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Student Reflections on Collaborative Technology in a Globally Distributed Student Project

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Abstract— **Collaborative Technology (CT) plays an important role in overcoming the challenges of globally distributed projects. It enables collaboration, but the specific choice of technology also imposes constraints on how projects are conducted. Over the past decade, we have engaged in an action research programme to develop an Open-Ended Group Project situated in an educational framework in which international collaboration, including interaction with a real world client, is an essential component. This paper investigates the manner in which students reflected on their patterns of CT use within the collaborative setting. In general, these reflections were found to be superficial and descriptive, exhibiting a reductive view of CT as a set of technological features, which acted as a neutral medium for communication and participation. One consequence of this was a lack of awareness of the ways in which the technology influenced the behaviour of individual students or the collaborative nature of the group. We explore some potential causes for this and reflect on some difficulties faced by the students. These have important pedagogical implications for courses in which the learning objectives include the development of suitable competencies for working in a global collaborative environment.**

Keywords-reflections; collaborative technology; open-ended group projects; global collaboration; scaffolding.

I. INTRODUCTION

The aim of this paper is to investigate the ways in which students use collaborative technology (CT) in the context of a globally distributed group project. By CT, we mean those electronic technologies that are designed to enhance communication and cooperation over long distances. We seek to address the problem of whether the use of CT, which is essential given the geographically separated context, affects metacognitive behaviour, such as the ability of students to reflect on their own patterns of use.

Information technology now pervades most social, academic and professional environments and its availability is taken for granted across much of the world. Advances in technology facilitate communication in almost all areas of life and allow geographically separated individuals to work together across multiple time zones. From an educational perspective, this has led to a requirement for students from a wide range of disciplines, but especially those associated with science and engineering, to be proficient in CT and be able to apply this technology to enhance collaboration in teams that often work on globally distributed projects.

The experience gained by working on projects such as these can be seen as part of the relatively broad concept of digital literacy which is now central to almost every graduate position in which university students find employment, and is crucial for effective use of CT for international collaboration. It is, therefore, an essential learning objective that students become capable of examining, criticizing and evaluating the potential benefits and consequences of CTs. Conversely, ascertaining the views and reactions of students to this technology is an important input for staff engaged in the creation of effective learning environments.

The experience gained by working on projects such as these can be seen as part of the relatively broad concept of digital literacy which is now central to almost every graduate position in which university students find employment, and is an absolute necessity for effective use of ICT for international collaboration. It is, therefore, an essential learning objective that students become capable of examining, criticizing and evaluating the potential benefits and consequences of ICTs. Conversely, ascertaining the views and reactions of students to ICT is an important input for staff engaged in the creation of effective learning environments.

One such environment, which seeks to enhance a range of professional competencies, including digital literacy and team-working skills, 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. This 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 healthcare domain on behalf of an external client. Close and genuine collaboration is essential for the success of this project and use of CT is a necessary component in achieving this due to the geographical distance between the two cohorts. On one level, this view is well appreciated by the students. One of them depicts the importance of CT thus:

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

However, it is interesting to look more closely and ask about the perceptions students have concerning the type of group interaction that result from the adoption and use of collaborative technologies. One issue is the way in which CT, while enabling long-distance communication, still requires, for effective use, adherence to certain social protocols. For example, in order for a team to be successful, participants need to develop positive dispositions about issues such as trust, and this means finding some way of establishing mutual knowledge

in a distributed setting. These types of issues are subtler than mere appreciation of technological benefits, but are potentially more important for the successful outcome of group projects.

Methods of global communication have undoubtedly become both more sophisticated and easier to use since the collaboration first started in 2005. While there is an ongoing need to maintain and upgrade technology, this process provides new opportunities to study the way in which students interact with different tools. One of these changes occurred during the 2011 instance when Swedish students were given access to a high tech communication room. This provided data on a variety of issues concerning the adoption of specific collaborative technologies. These have been reported elsewhere [3] but one result has been a greater understanding of the multifaceted ways in which students perceive communications technology as a collaborative tool.

Data collection for this study used two assessment exercises, the first focussing on student perceptions of cultural difference and the second on their use of technology. These were submitted by the students in the course of their academic work and were supplemented by a voluntary survey regarding the use of collaborative technologies. While the first set of assignments on culture showed a significant depth of reflection, the second set about technology use showed a remarkable lack of reflective content, quite puzzling given the high level of technical proficiency displayed by the students.

