients is that they also have other obligations and can be hard to get reasonable access to, which we have addressed by only using one reliable client and putting all students into one project. This solution has, as seen from an OEGP perspective, the added benefit that it adds to complexity. Another issue with a real client might be that some students feel ethically constrained to help certain clients, e.g. for political, religious, or competition reasons. We have for that reason chosen to work with in the public health sector, i.e. the Uppsala County Council and the associated academic hospital.

Also of relevance to this paper is that the students have more or less total freedom in choosing CTs. Examples of constraints set up by the staff are that some form of collaboration platform should be used and that there should be weekly synchronous meetings that preferably should include video. The choice of CTs and how to use them is up to the students and varies over the years, e.g. this year the team leaders required the members to keep track of the time they spent on the project. The CTs used this year are presented below.

The students participating in the course this year were all men of age between 20 and 37; the American cohort was between 20 and 22, and the Swedish cohort had all but one member in the range of 21 to 24. The majority of students had their major in computer science or IT, but some students had other majors such as mechanical engineering. This year there were ten Swedish students and eight American students taking the course. Most students had studied for three or four years at the university.

B. Uppsala Learning Lab and the Laboratory Classroom

Uppsala Learning Lab (ULL) was created in 2000 as a part of an effort to raise the level of IT use in education, research and especially international collaboration. It is now an administrative unit at the Swedish university with the task of spreading knowledge on how IT can be used in teaching and in research projects. ULL experts actively collaborate with faculty in order to develop their use of IT and an essential part of this effort is to maintain, to develop, and to evaluate the use of a high tech classroom, called the laboratory classroom. The laboratory classroom is open and free of charge to all teachers at the Swedish university for education and seminars. The classroom seats up to 80 persons and has four interactive whiteboards and four large screens that can be used for video

conferencing facilities, and the opportunity to lend laptops to students. The room can be subdivided into smaller sections and all furniture is on wheels and can thus easily be adapted to different needs. ULL's staff provide technical support for users, but above all help faculty to test and evaluate the possibilities offered by CTs in a classroom setting from a pedagogical perspective.

When using the laboratory classroom in the project course, the students were in charge of the contact with faculty at ULL, and they made arrangements regarding furniture, the use of different rooms and technology.

III. RELATED RESEARCH

A. The Digital Generation

The students have grown up in a world of CTs, and they have other ways of thinking, interacting, working and socializing that revolve to a much higher degree on CTs. This is seen as fundamental difference as expressed by Prensky [10] on what he denoted the Digital natives and the Digital immigrants and by Tapscott [11] on what he called the Net generation. Similar ideas are expressed by Veen and Vrakking [12] in what they describe as the Zapping generation. Selg [13] did a study of students and faculty in Sweden where he classified use behavior into Web 1.0 and Web 2.0 categories, where the latter is roughly the same as Digital natives, the Net generation, and the Zapping generation. He concluded that Web 2.0 behavior is predominant in the age group 25 years and younger to a much higher rate than for older age groups. Notwithstanding this observation, he points out that there are substantial differences within the different age groups that indicate that it rather is a question of culture than generation. That is, having the competencies to use CTs in a Web 2.0 manner can be seen as being in a culture, e.g. a Digital native, and is not a definition of a whole generation. It might thus not be appropriate to describe our students as digital natives just because they are young, but Selg observes that CS and IT students to a high degree belong in the Web 2.0 culture. The behaviors and views of this culture are thus relevant for our study.

B. Communication and Globally Distributed Projects

Technology plays a crucial role in supporting communication in globally distributed projects, and an increasing range of collaborative technologies are available for use, ranging from the ubiquitous email through wikis, blogs, text chat systems, version control systems, video-conferencing systems from desk-top applications such as Skype to dedicated rooms and services, cloud based file sharing services such as Dropbox, and virtual learning environments (often incorporating a range of features). Personalized social networking services such as Facebook, Youtube, Twitter are also complementing the more group focused collaborative technologies. However, this plethora of choice does not necessarily contribute to effective communication in a global team context. Many challenges remain to be surmounted, as noted by Olson and Olson [14] and elaborated in [15], where "common ground" needed to be established with respect to "collaboration readiness" and "technology readiness" in order to engage in "tightly coupled" work activities.

