A Comparative Analysis of Two Globally Distributed Group Projects:

A Perspective from CSCW/CSCL Research

Roger McDermott
School of Computing Science and Digital Media
Robert Gordon University,
Aberdeen, UK
roger.mcdermott@rgu.ac.uk

Mats Daniels
Department of Information Technology
Uppsala University
Uppsala, Sweden
mats.daniels@it.uu.se

Åsa Cajander
Department of Information Technology
Uppsala University
Uppsala, Sweden
asa.cajander@it.uu.se

Julian Bass
School of Computing Science and Digital Media
Robert Gordon University,
Aberdeen, UK
j.m.bass@rgu.ac.uk

JayPrakash Lalchandani
International Institute for Information Technology,
Bangalore, India
jtl@iiitb.ac.in

***Abstract*—Globally distributed group projects are becoming an attractive and increasingly common feature in computer science education. They provide opportunities for students to engage in activities that enhance both their technical skills and wider professional competencies with concomitant benefits for graduate employability. There have been some previous attempts to investigate these projects in terms of theories of technology use and collaborative learning, and this paper continues this process by examining globally distributed group projects from the perspective of salient issues in the fields of computer-supported cooperative work (CSCW) and computer-supported collaborative learning (CSCL). After detailing CSCW models that discuss the dimensions that characterise interaction and technology use in groups, we examine aspects of group learning from the perspective of theories of CSCL. Issues of cooperation versus collaboration, motivation for learning and models of group cognition are discussed in the context of two specific group projects. Analysis of these examples allows us to characterise behaviour within groups and provide insights that can facilitate the formation and effective development of project teams. This has important educational implications for the success of these distributed group projects.**

Keywords—computer supported cooperative work; computer supported collaborative learning; globally distributed group projects; global software development education

I. Introduction

Collaborative group projects now have a well-established role in undergraduate Computer Science and Information Systems courses where they are used as the main educational setting for students to learn important professional competencies [1, 2, 3]. Over the last decade, prompted partly by rapid globalisation in the computing profession, there have been attempts to integrate this kind of collaborative learning experience with opportunities for students to participate in authentic team working activities in geographically distributed settings. The technical and professional competencies developed in this type of learning environment have taken on greater importance as CS and IT education has responded to changing business practices within the industry. For example, the use of distributed software development models has now become the norm, while the implementation of large-scale information system projects often requires collaboration across considerable geographical distance and across conventional disciplinary boundaries [4]. Consideration of such factors has led to a recognition that student employability is significantly enhanced by participation in these type of distributed group projects, and as a consequence, there has been growing interest both in their operational aspects and in the particular learning activities around which they are built.

From an educational perspective, these projects present a fascinating environment in which to observe the interaction of students as they respond to a variety of novel and challenging situations. These may range from coping with intercultural differences in project management practices [5] to making decisions about the appropriation and subsequent use of collaborative technologies [6]. While specific projects throw up a variety of different problems, there are, nevertheless, common features which arise from the nature of the activity itself. The geographically-distributed nature of the project necessarily requires the use of some form of collaborative technology; the desire to provide students with an authentic experience of professional practice means that effective work processes are needed; the fact that these group projects are part of a university programme promotes an emphasis on collaborative learning. While some work has been done investigating specific challenges to collaboration in these projects, there have been relatively few attempts to situate such learning environments within the broader educational framework provided by related research areas which also focus on collaborative work and group learning mediated by technology. Two such disciplines are Computer-Supported Cooperative Work (CSCW) [7] and Computer-Supported Collaborative Learning (CSCL) [8]. Both areas overlap with the practice of globally distributed group projects, although in different ways and with different emphases, and both can provide important insights into their design and successful implementation. In this paper, we investigate some of the issues that have arisen over a number of years in the operation of two different globally distributed group projects. The first is an established setting based on a collaborative information systems project, while the second is more recent and centres on a global software development task. We give a brief overview of the different projects as well as an account of relevant CSCW and CSCL research. We compare elements of each course unit from these perspectives and make suggestions for future iterations of the projects.