The organisation of the paper is as follows. We first present the local setting to provide the reader with an understanding of the context of the study. This is followed by a general theoretical framework relevant for a discussion of the unexpectedly low level of student reflection on the value of CTs. We propose possible reasons to explain this lack of deep reflection and comment on some of the observed difficulties faced by students conducting group projects in this kind of distributed environment. Finally, we suggest possible ways in which this problem may be overcome.

II. BACKGROUND

A. The Student Collaboration

The context for this study is a collaboration between students at Uppsala University, Sweden, taking the IT in Society course and students at Rose-Hulman Institute of Technology, USA, taking the Computing in a Global Society course, where the two cohorts are almost 7000 km and six time zones apart. The educational setting, as well as different operational aspects of the project, have been described elsewhere [2, 4, 5, 6, 7, 8], but a summary is given here to provide the reader with a short review.

The main aim of the exercise is to develop those professional competencies that are essential for working in a global, collaborative environment. The underlying pedagogical approach is based on the concept of an Open-Ended Group Project (OEGP) which is designed to address the type of activities where a central concern is to balance the complexity of the problem with the multiplicity of possible approaches to its solution. An important aspect of the educational setting is that the project is placed in a real environment with a real client. This provides an authentic level of complexity that can be shown to increase student motivation [9].

One issue raised by interaction with real clients is that they have other obligations and consequently it can be difficult to gain reasonable access to them. This particular aspect has been mitigated by use of a single, reliable client and requiring all students to work on different aspects of a single project. From an OEGP perspective, this solution has the added benefit that it adds to the complexity of the task leading to increased "open-endedness". A further potential issue with a real client is that some students may feel ethically unable to help certain clients, e.g. for political, religious, or competition reasons. Because of this, we have chosen to work with the public health sector, i.e. the Uppsala County Council and the associated academic hospital, which was perceived very positively by participants.

Another factor, relevant to this paper, is the high level of freedom given to students to decide upon the specific communications technology that suited their task. While there were some constraints imposed by staff, e.g. some form of collaboration platform should be used and that there should be weekly synchronous meetings that should preferably include video, the choice of CT and how it was used was chosen by the students. This aspect has varied over the years and for this cohort, the team leaders also required the members to keep track of the time they spent on the project.

The students participating in the course in 2011 were all male, aged between 20 and 37. The American cohort varied between the ages of 20 and 22 years, and all but one member of the Swedish cohort was in the 21 to 24 year range. The majority of students had their major in computer science or information technology, but some students were pursuing other technical majors (e.g. mechanical engineering). This year there were ten Swedish students and eight American students. Most students had studied for three or four years at the university.

B. Critical Thinking and the Role of Reflection

An important part of the educational setting is the use of assignments where the students are asked to reflect on a relevant issue. There are both practical and pedagogical reasons for this approach. An example of the former was to alleviate an observed tendency to blame slow progress or failure on others, especially those members of the group from the other institution. We wanted to help the students see their own part in any problematic situation by analysing their role and reflecting on what they themselves actually did to contribute to progress. From a pedagogical perspective, the development of those professional competencies described in the course learning objectives is closely linked to metacognitive ability. As pointed out by Fincher, Petre, and Clark [10], "*Reflection on experience underpins the process of successful learning and is essential to the success of education.*" Using reflection as an educational tool is also supported by ideas presented by Schön [11], where he characterises effectiveness in professional work as the product of an ongoing process of reflective practice which involves self monitoring, continual improvement and action cycles (plan, act, observe, reflect).

The modern emphasis on critical thinking can be traced to Dewey's focus on reflective thinking [12]. His characterization

of these thought processes as active, persistent and carefully considered, has formed the foundation of many later attempts to distinguish critical thinking from other modes of cognition, and laid the basis for investigation of the mechanisms by which they are promoted. Moreover, the development of a specific competence in critical thinking has come to be seen as one of the primary goals of higher education [13] and, indeed, one that has been increasingly promoted on social and economic grounds [14, 15]. Unfortunately, it is also reported, e.g. [16] that the development of these competencies by students is not a guaranteed outcome of tertiary education and this has led to the inclusion of thinking skills as a specified graduate attribute in many university programmes.

Over the past two decades, there have been significant attempts to classify the factors that lead to good critical thinking. A report by the American Philosophical Association [17] suggested that the subject could be conceptualized in two dimensions by the requisite cognitive (and metacognitive) skills, and the affective dispositions that allow the appropriate skills to be used. The precise specification of the cognitive abilities themselves, including the definition of terms, often varies depending on the details of the research study but it includes capacities for interpretation, analysis, evaluation, inference, explanation and self-regulation. These abilities are often translated into a cluster of competencies concerning the identification and analysis of pertinent issues and assumptions in an argument, recognition of important relationships, the ability to make correct inferences and deduce conclusions from information or data, and to interpret whether conclusions are warranted on the basis of data [16]. Proficiency in the use of a critical thinking skill and the disposition to exercise it are clearly interdependent and, as a result, developing an aptitude in this area depends upon affective factors. Descriptions of critical thinking dispositions mirror those found more generally when investigating positive attitudes to learning, e.g. Claxton's 'four Rs': resilience, resourcefulness, reflectiveness and reciprocity [18]. Importantly, the disposition of reflectiveness finds counterparts in a cluster of concepts around metacognition, self-regulation, self-direction, and self-efficacy [19], which are exhibited at the highest levels of critical thinking.