Central to the functioning of geographically distributed collaboration is the creation of “common ground”, i.e. establishing “mutual knowledge”, which is addressed in a paper by Cramton [16]. Mutual knowledge can be established through 1) Direct knowledge created in first hand experiences with individuals, 2) Interactional dynamics, where it is created through any kind of interaction (although it should be remembered that uniquely held information, as opposed to commonly held information, is much less likely to surface in interactions [17], and 3) Category membership, where assumptions on another’s knowledge is based on social categorization [18], (e.g. a cabdriver is assumed to know how to get to the airport). Establishing such mutual knowledge in a distributed collaboration in which only the last two are available, is not an easy task. There are difficulties in conveying nuances when compared to face-to-face meetings [19] and these are exacerbated by the fact that CT communication is slower [20]. Cramton identifies a number of problems that contribute to difficulties in establishing this mutual knowledge: failure to communicate and retain contextual information, unevenly distributed information, communicating and understanding the salience of information, differences in speed of access to information, and difficulty interpreting the meaning of silence. She also points out that the difficulties are accentuated by the fact that the collaborators often are unaware of these problems.

IV. METHOD

In this study, data was generated during four months through observations, two surveys and two written reflection assignments. Faculty made observations throughout the course on the use of technology when participating in meetings, and in the university’s laboratory classroom. Faculty consisted of three people who were the main teachers responsible for the courses, and during meetings in the university’s laboratory classroom studies were made by people responsible for the high tech collaboration room. The first survey was sent to all eighteen students in the middle of the project. Thirteen students answered the survey. It consisted of 21 questions regarding CTs in the project course. Most questions were multiple choice, but there were also open-ended questions. The first reflection was a compulsory written exercise answered by all students in the course. The task was to reflect on the positive and negative aspects of the different communication technologies used in the project. The last reflection was also a written compulsory reflection sent to all students in the course, and it contained general questions regarding the work and learning in the project as well as some specific questions regarding their use of CTs.

Data was thematically analyzed [21] and reviewed, organized and read through to identify themes. At this stage a mind map was used, and data was then reviewed again to iteratively refine the themes and to categorize the findings in a data analysis software program. Finally the different themes were exported from the software tool in order to get an overview. This overview constitutes the basis for the written text presented in this article in the following section. When writing the quotations from the different data sources, language errors have been corrected in order to make them easier to read.

V. THE STUDENT’S DESCRIPTION OF COLLABORATIVE TECHNOLOGIES USED

The following is a description of how the students reported CTs in their project, categorized by the different technologies that were identified. In some cases, short descriptions of the technologies are provided, based on information from www.wikipedia.com.

Adobe Connect is software used to create information and general presentations, online training materials, web conferencing, learning modules, and user desktop sharing. It was used in the very beginning of the project and most students described that they used it once or twice during the project. The students’ ranking of the value of Adobe Connect was 2.46 on a scale from 1 to 5, and due to technical problems it was soon replaced by Skype during meetings: “We started out trying to use Adobe Connect for communication, but after a while we moved over to mainly using Skype”. It seems that the features in Adobe Connect were not appreciated by the students, and problems with sound and video made them abandon it. Moreover, the students found that it was easier to communicate with a technology that they were already using, such as Skype, and that the possibility to use Skype with their cell phones made a difference.

Email was frequently used in the project, and most students used it on a daily basis. However, compared to previous instances of the course, the use was less frequent, and much communication was directed through Skype instead. It was ranked as very useful in the survey (4.08 out of 5), and gave rise to comments such as “E-mail is the best way to spread information because everybody check their mail everyday” and “best way to get hold of people”. Some students stated that other means of communication such as Skype had been preferred and that email had also been an option when other ways of communicating failed. It is also interesting to note that many students did not answer emails, even though they frequently read them. This might be due to the students being “flooded with irrelevant information and therefore [didn’t] pay attention to broadcasted emails”.

