# HOW IS COGNITION DISTRIBUTED ACROSS A GROUP OF STUDENTS COLLABORATING ON A LEARNING TASK IN A TECHNOLOGICALLY ENABLED CLASSROOM IN A JAPANESE UNIVERSITY?

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**DECLARATION**

**This thesis is my own work and no part of it has been submitted for a degree at this, or any other, university.**

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## ABSTRACT

This study investigates a classroom learning activity where students collaborate using technology in a university in Japan. This dissertation adopts an interpretivist perspective using the notions of extended and distributed cognition to study the flow and organisation of information in a classroom. The main source of data comes from repeated classroom observations of 24 group activities, twelve group interviews with students and three individual interviews with teachers in a liberal arts college.

The first major outcome of this study is the conceptual mapping of a cognitive system of the classroom, which identifies and illustrates the processes of memory, distribution and information processing. The second outcome is the discovery of how students and teachers use artefact, interaction and cultural tools to leverage their cognitive processes to enhance their cognitive activity, particularly in the processes of memory, distribution and information processing. Other outcomes include the nature of collaboration at five levels of class, group, individual, sub-group and sub sub-group that engender learning interactions and interaction with cognitive artefacts. Another outcome revealed how cognition is distributed via nine distributional media where technological artefacts are leveraged for information on demand and at the same time. At the same time, these outcomes have implications for the development of theory, practice, policy and future research

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## LIST OF ABBREVIATIONS

| | |
|---|---|
| A | Artefact |
| Ac/ac | Acquire |
| App/app | Apply |
| BERA | British Educational Research Association |
| Cl/cl | Class |
| D | Distribution |
| EFL | English as a foreign language |
| E-wg$_n$ | Emergent interaction within group |
| E-og$_n$ | Emergent interaction with someone outside the group |
| G/Gp | Group |
| HCI | Human and computer interaction |
| HT | High-tech (High technology) |
| I/In | Individual |
| IT | Information technology |
| LT | Low-tech (Low technology) |
| LTM | Long term memory |
| M | Memory |
| MEXT | Ministry of Education, Culture, Sports, Science and Technology, Japan |
| OECD | Organisation for Economic Co-operation and Development |
| P1/2 | Phase one/ two |
| PDA | Personal digital assistant |
| PED | Portable electronic dictionary |
| S | Student |
| SG/Sg | Sub-group |
| SRQ | Specific research question |
| SSG/Ssg | Sub sub-group |
| STM | Short term memory |
| T | Teacher |
| TOEIC | Test of English for International Communication |
| WM | Working memory |
| ZPD | Zone of proximal development |

# CHAPTER ONE

# STATEMENT OF THE PROBLEM

## Introduction

Group learning activities using technology in classrooms are gaining popularity among teachers across the world due to the perceived benefits of collaborative learning and promises of advanced technology. Students working together in a group using technology are a common sight in today's classrooms. However, do we really understand how these groups work and learn? How do members in such groups receive, share and transfer information and ideas in order to complete a learning task in a classroom? What are the technological devices that store, transform and distribute information? Here lies the problem of how information flows in such settings. We have yet to sufficiently understand how these processes work and yet teachers proliferate collaborative activities in the classrooms. The purpose of this study is to understand how cognition is distributed, shared and represented in a collaborative task in a classroom. The study focuses on group activities with emphasis on the use of technology among learners in a Japanese University, where the researcher was employed as a lecturer.

The aim is to understand how students share information in groups while using artefacts in a technologically-enabled classroom. In such an environment, students have access to what is afforded in the classroom; the technological devices that students bring into classroom and those provided by the school. These devices are computers, electronic dictionaries, mobile phones and digital audio-visual equipment. This sharing of information can be understood with the notion of distribution of cognition (Hutchins, 1995a). The interest, therefore, lies in studying how students distribute cognition while collaborating on a task.