Barnett [14] extended this conceptual base to connect elements of cognition, metacognition and praxis in the notion of 'critical being'. *"Critical persons are more than just critical thinkers. They are able critically to engage with the world and with themselves as well as with knowledge."* The goal of the learner, therefore, becomes not only to analyse and evaluate information, but also to develop powers of critical self-reflection, which then allows the individual to take appropriate action. Here again, the process of reflection, specifically in the form of reflective practice, such as that described by Schön, acts as a fundamental link between the acquisition of critical thinking competencies and the metacognitive goal of learning self-regulation. Assessment of reflection on performance of assigned tasks then provides student and faculty with one possible mechanism for monitoring the development of competence in critical thinking, and for the self-regulation of engagement in subsequent learning activities.

Barnett also highlighted the need to consider the collaborative nature of skill development in shared activities, and in the type of learning that occurs within a community of practitioners. This analysis connects with the work of Vygotsky, his theory of the Zone of Proximal Development [20], the processes by which social interactions fundamentally shape and transform the way a learner acquires and assimilates knowledge, and so to the concept of scaffolding [21] by which a teacher or peer provides interactional support for learning. As a form of scaffolding for the development of critical thinking skills, reflective activity allows knowledge to be externalized by expressing concepts either verbally or in written form. While this kind of articulation is crucial to the organization of a student's knowledge, according to Vygotsky, the act of choosing words to represent thoughts also allows the further consideration and deliberation on the ideas being expressed. Written expression of a student's reflective comments should therefore promote critical thinking by providing students with an opportunity to articulate and refine their conceptual understanding of the learning process. As Flower [22] put it: '*writers do not simply express thought but transform it in certain complex but describable ways for the benefit of a reader'*.

Various forms of reflective activity have been used in the course over the years. While a final summative reflection followed by an individual meeting with the academic supervisor has always played a part of the assessment process, short written reflections and a varied number of individual meetings were also used. These reflections provide the staff with specific information and ideas for the development of the learning environment. In addition, they generate insights into how the educational setting functions to develop and enhance the desired professional competencies. In the 2011 instance, there were three such assignments.

III. METHOD

The data collection in this study is based on the results of two written assignments and a survey. The first assignment focused on student perceptions of cultural differences within the group, while the second sought reflections on the positive and negative aspects of different forms of collaborative technology use. This material was submitted by the students as part of their academic work. The survey concerning the use of CT was done half way through the course, shortly after the second assignment.

In both assignments, assessment was accomplished using a categorization framework based on the work of Hatton and Smith [23]. This scheme classifies writing according to the depth of reflective analysis, from an initial stage of non-reflective "descriptive writing", through basic "descriptive reflection" to the more sophisticated "dialogic reflection" and, at the deepest level, "critical reflection". This last stage is demonstrated by the elaboration of reasons for personal learning decisions that take into account a mature understanding of the psychological and pedagogical factors affecting the learning process. As such, it requires a high degree of metacognitive proficiency. The levels in this framework can be related to other classification schemes for reflective writing such as that of Moon [24], as well as those

which attempt explicitly to measure progression in critical thinking, such as that of Greenlaw and DeLoach [25].

Identification of reflective markers in student writing is often problematic and normalisation of the assessment criteria across the different supervising faculty was needed to provide a fair assessment of the assignments. This was achieved by detailed discussion, which correlated the different views on evidence identifying the different levels in the Hatton-Smith framework.

IV. Results and Discussion

The first assignment, on student perceptions of issues concerning cultural differences between group members, resulted in submissions that showed a significant depth of reflection (level 3: dialogic, and level 4: critical reflection, in the Hatton-Smith framework). This differed sharply from performance on the second assignment. In this case, students were provided with a description of the Hatton-Smith framework and were explicitly asked to write reflective accounts of their CT use that specifically addressed the factors characterising higher level reflection. The results from this second exercise demonstrated a much lower level of reflective content (Hatton-Smith levels 1 and 2), with hardly any submitted work attaining the third level. This poor level of reflection in the second student assignment was somewhat unexpected given the good performance in the first assessment.