Github is a web-based hosting service for software development projects that uses a revision control system while *LaTeX* is a document markup language and document preparation system. They were both used when writing up the final report, and many students described them as easy to use and without any problems. However, a few students not experienced in using Github and LaTeX stated that they were “tedious to learn” and at the same time as writing the report. Others stated that LaTeX can be “tricky” to use, but that the design of the report became very nice and professional. The technical matters when making LaTeX and Github work together on all computers were time consuming and frustrating. It is noticeable that the expectations on the usability of LaTeX was quite different the other forms of CTs mentioned, and that “this is to be expected if someone has not used it before”. Several of the students perceived Github and LaTeX as more similar to programming languages, and explain this difference in usability requirements as a consequence of this.

Google Docs is a web-based office suite and data storage service. It allows users to create and edit documents online

while collaborating in real-time with other users. It was used in the project to collaboratively write reports and for making presentations. Many of the students have used Google Docs extensively: "Google Docs is a well used tool in my small team. We have used it for drafts of what we gather now doing research. We also did write conclusions of what we found in a shared document. It is really good and you can get a direct look at each others work as they progress".

Microsoft Word was mentioned by very few students, but was presented as a "very simple tool" that fulfilled the basic needs during the course.

Phone. Some students reported that calling people when asking for interview times was one good way of getting a contact, which could then be followed up by emailing the person regarding questions etc. Most students did not use phone calls in the collaboration as their use was too expensive compared to Skype, for example. However, despite the description that phones were not very much used, faculty observed that most students used their smart phones for communication on a regular basis. This discrepancy might be due to the fact that many students had traditional models of phone usage in mind when answering questions about their use. One student reflection reveals this usage of phones in the project: "I often used my phone to check my mail and login on Skype to see messages and calls. I even had a Skype conference call from my phone once. ". Moreover, the example of phone use illustrates quite well that there are several grey zones to consider when talking about CTs, e.g. has the phone evolved into essentially being in the same category as a computer. We could perhaps choose to talk about voice calls instead of phone use, but what would then be the difference with using Skype for a voice call?

Skype is a service that allows users to communicate with peers by voice, video, and instant messaging over the Internet. The students described that they used Skype daily or several times a day in the project and its usefulness was rated very good with an average of 4.31 (out of 5) in the mid-term survey about collaboration. Skype was used in the project for chat conversations between two or several students as well as voice and video call. The reflections about Skype described a simple and useful tool that was easy to use, and with which the students think that they have had very few problems. For example, in this quote: "No problem, works great for team meetings". However, many students point to the fact that they would have appreciated the group video functionality in the project and that this would have improved communication.

There were several "permanent discussion groups in Skype", i.e. group chats where group members add a constant flow of comments from different areas, both personal and professional. These "permanent discussion groups" occurred within the whole project group with faculty as members, in subgroups, and within the writing team and the presentation team. Many of the conversations in these groups were informal, such as a virtual coffee room, and students posted items from YouTube or links to both unrelated and related websites. One feature of Skype mentioned several times in the reflections on communication was the delivery of messages

even when the recipient is off-line. This was perceived to have a positive impact on communication.

Some of the students reported that one advantage with Skype is that they used it in their day to day work. Moreover, it was seen as an advantage that you could chat in Skype at any time without risking disturbance to anyone: "We are able to communicate any time, any place and free of charge".

An example of a reflection regarding the use of CTs in the project, and how it affected the discussion was the following: "One interesting drawback of using Skype is that it is harder to discuss freely. A good [Skype] meeting is usually one where someone takes charge and decides who should speak when, but this means that opinions and thoughts that would've been shared if the meeting was on location in the project room might get missed. Having frequent Skype meetings means that you are less likely to meet the people you're working with in person so in that sense the technology actually separates us when the spatial distance is small (but connects us when the distance is big, as it is with the Americans)"

Another interesting reflection about using this technology for meetings is that many students did things other than participating in the meetings during the time allocated. This was perceived by many as very disrespectful, and some students reported that they explicitly asked people to stop typing during meetings, or to turn off their microphones when not talking.