## 1.1 Background

In today's burgeoning world of information and connectivity, collaboration has become an essential activity in both the workplace and education. Very few tasks can be done without collaborating with others and even seemingly individual tasks require some form of collaboration with someone or something. With "over twenty years of educational research that has consistently demonstrated that collaboration helped students to learn" (Sawyer, 2006, p. 187), many teachers are moving away from the didactic form of teaching. These benefits include increased academic abilities such as critical thinking skills, higher content recall due to active learning; psychological changes such as higher self esteem, more positive attitude towards learning and teachers; and social abilities such as better leadership, teamwork and networking skills (Panitz, 1999).  Collaborative learning research in colleges and universities has also been increasing (Barkley, Cross, & Major, 2005). Schools, in adopting the collaborative approach and other forms of group work, are beginning to seriously study the effects and nature of collaboration (Bruffee, 1999). Research on learning in small groups, in fact, eclipses all other instructional methods for the last twenty years (Johnson, Johnson, & Smith, 1991).

At the same time, the lure of information technology's (IT) infinite possibilities for communication and its inevitable introduction into the classrooms has encouraged the use and research of IT in schools. In today's campuses, IT tools have become so essential that "without which we cannot function" (Cohon & Smith, 2005, p. 3), making technology-enhanced learning an integral part of teaching and learning. To date, the use of computers in education has resulted in mixed reports of its effectiveness. Some have reported lower class performance (Fried, 2008; Hembrooke & Gay, 2003) where students were found to be distracted by the computers in class (Young, 2006). Most educationists agree that technology is only useful to students' learning when used strategically under careful pedagogical considerations (Fried, 2008). There were however positive learning results in some cases (Poirier & Feldman, 2004), particularly when computers were used with the constructivist approach in classrooms (Wurst, Smarkola, & Gaffney, 2008). Some showed that laptops can facilitate teacher and student interactions and in-class participation, increasing engagement and active learning (Stephens, 2005). Collaboration and constructivism are considered to be important educational philosophies for effective use of electronic devices (Patten, Sánchez, & Tangney, 2006). In spite of the mixed reviews on effectiveness in the use of computers, technology continues to be integral to modern classrooms (Weaver & Nilson, 2005).

As technology advances with new and more communication and information devices, learners are finding added ways to receive, store, send, and distribute information. Snapshots of current collaborative learning activities see a learner accessing a personal digital assistant while listening to the teacher talking in the background, and another student surfs the internet looking for more information. Simon (2005) noted how easily students were able to collaborate and that technology itself was enabling them to do so. He argues that this new phenomenon of using multiple technologies simultaneously presents a new paradigm (Simon, 2005, p. 10) for classroom learning. Indeed, this new and different nature of collaborative learning with technology calls for a model to understand the emerging dynamics involved (O'Donnell, 2006). Faced with this reality, this research seeks to understand the nature of such a learning environment.

## 1.2 The research problem

With this new and emerging paradigm of classroom learning, we know relatively little about the dynamics of collaboration, the interaction and sharing of information by students in the group. Being vastly different from the past (Weaver & Nilson, 2005), new technologies in the classrooms invariably affect and change the way students learn (Beetham & Sharpe, 2007; Naismith, Lonsdale, Vavoula, & Sharples, 2005) and communicate. While Simon (2005) feels that there is no longer a debate about the benefits of technology in schools; the issue is how to use it more constructively. With increased use of technology comes increased collaboration with technological artefacts in today's classrooms. The problem with studying collaborative learning activities is that it is complex and hence many empirical studies have avoided the phenomenon (Hatch & Gardner, 1993). It is not just the sole interaction between computer and user, but the multiple interactions with other technological devices as well as human agents and documents (and artefacts). Additionally, the interaction between computer and human is often not seen as a singularity, but often interrupted with interactions with a peer or another artefact. The cognitive activity between the human and computer is also influenced by the cultural, historical and emotional aspects of the subject vis-à-vis each artefact, document, peer and electronic device. While most, if not all, research on collaboration involves looking at the interaction between humans or between humans and computers, there is little research considering both.