II. Background

In this section, we provide a brief description of some of the main issues in the fields of Computer-Supported Cooperative Work and Computer-Supported Collaborative Learning that are relevant to our subsequent examination of international group projects. It is not our intention here in this paper to give a comprehensive account of either research field but rather to draw attention to those areas which we consider to be of use in the subsequent analysis.

A. Why CSCW/CSCL?

A major goal of higher education is to help students bridge the gap between theory and practice and perhaps, more importantly, between the types of convergent, highly structured learning exercises of the classroom and the reality of open-ended and less structured activities that they find in the workplace as graduate professionals. To do this, universities need to offer students opportunities to develop the competencies that professionals exhibit, which for those in the computing disciplines, include the ability to participate effectively in a globalised working environment, often using a range of information technology to assist productivity and facilitate collaboration.

For the university sector, this will involve the active search for, and purposeful cultivation of, pedagogical activities that foster the knowledge, skills and attitudes necessary for collaborative group working with colleagues at a local level, as well as in teams whose members may be separated by large geographical distances. To do this effectively inevitably involves the use of information technology. Early studies of technology assistance in education was based on individual learning. This has changed over the last 10-15 years as the importance of the social dimension to learning has been realised. In recent years, ICT in education has focussed on the way in which technology can facilitate such interaction.

Globally distributed group projects are a relatively recent phenomenon relying as they do on the use of information and communications technologies which have only become widespread in educational settings within the last twenty years. Whether in the context of an IT design and implementation group or a software engineering team, the geographical and temporal separation between individual team members brings a reliance on technology that impinges on the achievement of project goals in a much more critical way than with a collocated development team. The precise nature of the course aims and learning objectives of such projects will clearly depend on the specific context of the programme of studies in which each is situated. However, it is possible, even if only from a historical perspective, to draw some conclusions about what the underlying educational benefits of such activities are deemed to be. Firstly, they are set up to provide an environment in which students can attempt to gain an experience of work which has a higher degree of authenticity compared to more conventional classroom exercises. The authentic nature of these projects is often generated through the use of some kind of work-based learning pedagogy [9]. There is an emphasis on experiential learning [10] through mechanisms such as open-ended, problem-based and negotiated learning [11] and on the observation of, and reflection on, that experience [12] using reciprocal peer learning.

A number of observations can be made about this process. Firstly, the group projects' use of a work-based learning approach has a focus on both learning and on work (where by "work" we mean the technical, professional and social competences that are needed in graduate employment). Secondly, there is an irreducible cooperative or collaborative aspect to the learning. While there may be some variation on the cooperation/collaboration axis held by individual instances of a globally distributed group project, both the academic learning objectives and the development of work-based competencies are contextualised in terms of a collective approach rather than individual one. Together with strong reliance on a ICT infrastructure, this gives a characterisation of these projects in which information technology plays a critical role in support of team-based working and group learning. These are precisely the areas which CSCW and CSCL study and some researchers [13] have suggested that this overlap area of collaborative work-based learning will provide a key focus for such research in the future.

III. Computer-Supported Cooperative Work

The growth in importance of globally distributed teams in major industries such as software engineering means that a large body of academic work has been developed investigating various issues and practices that lead to operational success. One component of this is a good understanding of the technological support structures that underpin communication across distance, and the way in which these structures facilitate collaborative work between individuals within teams. The field of Computer-Supported Cooperative Work (CSCW) [14, 15], is an attempt to systematise this research area and encompasses both the systems that are used to collaborate ("groupware") and the social component that such collaboration entails. Over the last thirty years, it has developed into a mature research field which has given rise to important insights into the successful practice of globally distributed teams.

A. Factors Affecting Interaction: Matrix Models

One aspect of the research that has become widely known is its attempts to classify the independent components of interaction that are relevant to cooperative work. The most well developed of these is the so-called Space-Time diagram, usually just called the "CSCW Matrix", devised by Johansen [16, 17] which became the de facto standard taxonomy with which to analyse tools and technology [18, 19, 20].

The work attempts to characterise cooperative systems according to time and spatial relationships. A cooperative or collaborative interaction is construed as having a time component which states when the interaction takes place, either synchronous or asynchronous, while its spatial component takes a locational classification, namely colocated or distributed. This therefore admits a fourfold decomposition with time and place axes which gives a matrix structure to the classification of technologies used in the interaction (see tab 1).