SMS is a form of text messaging communication on phones and mobile phones. Very few students used SMS in the international collaboration on either side of the Atlantic. A small group of students in Sweden used it quite regularly, however. This is quite surprising since generally many students regularly use SMS quite extensively. It is interesting to note, in this context, that the "Group SMS" feature was used extensively for communication when the first year IT engineering students did a small collaboration project studying their seniors working in the IT in Society course.

TeamLabs is an open-source platform for project management and business collaboration. TeamLabs was chosen by the students themselves as a collaborative platform, and one student described the choice in this way: "They have a quite flashy introduction video, and I think that that is what caught everyone's interest". The vast majority of the students had never used a project management tool before, and they reported that it initially took some considerable time to understand what they were supposed to use it for. The reflections also reveal that the use of TeamLabs as a collaborative tool varied: "The members of the project have adopted the use of TeamLabs to different degrees, which result in a lack of communication"

Most students used TeamLabs about once a week, and they rated it as functional (an average of 3.31 out of 5). All students reported the time they had put in the project on TeamLabs, and they also kept track of the different milestones that the students had decided to have in a calendar with TeamLabs. Some students miss functionality in TeamLabs, such as the possibility to do Gantt diagrams. However, others described

that TeamLabs also contained features never used in the project such as chats and forums.

The team leaders and the project leaders reported that they have used TeamLabs to keep track of time in their group, and to get information about and set new milestones in the project. From the reflections it seems that team leaders and project managers appreciated TeamLabs to a very large extent, which is also verified by reflections from team members: "I see it more of a tool for the team leaders and project leaders to help manage their team and track progress of the project"

Some also described TeamLabs as difficult to use and stated "it isn't exactly clear where you need to go in order to do certain things. There are too many different tabs that you can navigate". This was also illustrated in the quote: "getting to some features is just flat up confusing".

It is also noteworthy that many students described their use of TeamLabs as a way of showing others what they have done, and not for finding information written by their peers. "I used it mainly to add documents for the full group to see", "Very few members read all documents that are uploaded to teamlabs". The reflections regarding TeamLabs reveal that many of the students thought their use of TeamLabs was not particularly valuable, as there was "too much information in TeamLabs and it is difficult to find information you need quickly". Others noted that, after having uploaded the material found or written to TeamLabs, it was forgotten, and not used in the project: "I'm under the impression that information uploaded into teamlabs is distanced from the project members, and then forgotten". Another student reflected on the same problem, and stated that a simpler file sharing tool such as Dropbox would have changed the use of the documents. "Dropbox could have been used instead of TeamLabs to maintain a document archive. My personal belief is that this would have rendered a higher relationship on all documents created within the project /.../ This way all documents would have been available closer to the actual usage situation"

It is noticeable that many of the students thought that TeamLabs could have been replaced by the use of Dropbox as a common document library. This reveals that most functionality provided by TeamLabs were not appreciated, and that the document storage was the most useful functionality. "I see the point of having the whole project located on a single site, but personally I'd rather just used a shared dropbox".

ULL, the university's laboratory classroom, is described earlier in this paper. Most students really appreciated ULL, and when valuing the usefulness of the classroom in the collaboration the average was 3.82 on a scale from 1 to 5. Faculty also noted that the general feeling from using ULL had a positive impact in terms of increasing motivation and commitment to the course. The first reactions when entering the classroom was one of amazement at the high-level of technical equipment. Use of the classroom significantly enhanced student motivation as well as other affective reactions to the course, and there was considerable appreciation for the opportunity to use the state-of-the art facilities. However, from a purely technical perspective the classroom's impact on their use of CTs was limited. ULL's staff assisted in setting up some of the Adobe Connect and Skype meetings,

providing cameras and speakerphones. On one occasion, students used an interactive whiteboard when presenting their work to other students in the hall. However, the technologies most frequently used in the project were not connected to ULL, and one student describes their use of the classroom in the following way: "We haven't really used it as much as we should". However, the students' comments regarding the classroom are very positive as for example: "Great for collaboration" and "With the technology available in the learning lab it has been great for project meetings and as well as for the presentations".