The social and cultural reorganisation of the society today is shaping the contexts of our education scenes today. How do students today learn in groups with technology? How do they share information with each other under a complex digital environment? This study seeks to address these general questions. Cognition and collaborative learning is taking on new levels of meaning and practice with these ubiquitous electronic devices. There is clearly a need to understand this new phenomenon in order to inform classroom learning and teaching strategies. Because "collaborative learning situation includes a variety of contexts and interactions" (Dillenburg, 1999, p. 12), this study seeks to fill this gap and looks at both the collaborative activity with humans *as well* as the activity with artefacts.

### 1.3 Personal motivation

I used to teach in a private college in Japan which was the site of my research data collection. One of the key features of this college is its emphasis on active learning and critical thinking in its classrooms, as well as the use of English as a medium of instruction. As a result, the classroom activities often consist of group work and a high level of student and teacher interaction. The students are pre-dominantly Japanese with about 1% of students of other nationalities. As an educator and researcher, the different types and levels of interactions that students engage in during class often intrigue me. As such, I find it interesting to study the learning behaviour of students who have a different ethnic background. The Japanese learning culture in classrooms is known to be more mimetic and teacher-oriented (Littlewood, 2007) with learning behaviours such as "submissive" and "passive" (Hess & Azuma, 1991). This runs contrary to the college's more communicative group-orientated style of learning that I am accustomed to.

With group work being widely deployed as a learning strategy in the college and the prevalent use of electronic devices in the classrooms, my curiosity was aroused as to how students use such devices in groups. The multiple interactions between not just peers but with technological devices add to the conundrum on how students manage their learning task. How is the information negotiated, transferred, represented and what is the pattern of distribution? What do the students spend most of their time on? What sub processes do they engage in and how do they use artefacts to learn? Essentially, I am interested in group activity from the perspective of cognition. This study will attempt to delve into the complexities of the nature of collaboration not only between and among students, but also between computers and other technological devices. It will be an attempt to understand how students distribute cognition in such a complex setting.

This study will be useful to inform on the intricacies of the nature of collaboration with technology. There has been little research in this area, especially on Japanese students. Japanese students are known to carry their mobile phones and portable electronic dictionaries (PED) into classrooms (Chen, 2010; Kobayashi, 2008). Japanese students are reliant on their technology gadgets not just in their daily living but also in the classroom. Regarded by some teachers as a divergence from the intentional learning activities (Simon, 2005), such multi-tasking activities make an intriguing learning environment in Japanese universities. This research will therefore attempt to study the complexities of these collaborative activities of a group of Japanese students in a college using multiple technological devices. In particular, how students collaborate *with* many technological effects and how they transfer and receive knowledge *under* such an environment. This research is located within a naturalistic learning environment: a classroom.

### 1.4 Ethnographic case study

The approach is to conduct ethnographic case studies of student groups over a period of time in order to examine their activities in the classroom. Twelve groups of three to four students were observed, making this study a twelve cases group. The case study approach enables an "intensive, holistic description and analysis of a single bounded unit" (Merriam, 1998, p. 193) to understand how students collaborate. It is ethnographic in nature due to the complexities of the socio-cultural factors on how humans think and interact with artefacts, computers and each other. Using the case study approach, the research endeavours to understand the nature of distributed cognition in a classroom: across learners and learning aids in an open and natural environment. Human actions and behaviour in a real life classroom that require the qualitative approach to harness the richness of data for analysis (Marshall & Rossman, 1999) are the main investigation interests of this research. The study is qualitative primarily using observational methods.

Ethnography is a common research method in distributed cognition studies (Hutchins, 1995a). Hutchins' "cognitive ethnography" (p. 371) studies how cognition is distributed in a system in a natural setting. This is an example of contemporary cognitive anthropological methods being used to produce data to advance theoretical knowledge on how the mind operates (Weller & Romney, 1988). Cognitive ethnography studies the socio-cultural influences on the mental representations and processes of cognition, which is the focus of this research.