	Synchronous (same time)	**Asynchronous (different time)**
Co-located (same place)	Face-to-face meetings Live/IRL Classroom teaching	Shiftwork Shared representation, bulletin boards Shared workspaces, project walls
Distributed/ dispersed/remote (different place)	Parallel teaching, Dispersed collaborative teams Breakout rooms	Individual self-study Email Discussion forums, Wikis, blogs Content Management Systems

Table 1. The basic CSCW Matrix (Johansen, [16]; this version adapted from: Jørno et al, [21])

It is worth noting that, while ostensibly classifying interaction, the matrix is more commonly used to classify the temporal and spatial affordances of the technologies that enable this interaction.

While providing useful information in some cases, the overriding focus on the time and space characteristics of technologies may not give us useful information about the way in which those technologies actually contribute to the interaction, especially to elements of learning which may well be the primary concern. For example, as pointed out by Jørno, a telephone and a video chat both overcome geographical constraints and provide synchronous communication, but grouping these technologies together does not really provide an insight into their different learning affordances.

Other classifications have been proposed (see Cruz et al, [22] for an extensive review). An interesting development is categorisation based on a technology's mode of use rather than its properties. For example, Jørno et al [21] describe a "codification/articulation" matrix which uses a horizontal axis (codification) based the control mechanism that is used to achieve the maximum level of coordination among cooperating parties. This differentiates between central and decentralised control where centralised control is usually established through some form of leadership perspective while decentralised control is a more local and autonomous feature. An independent vertical axis is formed from a focus on the mechanism used to gain and exhibit proficiency. The axis differentiates between standardised articulation in which there are verifiable criteria for gauging success and attentive articulation in which evaluation is performed on a case-by-case basis, e.g. through some kind of mentorship or apprenticeship method.

B. Multidimensional Models of Interaction

The array structure of both the Space-Time CSCW matrix and the Codification-Articulation matrix arises from the abstraction of two orthogonal components from an analysis of the main features of a cooperative interaction. There are however, multidimensional models (where the number of dimensions, N, is greater than 2) that try to capture a broader conceptualisation and so extend the number of components considerably. One recent example of this is the Model of Coordinated Action proposed by Lee and Paine [23] which uses a seven dimensional framework of factors affecting interaction (see Table 2). The first two dimensions, "S*ynchronicity*" and "*Physical Distribution*", are essentially the time and location components of Johansen's space-time matrix and are characterised by degrees of synchronicity and proximity respectively. The third is "*Scale*", which is the number of participants involved, while the fourth is termed the "*Number of Communities of Practice*". Here, Lee and Paine use a slightly unorthodox terminology and have extended Wenger's original concept [24]. They put the idea of communities of practice to use as a measure of diversity, referring to the number of culturally distinct subgroups within the cooperative interaction. The concept of culture is taken to operate in both the macrocultural and microcultural sense, e.g. including subgroups based on ethnicity, as well as others based, for example, on the "work culture" found in different academic disciplines, or on shared personal histories or practices. Culturally homogeneous teams would be one end of this spectrum while the other would be extremely heterogeneous teams which would occur where the coordinated action of the group was greatly influenced by the expectations, norms, and practices of the individuals. The fifth dimension is "*Nascence*": this attempts to encapsulate the degree to which the work of the group is static or changing and emerging over time, and denotes a spectrum of activities between routine tasks and those that are new to the group members or developing over time. The sixth dimension, "*Planned Permanence*", tracks the intended permanence of the group itself, i.e. whether there is an expectation that the collaborative action will be short-term or long-term. The last component is "*Turnover*" and refers to the relative stability of the participant makeup. It measures the rapidity with which participants enter and leave the group. This is different from both the Planned Permanence component, which is a characteristic of the group itself, and Nascence component which is a property of the production process for the collaborative artefact produced by the group.