The high level of technical proficiency displayed by the students throughout the project also suggested initially that the second assignment would prove less problematic. The students were, in general, quick to grasp the possibilities and limitations of each collaborative tool they encountered, and classified them in terms of stability, user-friendliness, and their perceived potential to further the ends of the project. Critically however, it was rare for a student to show an explicit awareness of how the various tools, and the communicative contexts that they supplied, influenced the project process itself. One student observed that the "*quality of communication is mainly evident in the fact the situation does not seem personal so you do not feel connected with anyone else*", which caused "*a lack of responsibility to the team*". Yet, the same student also claimed that the communication tools "*allowed the group to work well together*", and helped to "*build a better understanding of each person as a colleague and a friend*". This seeming contradiction may mirror a gap between the general, team level, whose formal meetings sometimes suffered from a combination of poor communication and insufficient organization, and the level of work groups, whose members seem to have communicated informally and more efficiently about their more narrow areas of responsibility. A higher degree of reflection on the interrelationship between communication structures and project requirement might, if acted upon, have improved team building, to the benefit of the project.

A. Potential Causes of the Low Level of Reflection

A number of possible reasons for the observed results can be proposed. One suggestion is that information technology has become an almost invisible tool [26, 27, 28], and consequently it is possible that the cohort was so accustomed to ubiquitous access to communication media that they saw all difficulties in long-range communication as essentially technical problems.

According to Selg [29], the Web 2.0 culture is characterized by two-way communication patterns, where users are both consumers and producers of digital content. Blogs, on-line communities, and file sharing are typical forms of activities. This contrasts with a Web 1.0 culture where CT is used for such activities as information searching, ordering products, and, predominantly, using e-mail for communication. While email is used in both cultures, instant messaging and the use of SMS as an almost synchronous communication mode are characteristic of the Web 2.0 culture where they seen as complementing each other. Furthermore, this form of technological proficiency can be seen an example of the generally high level of competence in the use of CT in that culture. This proficiency also manifests itself as an understanding of the benefits of information technology, such as the value of a large network of "weak ties" in community building, and the need for strategies for handling technology misuse. Much of what Selg reports about the behaviour that differentiates between the cultures is related to how the Web 2.0 users are able to make distinctions between personal life and professional/public life in their use of technology.

It is also possible that the low level of reflection is a consequence of how the assignment was formulated. The rubric for submission, stated that students should "*[r]eflect on the positive and negative aspects of the use of [the] different communication technologies in [the] project. What are they good for? What are their drawbacks?*". This led predominantly to descriptive reflections, even though students were asked to address those causal and correlative factors which characterise reflection at the upper levels. It is possible that students misconstrued the assignment as being directed to efficacy of the software tools and therefore interpreted this task as a request for an appraisal of the (software) products rather than the processes involved. This may have given rise to a submission based on commentary about products, rather than reflection on communication as a process itself. The former requires comparatively lower-level cognitive skills such as categorization, querying evidence, assessing claims and stating results, whereas reflection on the process itself would need the higher-level, evaluative, cognitive skills as well as access to the metacognitive skills necessary for the higher levels of the Hatton-Smith framework.

B. Establishing Mutual Knowledge in Distributed Collaboration

Central to the effectiveness of geographically distributed collaboration is the concept of "mutual knowledge" or "common ground", as described by Cramton [30]. This type of shared understanding can be established in a number of ways. Individuals can interact directly, in which case the knowledge is grounded in their shared first-hand experience. Alternatively, individuals can interact indirectly, e.g. through a proxy or through some experience both share with a third party [31]. Finally, mutual knowledge can be based on category membership, i.e. assumptions about the knowledge someone possesses by virtue of the job they do or the role they play [32].

Establishing such mutual knowledge in a distributed collaboration in which only the last two elements are available is not an easy task. There are difficulties in conveying nuances of meaning when compared to face-to-face communication [33] and these are exacerbated by the fact that communication using information technology is slower [34]. Cramton identifies a number of problems that contribute to the difficulties in establishing mutual knowledge, such as the failure to communicate and retain contextual information, unevenly information distribution within a message, a need to understand and communicate the salience of information, differences in speed of access to information, and difficulty interpreting the meaning of silence.