In the field of cognitive studies, much of the research into distributed cognition has been centred on the fields of anthropology, cognitive psychology, cultural psychology, and sociology (Hutchins, 1995a). However, there has been limited research in education where learning and thinking are the main businesses of schools. Brown et al. (1993) study into classroom practices was one early reported instance of research into a formal learning institution using distributed cognition. Distributed cognition has primarily been analysed in working environments such as airplane cockpits (Hutchins, 1995b), and engineering workplaces (Hollan, Hutchins, & Kirsh, 2000) but little in the area of educational settings. It has also been advocated for collaborative learning activities (Mok, 2006; 2008). Hence there is a need to study distributed cognition in learning environments.

### 1.5 Research questions

The main research question for this study is:

**How is cognition distributed across a group of students collaborating on a learning task in a technologically enabled classroom in a Japanese university?**

The focus of the study is on the distribution of cognition, analysing how information is transferred and represented through and by the students and the artefacts used in the process. In order to understand this main research question, three specific research questions (SRQs) were generated:

**SRQ1. What are the observable cognitive processes and representations in the classroom?** This question looks at the nature and type of processes and how information is shared and received through external representation.

**SRQ2. What artefacts are accessed and how are they used?** This question identifies the range of both technological and non-technological tools used during the group task.

**SRQ3. What are the levels of collaboration and how do they interact?** This question looks at the relationships and activities of the members and artefacts of the cognitive system.

### 1.6 Institutional context

The setting is in a private liberal arts college in Japan with the unique feature of English as the medium of instruction. This college falls within the 76% of all universities in Japan which are private (Ministry of Education, Culture, Sports, Science and Technology, Japan (MEXT), 2004, p. 4). Liberal arts education is popular with 55% of the total university students taking humanities and social science courses in 2003 (p. 6). This college's liberal arts program is modelled after the American liberal arts system where the first two years focused on general courses and students specialise in the final two years. All Japanese students would have finished twelve years of education before entering the college. The instructional medium in English is to provide the students with an experience similar to that of an English-speaking country. This immersion strategy is fast becoming a practice in many non-English speaking countries in schools today (Hu, 2005; Nunan, 2003). In the use of technology in schools, there is a near 100% internet access in all schools in Japan (MEXT, 2004, p. 29) and a high computer student ratio at 3.8 (p. 28) at the secondary level. With 3.8 students per computer at the secondary level, Japan stands at eighth highest among the OECD countries (p. 28). In an IT survey on this college, about 88% of students own at least one computer (Mok, Kang, & Ha, 2008).

The participants were college students where the classes consist of mixed gender and ability with the male and female ratio at 4:6. The teacher and student ratio was around 1:15, which is typical of liberal arts colleges worldwide. The participants are all aged between 18 to 20 years old and they shared a common ethnicity and culture: Japanese. The choice of college and classes were based on easy access, ethical issues and costs (Mertens, 1998).

### 1.7 Researcher positioning

This research employed naturalistic observation methods which offered the researcher not only a holistic view, but an uninvolved participation in recording field notes. Because the researcher was observing another teacher's class, there is a lessening of the halo or bias effect of an involved observer having a student and teacher relationship. In order to offset the problem of obtrusiveness, the researcher was positioned outside the zone of activity, at a corner of the room. Visual familiarity of the students with the observer was achieved by visiting the class one to two times before the actual observation class. Students were told on which days they were being observed.

At each stage of the data collection and analysis, it was important to recognise the researcher's effect: that is, the social political role and the presence of an observer (Denzin & Lincoln, 2000). The researcher was aware of his "insider" status, and his responsibility to report and clarify bias and subjectivity. As an insider who knows much about the college's situation, the researcher had to contend with his own pre-conceptions while enjoying "freer access, stronger rapport and a deeper…frame of shared reference with which to interpret the data" (Mercer, 2007, p. 14). Acknowledging the limitations helps qualify and hedge any results and findings from over generalisations and assumptions. Thus, this data collection design acknowledges the observer's effect on the participants, as well as the interpretive nature of the data collected from the researcher's interaction with the participants. In addition, the researcher acknowledges that he was guided by his own set of values, beliefs and culture in the way the world and the phenomenon is understood (Denzin & Lincoln, 2000).