Dimension	**Continuum**
Synchronicity	asynchronous ⟷ synchronous
Physical Distribution	same location ⟷ different location
Scale (number of participants)	2 ⟷ N
Number of Communities of Practice	0 ⟷ N
Nascence	routine ⟷ developing
Planned Permanence	short-term ⟷ long-term
Turnover	low ⟷ high

Table 2. Model of Coordinated Action (Lee & Paine, [23]).

The basic CSCW matrix has proved useful for describing the relationship between the affordances of technology and the process of cooperation but from a classification perspective, it is hampered by a reliance on just two components based on physical constraints. For our purposes, a more complex, multidimensional model, such as the coordinated action model proposed by Lee and Paine, which acknowledges the influence on interaction of factors other than synchronicity and proximity, would potentially provide a richer taxonomic framework to describe features of globally distributed group projects. It should be noted that we are not claiming that there is a unique attribution for each component for the group activity as a whole. Instead, each technology used to facilitate interaction will be represented on the synchronicity and location dimensions (in the same way that it is represented in one cell of the Space-Time matrix). The remaining dimensions would then provide a representation of the collaborative components.

The models and theories of cooperative and collaborative professional practice that underlie the field of CSCW produce valuable insights into the use of technology and its effect on group interactions. However, given the educational context of globally distributed group projects, it is natural to look to enhance these descriptions of cooperative activity with others which make specific reference the effects on learning. While CSCW does address some of these issues, especially in the context of organisational efficiency and workplace learning, it is a fact that the main focus is on the the design and use of technologies that affect groups, teams and networks. If, instead, we require a greater emphasis on the educational components of group work, we can turn to the related field of computer-supported collaborative learning.

IV. Computer Supported Collaborative Learning

The subject matter for CSCL is how collaborative learning supported by technology can enhance the interaction of peers working in groups, and how collaborative technologies facilitate sharing and distributing of knowledge and expertise among community members. [25]. As with CSCW, we focus on a small number of issues with direct bearing on the globally distributed group projects rather than giving a general review of the background work.

A. Cooperation versus Collaboration

The first issue that should be addressed is the distinction made between cooperative and collaborative activities. According to Dillenbourg [26], "*in cooperation, partners split the work, solve sub-tasks individually and then assemble the partial results into the final output*". By contrast, a collaboration is "*a coordinated, synchronous activity that is the result of a continued attempt to construct and maintain a shared conception of a problem*", [27]. In collaborative situations, learning is a social process and individuals engage in group activities such as negotiation and sharing. These member interactions are themselves mediated by information and communications technology. This shift from cooperation, which can be performed as an individual activity prior to incorporation into a communal endeavour, to collaboration, which is fundamentally directed towards shared action is significant, and represents a important departure in a CSCL theory of learning. It also allows us to use it as a major classificatory tool for describing student activity in group projects.

B. The Issue of Motivation for Learning

A second issue suggested by approaches from CSCL is the origin of motivation for the collaborative work itself, i.e. what makes the learners feel they need to contribute to the work of the group. In their review of cooperative work and achievement, Slavin et al [28] identified four major theoretical perspectives on the achievement effects of collaborative work. The first two of these share a common emphasis on the importance of motivation as the key element in determining the success of a learning activity although they differ in ascribing to a source which is intrinsic or extrinsic to the group itself. The last two are more easily described in terms of cognitive development.

The underlying presupposition of the first viewpoint, sometimes called the *Motivational* perspective, is that it is the individual's desire to accomplish a task that is the single most important factor in accounting for group success. Group members are required to cooperate in order to further their own personal interests and consequently, when developing groups, there is an emphasis on building reward structures which promote alignment between the self-interest of the individual members and the stated aims and objectives of the group itself. Creating such cooperative incentive structures means that the only way group members can attain their own personal goals is if all the members of the group are successful. One interesting feature of this perspective is that individuals do not have to explicitly collaborate with other group members in order for the group to function effectively. It is the group members' behaviours in response to group oriented tasks that elicits praise or approbation based on the interpersonal reward structure that has been set up. The interdependence of group and personal goals is considered sufficient to induce students to act in ways that are conducive to group success. This type of individual motivation may lend itself more to cooperative ventures rather than full-blown collaboration (which may be a difficult goal to achieve in a globally distributed setting).