The problem with mutual knowledge in distributed collaborations is compounded when collaborators are themselves unaware of the difficulties associated with this particular issue. In the study, most of the problems with establishing mutual knowledge were clearly influenced by the characteristics of the CT used, e.g. having a low capacity for providing back-channel feedback was likely to lead to misunderstandings. In this regard, the low level of reflection about CT is worrying since it may indicate a naivety concerning the impact that technology has on the ability of students to engage in establishing this mutual knowledge. There were, however, some glimpses of insight, such as this quote related to an occasion when the students were forced to use the text-only mode of Skype:

"*... I realized something important after we had ended. I noticed that, despite not insignificant cultural and language differences, we still communicate using a large percentage of nonverbal cues. I did not realize just how much we can convey with spoken conversation even across a cultural barrier.*"

It is interesting, however, that the student who made this remark omitted to pursue this point further by speculating about differences with regard to other forms of CT, e.g. video, or to face-to-face meetings.

C. *Types of Collaborative Technology used in the Project*

Clearly, technology plays a crucial role in supporting communication in globally distributed projects, and an increasing collection of collaborative tools is available. These range from ubiquitous email facilities, through wikis, blogs, text chat systems, version control systems, video-conferencing systems (from desktop applications such as Skype to dedicated rooms and services), cloud-based file sharing such as Dropbox, and virtual learning environments (which often themselves incorporate a range of these features). Personalized social networking services such as Facebook, Youtube, and Twitter also complement the more group-focused collaborative technologies. However, this abundance of choice does not necessarily contribute to effective communication in the context of a globally distributed team. There are significant challenges and, as the authors of [35] and [36] note, it is necessary to establish common ground with respect to "collaboration readiness" and "technology readiness" in order to use them successfully [3].

This may go some way to explain why students did not make extensive use social software in the collaboration. Social networking was not used for academic purposes despite the students clearly belonged to the digitally native culture. The forums, available as part of the TeamLabs technology, remained silent, and students did not use Facebook, blogs or Twitter for the project, despite other researchers having noted an increasing use of social networking websites for academic work. It is known that active engagement in these sites can help to establish virtual relationships and provide individuals with access to a diversified set of information from multiple sources [37]. We believe that a higher level of reflection on their use of collaborative technology would have led to investigation of the capabilities of social media in order to find alternative communication mechanisms, especially since they were already very familiar with such tools.

V. CONCLUSION

The ability to evaluate the use of technology-based environments that enable communication and collaboration in globally distributed student projects is, as mentioned in the introduction, an important skill for students to learn. Reflections were chosen to help students attain this learning objective and to develop their digital literacy. However, the reflections provided by students were quite shallow, merely describing the collaborative technologies used.

This raises an important issue, namely, under what circumstances can this type of reflective exercise be used to promote the development and exemplification of critical thinking skills. As critical reflection is itself a high-level metacognitive skill associated with learning self-regulation, its exercise requires a mature engagement with a wide range of purely cognitive skills. If a student does not have the opportunity, or disposition, to exemplify enough of these, there will not be sufficient cognitive content to allow substantive metacognitive activity to take place. It would appear that reflective activities, such as those described, act as good support for critical thinking provided the person doing them has the opportunity to illustrate a significant number of the requisite cognitive skills within the reflective process itself, especially those higher level evaluative skills.

In the case of this study, despite a clear statement that the objective for the assignment was high-level reflection, most students interpreted the task in terms of superficial description of the context and operation of the software. The result was a focus on the products that mediate communication rather than processes that enable it. Given that students find the experience of this kind of reflective activity both unfamiliar and difficult, it is, perhaps, not unexpected that they would attempt to reduce the task to simpler descriptive modes of expression. However, this does not explain why they managed to do much better in the first assignment. It also highlights the need for care in articulating the learning objectives of assignments, and providing suitable scaffolding to enable engagement.

From a pedagogical perspective, activities that scaffold engagement in reflection, and so promote the development of critical thinking skills, could be based around opportunities for students to recognise cognitive conflict between contrasting or distinct sets of data (e.g. assumed conditions and reality, student and staff perspectives). Such scaffolding should

promote the dialectical aspects of critical thinking such as clarifying meaning, challenging ideas and conjecturing alternatives, and may be contrasted with activities that primarily serve to expand the number of ideas under consideration, with the consequent need for further preliminary categorisation and classification, before more advanced critique can take place.

In conclusion, results from the study indicate that these students found it more difficult to reflect on their use of CT than, for example, on intercultural communication or the personal development of other professional competencies. Most students seemed unaware of the impact such technology has on their communication and collaboration, and they appear to view CT as, for example, gender neutral, and a tool that can be used and modified according to their needs. This simplistic view has most likely influenced the collaboration in a negative way, e.g. by leading to difficulties in establishing mutual knowledge. The results of our study indicate that there may be a need for more scaffolding related to reflective writing and further work to investigate if this will impact on their use of CT is underway.

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