As a believer in the constructivist approach to learning, I was mindful of my personal preference to a more open, less controlled, and learner centred type of learning environment. And as I enjoyed using technology in my classrooms, my personal theoretical and pedagogical dispositions would affect the way I observed and analysed this case study. Any such bias would be highlighted in the discussion.

### 1.8 Theoretical context

In order to understand how cognition is distributed across a group of students collaborating on the learning task, this study draws from theories of social cognition and collaboration to frame this study. First, cognition is understood as a relationship between the intra- and inter-psychological processes of an individual cognition (Vygotsky, 1981b). Cognition can be seen as distributed in the external behaviour and activity of the members of the environment. As a result, the classroom is seen as the unit of analysis, an extended cognitive system, which teacher, students and documents (and artefacts) are situated (Clancey, 1997, Hutchins, 1995a). Second, in collaboration, the inter-play of the levels of communication, cooperation and coordination (Engeström, 1992) can be seen as the relationships and cognitive processes between members. Third, cultural tools (Wertsch, 1991) used (discourse, electronic devices and artefacts) are considered as falling within the cognitive domain in their role in cognitive development. Last, the historical and cultural aspects (Bruner, 2005) to the members of the unit of analysis are considered as influences in the cognitive activity. Accounting for them will provide for a fuller understanding of a collaborative cognitive activity situated in a context. I will now briefly discuss the theoretical underpinning for each of these propositions.

### 1.8.1 Extended cognition

Vygotsky's (1981b) notion of internalisation- "any higher mental function necessarily goes through an external stage in its development because it is initially a social function" (p. 162), lays the foundation that cognition is extended because of its social origins. Vygotsky's belief that the specific processes of the intra-psychological level can be accounted for from the inter-psychological level that externalises the intra-psychological level (Valsiner & Van der Veer, 2000, p. 379), making cognition observable. Individual cognition is also argued to be socially mediated due to individual thought being shaped by the social context of social relationships, self identities and group associations (Clancey, 1997). Cognition is seen as distributed (Hutchins, 1995a; Salomon, 1993) in the jointly and socially mediated activity (Cole, 1991) where knowledge is “represented”, “retrieved” and “constructed” jointly by the “person plus” (Perkins, 1993, pp. 93-95) and does “off-loading” (Pea, 1993, p. 69) functions. This relationship with others, humans and machines, extends cognition to a larger unit of analysis (Clark & Chalmers, 1998).

In this study, we are interested in the active representation of the cognition in the group activity. This study is asking what and where is information stored and in what form during the activity. This study is also asking about the pattern of distribution of cognition: how information is distributed, transformed and represented. The classroom then, is the unit of analysis consisting of students, teacher, and artefacts in the environment. This study will seek to map the information flow of the cognitive system. So, rather than needing to “go inside” the heads of the students in the classroom, which we cannot, we map the external representations of what is cognitive in the new unit of analysis: the classroom as a whole.

### 1.8.2 Collaboration

Vygotsky’s (1935) zone of proximal development (ZPD) forms the theoretical basis for the understanding of collaboration in this thesis. ZPD involves the “inter-psychological” and “intra-psychological” planes of social interaction which facilitate the development of the mind (pp. 378-9). The manner in which the individual and social activity interacts with the internal cognition are the representations of cognition, seen in the joint activity of "coordination, cooperation and communication" (Engeström, 1992, p. 64) among the students. This interplay of the coordinating (organising), cooperation (sharing), and communication (discourse) of knowledge can be observed and analysed. Leont'ev's activity theory (1978) sees Vygotsky's action producing "tools" (1981a, p. 137) as representing mental processes of the individuals that mediate the learning activity. Such tools (language, documents, etc.) serve as the communication that facilitates collaboration. The tools mediate the cognitive activity at both the individual level as well as at the group level. Through verbal or written discourse, knowledge (and cognition) is co-constructed and can be observed. In this research, "collaborative learning" is understood as a "situation in which particular forms of interaction among people are expected to occur, which would trigger learning mechanisms" (Dillenburg, 1999, p. 5).