In contrast to the motivational perspective, which emphasises optimisation of cooperative performance as an extrinsic result of aligning group aims with that of individuals, the *Social Cohesion* perspective suggests that the effectiveness of individual participation in a group is mainly dependent on its level of social cohesiveness. Individuals contribute to group objectives insofar as they are drawn into its social structure and start to become intellectually and emotionally invested in the group. Instead of motivation arising from extrinsic factors such as external incentives and individual accountability, it is generated intrinsically as individuals come to see their own self-identity and goals, and that of their colleagues, as being bound up with that of the group. Again, this perspective has important implications for group formation and suggests that activities such as team-building that promote this sense of mutual interdependence are an important part of the group development.

While these two perspectives stress motivation (in either its intrinsic or extrinsic form) as the main explanatory factor for success in group learning, there are two others that can broadly be termed cognitive perspectives as they focus on the cognitive processes that occur when collaborative work takes place. The first of these was termed the *Developmental* perspective by Slavin and draws on the theories of developmental psychologists such as Piaget and Vygotsky to explain why interaction among team members would enhance learning. Both the Piagetian theory of learning through assimilation, accommodation and, finally, equilibriation, and Vygotsky's theory of the zone of proximal development, involve an understanding of learning enhancement through interaction with peers. In the case of Piaget, interaction with other members of the group can provide occasions for disequilibrium, the basic prerequisite state for learning to occur, through cognitive conflict with previously learnt schemata. Vygotsky's theory also suggests that learning initially occurs through a social interaction which then leads to a process of individual internalization and understanding. In both cases, group-based learning activities allow peers to provide feedback to individuals which encourages them to go beyond misconceptions (whether through a Piagetian or Vygotskian mechanism) and proceed to a more stable understanding of phenomena. In this context, group work provides an environment for members to gain an experience of peer communication which can enhance social learning skills such as participation, argumentation, verification and criticism [29].

The fourth perspective is that of *Cognitive Elaboration* [30]. In a similar way to the developmental perspective, this approach holds that, for learning to take place, new information has to be connected with related material held as prior knowledge. However, the most important driver for learning is considered to be the fact that collaborative interaction requires learners to explain their ideas and clarify potential misconceptions to other group members. This process of elaboration allows students to improve their understanding of relevant issues within the group and also serves to provide opportunities in which they can observe, and give and receive critical feedback from peers on learning strategies that are in use.

The point of discussing these four approaches to understanding motivating factors which lead individuals to contribute to the group is because they have implications for how project groups are created, how the learning activities are devised, how communications channels are set up and how the interaction among members are maintained.

C. Models of Collaborative Knowledge Building

A third element from CSCL research that we feel has an important bearing on the educational success of distributed group projects is its emphasis on group learning as a qualitatively different phenomenon compared to learning in individuals.

A key fetaure of collaborative learning is the process of knowldege building. Within the group, there will be elements of knowledge creation in multiple contexts. This is nicely illustrated in a diagram by Stahl [31] (Fig. 1.) which attempts to visualise the interdependent relationships between individual cognition and the process of "meaning-making" in small groups and again in the wider social context.

Much of the cyclic nature of knowldege creation is familiar to observers of how individuals learn in group projects. At the level of the individual, prior knowledge and beliefs, which are often tacit and held in a pre-articulated form, undergo some form of disequilibriation process when subject to the kind of experiences thrown up by group involvement. Some of this is dealt with at the individual level while some of it feeds into a new knowldege creation cycle involving rational discourse, argumentation, critical interaction with other members of the group as they go about their task. The key features here for the collaborative process are the articulation of the shared problem, discussion of different solution strategies, clarification of alternative viewpoints and the formation of a negotiated perspective with the other members of the team as a part of the production of whatever artefact the group task required.

Moving to a wider societal arena, the solution of the task then invites participation in a larger social context through the development of shared cultural perspectives such as professional competencies and institutional practices.

This view of different layers of value and meaning creation contributing to the goals of the group is a powerful one. While it may seem at first sight to be somewhat divorced from the practicalities of group activities, it nevertheless provides an underlying framework for understanding the many aspects of learning that emerge in these activities.