VI. DISCUSSION AND CONCLUSIONS

One conclusion from the study is that students use numerous examples of CTs in their collaboration and that, during the semester, their choice of particular technology depended on their previous experience of its use, and the activities that needed to be done. Many used several CTs in parallel and multitasked in order to collaborate. Another interesting result was that student perception of usefulness depended on factors such as the possibility of using the CTs on a smart phone. In this respect, a CT without an app-technology was perceived as less practical. In addition, being forced to log on to a web page before being able to use a technology affected the perceived usability in a negative way. Indeed, many students simply did not log into those systems that used this method of access. Choice of CT was also much colored by the possibility of combining synchronous and asynchronous communication, such as the choice of Skype chat in comparison with similar technology.

Very few students appreciated that CTs were complex, multifaceted with many different features. Adobe Connect was replaced with Skype for meetings, even though former had more extensive functionality than the latter. In one of the teams, Teamlabs was abandoned for Dropbox, and most students reported that they would recommend the use of Dropbox in future projects despite the fact that Teamlabs had more features specifically designed for collaborative projects. Most students in the study preferred to put together a package of CTs which suited their needs for the project, and which had the lowest possible accessibility threshold, as described thus: "Use simple tools for the collaboration" and "KISS. Keep It Simple Silly". Despite many students' view of TeamLabs as something they would not recommend, faculty nevertheless strongly believe that a tool that enhances the awareness of other students' work and give a context to one's own work is necessary for a good collaboration. This is in accordance with much research on computer supported collaborative work, (e.g. [22])

Surprising results revealed that email was much less frequently used than expected and had been replaced by asynchronous use of Skype chats. A further interesting finding is that the students chose not to use online social networking technologies in their collaboration. The forums available at TeamLabs were all silent, and the students did not use Facebook, blogs or Twitter for the project. Other researchers have noted that students are increasingly inclined to use social networking sites such as Facebook, Xanga and MySpace. Active engagement in these websites to establish virtual

relationships provides individuals with access to a diversified set of information from multiple sources [23]. Nevertheless, these technologies were not chosen by the students despite the fact that many of the students met new friends, and are planning to continue social interaction in the future. Selg's [13] discussion concerning the differentiating between professional and private use of CTs may be relevant here.

One cause of irritation in virtual group conferences was that many participants were unaccustomed to using shared microphones/speakerphones. This might be a contributing factor behind the counter-intuitive but recurring observation made by ULL staff that open discussions and exchange of ideas using Skype or Adobe Connect seem to work better if the participants take part from computers in their own homes. Participation from one's own computer tends to favor a more open climate, and allows for additional communication by way of chat. An alternative to Skype and Adobe Connect is the professional video conference, which allows for video and audio of a quite superior quality, and where students gathered together to participate works smoother - but at a price.

It is interesting to look at the use of scaffolding with regard to use of CTs and student collaborative projects. From the discussion of Digital natives or Homo zappiens, it is evident that the basic view and underlying assumptions of faculty in relation to effective use of CTs might be mistaken. Faculty's use of CTs is not the same as the student's use, and consequently, scaffolding in this area is something that needs to be done with care, with more attention to the general principles of communication than to specific technology. Wiggberg [24] elaborates in his thesis that students often experience something quite different from what the staff expects in project courses, and this might also be the case with the use of CTs.

Another interesting results from the study is the reported usefulness of LaTeX despite the fact that most students spent considerable time trying to integrate its operation with Github. This can be contrasted with the perceived lack of utility of Adobe Connect that was abandoned when problems occurred in two meetings. It would appear that LaTeX and Adobe Connect are seen by students as two different kinds of CTs and that they apply different criteria for utility to each. Perhaps one reason for LaTeX perceived usefulness is that most students believed that mastering LaTeX is a competence which is relevant for their future careers. Faculty also felt that discussion about LaTeX in relation to MS Word or similar programs, was, for many students, akin to a political discussion with many layers of values affecting what was being said.

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