### 1.8.3 Affordances and Artefacts

This research's unit of analysis is located and situated in a physical context. The size, type and location of the physical environment constrain, as well as afford the cognition to be distributed. The properties of the learning environment permit "allowable actions" (Zhang & Patel, 2006, p. 336) of cognitive activity. Affordances are the functions that can be carried out (afforded) by the properties in the environment (Gibson, 1977) such as Vygotsky's tools. Cognition can be triggered, sustained, propagated or transformed by the artefacts. However, affordances are constrained by the cultural conventions and the differences between perceived and real usability (Norman, 1999). Therefore, the location, with its affordances and cultural influences, is very much part of the extended cognitive system that is to be studied.

### 1.8.4 Socio-cultural influences

Finally, Vygotsky's "social and cultural line" of development (Wertsch, 1991, p. 88), which refers to the cultural means (use of pictures, language, etc.) to enhance mental development, completes the framework for understanding cognition with the consideration of the socio-cultural view. This study, like Vygotsky, seeks to "create an analysis of mind that recognises its historical, cultural, and institutional situatedness" (p. 92). Contextually, any social cognition is highly situated in its local context and culture (Bruner, 2005) and the mind is best understood as the activity of "an essentially situated brain" (Clark, 1998, p. 258) in its bodily, cultural and environment context. Affordances in the environment have cultural conventions (Norman, 1999) and histories of the "social entity as a learning system" (Salomon & Perkins, 1998, p. 5) have an impact on the cognitive development of the group (Roschelle, 1992). Therefore, accounting for this interplay and inter-connection of personal histories and socio-cultural aspects of the students will provide a fuller picture of how cognition is distributed. This research places the cognitive system as highly contextualised in its own setting: a classroom in session. These theoretical considerations are significant from the literature review which undergirds this study and they serve as complementary lenses to see how cognition is distributed in the classroom of a Japanese University.

## 1.9 Significance and rationale

Today's learning environments have changed to a more collaborative and technologically filled context. These multi-tasking and cognitively crowded learning environments are posing intriguing questions on how students learn. There is a need to ethnographically understand how our students learn in our digital age. Ethnographic studies revealed how magnetic strips and tags in operating rooms (Xiao, Lasome, Moss, Mackenzie, & Farsi, 2001) and sticky notes on instrument panels of a pilot's cockpit (Hutchins, 1995b) provided for a more informative environment to other members requiring the information for effective operation and coordination. An ethnographic study is significant in two major ways: one is to inform us the processes and information distribution of the students in the classroom and the other is to draw from this information, implications for classroom practices. Such a study will give us an indication on how students learn and our design of future classroom learning environments.

Technology has played an enormous role in the transfer and distribution of knowledge and information in modern classrooms (Naismith et al., 2005). The ubiquitous use of computers and technological handheld devices such as PED and mobile phones are affording a complex and efficient exchange and distribution of information for learners and teachers. This research is cognisant of the mixed reviews of the use of computers in the classrooms but the reason for this study is not due to the success of the use but rather its inevitable ubiquity in the way information is distributed today. In a highly technologised society like Japan, this study also seeks to further understand how Japanese students learn in a group with technology.

Studies into human and computer interaction (HCI) that began solely to understand the end user perspective (Suchman, 1987) have moved on to understanding relationships from a learner's perspective (Crook, 1998). Computer supported cooperative work research in the 1980s has also moved on to computer supported collaborative learning where the focus is on learning with computers (Salomon, 1993). Now, with the dimension of collaborative learning with technological devices and the practice of multi-tasking in the classroom, a new paradigm is emerging in the learning environment. The focus is thus on how the learner is learning with technology *while* collaborating with others. A study such as this not only informs the area of HCI but also posits new knowledge into how humans learn with more than one technological device. This research seeks to enlighten the boundaries of the complexities of learning in today's technologically enabled classrooms. In fact, this study seeks to continue the tradition of socio-culturalists' recognition and investigation into human intelligence that is realised in "a complex environment – a human created environment filled with tools and machines, but also a deeply social environment with collaborators and partners" (Sawyer, 2006, p. 9).