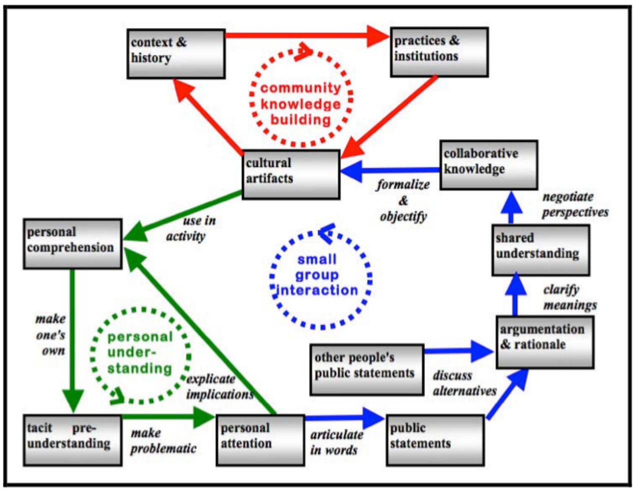

Fig 1. A Model of Collaborative Knowledge Building (Stahl, [31]; adapted from Stahl, [32], Ch. 9)

V. Two Examples of Distributed Group Projects

The objective of this paper is to use those aspects of the theories presented in the previous section to establish a framework for describing globaly distributed student projects and appropriately characterising the salient features of the collaborative learning environments. We will do this in two cases. The first of these is the well-established "IT in Society" course unit which has been developed by Daniels and his collaborators at Uppsala University, Sweden, in conjunction with Rose-Hulman University, USA. The second is a newer collaborative course unit undertaken by computing science students at Robert Gordon University (RGU), Aberdeen, UK and their counterparts in the Indian Institute for Information Technology at Bangalore (IIITB), India. While the focus and content of the group project is different (the Uppsala /Rose-Hulman is an IT project whereas that involving RGU/IIITB students is a software engineering project), there are similarities in the approaches taken and with some of the difficulties which the newer collaboration has faced.

A. *The Uppsala/Rose-Hulman Collaboration*

The “IT in Society” course at Uppsala University was designed to meet demands from industry regarding improved communication competence among graduating engineers. This included the ability to work in heterogeneous groups and to communicate in an appropriate and effective manner, both orally and textually. The course has had a focus on competencies from the very start, and had its starting point in the Open-Ended Group Project (OEGP) framework [35]. The focus on competencies is therefore explicit in the course and learning goals related to their development are found in the course description.

An element of international collaboration was introduced to the course in 2005 with a partner course unit called “IT in a Global Society”, which was developed at Rose-Hulman Institute of Technology. The collaboration between these universities has been running for ten years, and has developed through the use of action research oriented series of changes [33]. Some examples of these are the introduction of personal learning contracts [2], written individual reflections [1] and speed dating exercises based on the constructive controversy theory [34]. The course has developed iteratively with a series of action research cycles each year as the teachers on both sides of the Atlantic are researchers in the area of computer science education. The course unit itself consists of an IT project and work-based learning activities that are related to understanding technological solutions in context and from a holistic perspective. Students are given a specific task, asked to investigate the background problem area, analyse and evaluate possible options and to suggest a solution. Design and implementation of software itself are not typically part of the project, even though some prototypes have been built to illustrate the proposed solution.

The projects themselves are grounded in real-world applications and, since 2004, the client has been Uppsala County Council. Typically the client requires the students to address a problem in some area relevant for their current practice, such as eHealth. One example of this was an investigation into unauthorised use of medical records prompted by the Swedish Data Inspection Board which had demanded improvements to processes related to illegal intrusion. As a result of this, the students were given the task of investigating the problems of access control, looking at possible solutions inspired by other organisations, and suggesting improvements. Another example of a project in this area was an investigation into issues of “interoperability of eHealth” processes when integrating medical systems.

The class is introduced with a two hour lecture explaining the set-up of the course, where the learning outcomes are presented together with an explanation of the Open Ended Group Project’s framework and the international collaboration. Most students have never worked in a project of this kind, and often have many questions regarding the requirements, tasks and set-up. During the initial lecture, the students are given documentation explaining the framework of the course, and the project requirements, e.g. that all groups must have weekly meetings with faculty, that meeting must take place when all international students can participate (which is difficult due to time differences) and that weekly meetings with the whole project and with the client are required. The open ended course setting requires the use of scaffolding for the students in order to work well. For example, two sets of individual meetings take place with all students regarding the nature of the learning contract that they write. The IT in Society course has not run without problems, but has now reached a mature state where changes made are minor and related to circumstances, context and the students or faculty participating in the course.

B. *The RGU-IIITB Collaboration*

The RGU-IIITB collaboration is a globally distributed software engineering group project in which a development task is shared between students in Scotland and India. The project itself has now completed four main action research cycles. The first was an initial pilot, in which a small number of students from RGU undertook a software development task in collaboration with a similar number from IIITB. This was done as an extra-curricular voluntary activity associated with a software engineering module. The second iteration involved six student volunteers from each institution and the task that they were asked to complete was credit-bearing. Assessment of the module involved examination of both the technical capabilities of the participants as well as their project management skills. The latter were assessed using a reflective journal which included entries made at critical points throughout the project. These journal entries were then reviewed, coded and analysed [35]. In addition to these, students were asked to complete an open-ended survey questionnaire which was used to elicit feedback from students on both the technical and project management challenges faced by participants. The third iteration involved a scaling up of the numbers in both institutions with an entire class of about twenty students from RGU and the same number from IIITB. The groups comprised an equal number of students from each institution. Training on agile software development methods was provided to group members. The academic supervisors acted as product owners for the project using the scrum agile method. The product owners provided a prioritized list of the softwares functional requirements. However, the academic supervisors did not project manage the teams, as such. The fourth and latest iteration is ongoing at the time of writing but has reverted to a smaller number of participants mainly due to logistical difficulties associated with technology failure in the previous iteration.

The groups were responsible for establishing a project manager role, which was rotated through different group members during the project. Each of the groups had online meetings. Further, the decisions taken in such meetings were documented through meeting minutes. Each group was asked to produce the requirements and design documents, implemented software, testing results, and a project report. Interactions during group meetings were scheduled through timetabled class time as this simplified the process of arranging real-time conversations between group members. Groups were also encouraged to arrange additional meetings outside class.

Each of the teams was required to build a software application consisting of an online survey environment involving mobile phone client software for asking questions which was then collated into a server for storing survey results in a database. The quality of the final software deliverable was assessed and, together with an assessment of project management aspects of the activity, contributed to the final module grade.

VI. Discussion

The basic classification scheme that we adopt is constructed from the features of CSCW and CSCL research that were elaborated in sections III and IV. The first element of this is a description of the potential for group activity in terms of the independent components that characterise the interactions. We choose to use a multidimensional continuum model (N > 2) rather than a a matrix structure since the descriptive power of such a model outweighs the reduction in complexity that arises when restricting constraints to, say time and space factors. We therefore use the seven dimensional Model of Coordinated Action of Lee and Paine to describe the parameters that affect interaction and, by extension, the technologies that facilitate this interaction.

The second element of description is a determination of whether the activities of the group are cooperative or collaborative. This can be ascertained through identification of the mode of working of the individuals within the group. However, it should be noted that, for student projects with a remit to provide a positive educational experience (as opposed to, say, professional software engineering teams, where other commercial factors may be at play) it is proximity relations (together with the reliability of communications technology) that determine the extent of collaboration among the group members. This may mean, for example, that in situations where half the group members are collocated in one place and the rest collocated in another, genuine collaboration occurs only within each collocated subgroup. However, technological difficulties and the need for a positive attainment of learning goals in the course unit may mean that each collocated subgroup has its own specific learning objectives which can be fulfilled independently from those of the other subgroup. This would then tend to reduce the relationship between the two subgroups to one of simple cooperation.