In the field of social cognition, and in particular the study of small groups, a study into the cognitive processes can yield invaluable insights into group phenomena (Fiske & Goodwin, 1995) especially in the area of using extended cognition to understand learning in groups. In addition, the notion of extended cognition is arguably ushering in a new dimension of understanding on how cognition is socially negotiated. Distributed cognition is one such theoretical concept (Mok, 2008), alongside others such as embodied cognition, hive mind, ecological psychology and enactivism that are advancing the anthropological and sociological fields of cognitive studies. The adoption of this extended cognition concept is still relatively new and limited in educational research. Clearly, this research will contribute to educational studies in this area. This research hopes to map and identify processes of memory and information in the classroom so as to see how educators and students can improve cognitive processes for higher scholastic performances.

In addition, the issue of authenticity confronts most cognitive studies. How do we know what participants will naturally do outside the experimental period? If all learning "occurs in some situation" (Greeno, 1998, p. 14), it needs to be studied authentically where learners are engaged in "ordinary practices of the culture" (Brown, Collins, & Duguid, 1989, p. 34). Most group cognition studies are laboratory based research rather than situated in natural groups (Scheerhorn, Geist, & Teeboul, 1994). And they are also either focused on cognitive or social processes (Kreijns, Kirschner, & Jochems, 2003), and either individual level or group level (Hirokawa & Johnston, 1989). The focus on one or the other aspects of research does not adequately explain a naturally occurring cognitive phenomenon. By considering both cognitive and social, both individual and group, this research will yield not only a more holistic picture but also an accurate picture on how students learn "in the wild". In a way, this research seeks to address the imbalance of the types of studies into cognition, particularly in group cognition in a formal learning environment. This study of cognition in activity allows us to uncover and explain how and why group members collaborate and share information. Using the situative perspective helps us design learning environments that deliberately target the characteristics of learning activities that can result in higher student learning (Greeno, 2008).

Finally, arguably, there has yet to be a study done in the Asian context and in particular, with Japanese students. Greater research of Asian contexts is appealing indeed, given the traditional emphasis of research on Anglo-American settings. Thus, it will indeed be significant and relevant for this study to be conducted in Japan. Equally interesting is the study is sited in an English-medium instruction classroom for non-English speaking students. This language scenario is fast becoming a common trend in many non-English speaking countries and the findings will have implications for these colleges. Whether it is a "critical enquiry aimed at informing educational judgments and decisions in order to improve educational action" or a "discipline research" which seeks to inform the understanding of phenomena (Bassey, 2005, pp. 108-109), this research seeks to enhance the body of educational research in the area of cognitive development in technology rich group settings.

### 1.10 Outline of the chapters

Having positioned the purpose, background and aims of this study, the rest of the thesis is structured as follows. Chapter 2 presents the literature review, further detailing the theoretical context of this study. It will undergird the study from both social cognition and social cultural theories, in particular the theory of extended and distributed cognition, and adopt at the same time, a critical and evaluative approach to these concepts. A conceptual framework based on these concepts will also be proposed to frame the study. Chapter 3 will locate and detail the design and methodology of the research approach, elaborating the data collection and analysis methods. The trustworthiness and ethics of the methods and study are also be accounted for. In Chapter 4, the analysis and findings are reported with ethnographic description. Chapter 5 discusses the data analysis and results of the study. Finally, in Chapter 6, the conclusions, implications and recommendations are made.