A third characteristic of the interaction among the students is the motivation for learning. Intrinsic or extrinsic motivational factors, or developmental or elaborative cognitive factors may drive the learning and it is probable that this aspect is determined at the level of the psychology of the individual group member. For example, it is highly likely that some students will mainly be motivated by extrinsic factors while other will place more emphasis on a sense of belonging. Moreover, there will be a relationship between these motivational drivers and the cognitive factors described previously. Nevertheless, an understanding of the general disposition of group members in this area will enable the academic in charge to incorporate elements of appropriate scaffolding into the initial group exercises. Group goals could be clearly stated and and shown to be aligned with individual learning objectives, or team-building exercises used to develop a sense of group identity. From a cognitive perspective, exercises which challenge hidden or unarticulated views might be appropriate as would some kind of peer interaction to promote elaboration.

Finally, while not part of the classification scheme per se, it is interesting to look at the knowledge creation cycles for both individuals and the group, as well as the way in which completion of the group task relates to wider issues of professional competence and employability.

If we turn to the Uppsala/Rose-Hulman group project, we see that the relative maturity of project infrastructure allowed for some degree of regular synchronous communication, although asynchronous methods were used as well due to time-zone differences.The physical distribution dimension for students in Sweden and the USA was clearly distributed but this was mitigated by a collocation event at the start of the project when the american students visited Uppsala for a week to meet their Swedish counterparts. The number of people in the teams varied from year to year. The number of communities of practice, that is the measure of diversity within the project group was somewhat skewed since while the American contingent was relatively homogeneous from year to year, the subgroup from Sweden was often made up of a variety of nationalities as well as native Swedes. The task chosen each year was different and unfamiliar to the students comprising the project group. In terms of group structure, it was relatively short–term, lasting one semester but the students were expected to remain within the allocated subgroup.

The fact that there was an initial face-to-face meeting between members of the Swedish class and those of the American class meant that the potential to set up relationships which bound individuals to the group was much greater than if this had not occurred. Genuine collaboration was certainly possible while the subgroups were collocated and this may have continued after separation due to the availability of synchronous communications channels. Moreover, the greater potential for self-identification with group goals also meant that motivation intrinsic to the group was possible.

Examining the RGU/IIITB group project, we find that although there was some use of synchronous technology, the difficulties with logistics, specifically with the network infrastructure at both RGU and IIITB, meant that there was a much greater reliance on asynchronous technologies after the initial contact stage. The split between the two collocated subgroups in each development team also impacted on the technology used. The number of participants within each team varied with each iteration of the course and the make up of both the software development group and the collocated subgroups was culturally diverse leading to high scores on the number of communities of practice scale. The activity itself was unfamiliar to almost all students and the groups were clearly set up to be relatively short-lived, being dependent on the length of the module itself (twelve weeks). Finally, once the groups were set up, it was not anticipated that the membership would change and where this was not the case, the reason was because of lack of student engagement.

The two distinct locations for the software development subgroups meant that some collaboration took place at the local level but the main interaction between RGU and IIITB students was cooperative. Finally, in terms of motivation for learning, there was little opportunity to build up personal relationships between members of the distributed teams and so the course relied on extrinsic factors such as compliance with university assessment regulations to align group and individual learning objectives and so encourage engagement in the project processes.

VII. Conclusion

We have discussed in some detail a range of issues arising from CSCW and CSCL research which have an impact on our understanding of globally distributed group projects within a higher educational setting. These have been used to analyse the learning activities and use of collaborative technologies undertaken by group members and lead to a preliminary classification scheme for different aspects of the group project. The scheme was then applied to two examples of group project to see what insights could be gleaned from framing a discussion of their effectiveness in these terms.

We conclude by noting that, given the rapid spread of globalisation that has occurred in the world-wide Computing industry coupled with the advent of reasonably cheap and accessible communication technology, it is highly likely that universities will look with greater urgency to activities such as distributed group projects as a way of enhancing graduate employability in Science and Engineering industries such as Computing. Elaborating the nature and scope of those parameters that characterise the successful outcome of these projects will be extremely important as a step towards understanding the problem and so being able to control the learning environments using the technical infrastructure and appropriate pedagogies. We anticipate that this characterisation problem is one that will preoccupy academics in the future and this paper is a preliminary attempt to develop a framework in which this can be done..

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