# CHAPTER TWO

# LITERATURE REVIEW

## Introduction

Having introduced the research problem and background of this study, this chapter seeks to bring together several theoretical concepts to undergird the main research question: How is cognition distributed across a group of students collaborating on a learning task in a technologically enabled classroom in a Japanese university? Three SRQs were formed to explicate the main questions:

**SRQ1. What are the observable cognitive processes and representations in the classroom?**

**SRQ2. What artefacts are accessed and how are they used?**

**SRQ3. What are the levels of collaboration and how do they interact?**

This chapter, then, reviews literature relevant to the research question of this study and the SRQs in order to undergird the epistemological approach and methods of investigation. It will begin with locating and positioning this study with the notion of extended and distributed cognition, followed by the understanding of representations, memory and information processes. Lastly, notions on cognitive artefacts and collaborative levels will be discussed. This chapter is structured in the following manner:

2.1 Naturalistic study into cognition

2.2 Extended cognition

2.3 Educational view of cognition

2.4 Affordances and cognitive artefacts

2.5 Collaborative levels of interaction

2.6 Japanese classroom culture

2.7 Summary: Framework for unit of analysis

Importantly, the literature review is scoped to the educational perspective rather than the psychological and cognitive science angle towards learning. Thus, this is a qualitative educational research into students collaborating with technology. However, concepts from the fields of socio-cognition and socio-cultural studies are borrowed to help frame this educational study of learning and cognition.

## 2.1 Naturalistic study into cognition

The aim of this research is to study students in their natural settings: in the classrooms as they collaborate in a learning task as they normally would on a typical day. While most empirical and hypotheses-testing studies into cognition do inform and add to the knowledge of group activity, they are largely investigated in laboratory experiments that ignore the social context. These studies also assume that groups can be explained by the reduction to studies of individuals (Sawyer, 2005). Such methods of reducing and later aggregating to the whole in order to understand group activity risk reaching conclusions that may not be reliable for the individuals, which do in fact, depend on the broader aspects of the activity system (Greeno, 2008). A reductionist approach to study collaborative learning then would have serious ecological validity as it has become “notoriously difficult to generalise laboratory findings to real-world situation” (Hutchins, 1995a. xiii). An authentic setting to study learning would naturally follow. Authentic settings suggest authentic activities where learners are engaged in "ordinary practices of the culture" (Brown et al., 1989, p. 34), "arising from the socially and culturally structured world" (Lave & Wenger, 1991, p. 67).

In fact, since the beginning of the 1990s, learning scientists have been typically analysing "real classrooms engaged in everyday learning activities" (Sawyer, 2006, p. 188). This differentiating notion of authenticity has critics arguing that the socio-cultural perspective view implies that cognitive studies cannot be carried out in settings other than naturally occurring activities (Vera & Simon, 1993). Laboratory-based researchers addressed this criticism by qualifying that the focus was in the interactions that were studied and authentic activity should not become an issue (Greeno, 1998). However, even if interactions were studied under laboratory conditions, how could one ignore the social interdependency of the individual and the environment? Laboratory experiments can only throw some light or "abstraction" (Clancey, 1993, p. 89). Even so, studying a phenomenon such as learning in a laboratory setting may yield reliable statistical but consequently limited understanding of little generalising value (Greeno, 2008). The reductionist approach to experiments illuminates the single cause cognitive relationships, but in reality, contemporary social settings are more complex (Perret-Clermont, Perret, & Bell, 1991). It is almost impossible to control the many variables that have an effect on interactions in experimental studies (Sawyer, 2006). Indeed, there is a move away from experimental analysis to in situ observational research (Liu, Nersessian, & Stasko, 2008). Perhaps the "quantitative-qualitative argument is essentially unproductive" (Miles & Huberman, 1994, p. 41), rather, they complement each other in the quest for a fuller understanding of the investigated phenomena. A “link” between the two and a careful design on “whether it should be done, how it will be done and for what purposes” (p. 41) is preferred. Possibly then, a fuller understanding of cognition situated in an environment is neither one nor the other, but a careful consideration of both.

There have been attempts to reconcile both perspectives but in reality, both have very different epistemological and ontological starting points (Billet, 1996; Greeno, 1998). This research is sought to understand students' activity in a real world setting and most research on interaction prefer to study interaction occurring in authentic settings (Sawyers, 2006). In order to study these processes and interactions of students learning in an activity, this research followed an ethnographic approach in looking at the social interactions of a collaborative learning activity in a regular classroom. It took an interpretive view where individuals have unique experience and perspective towards learning. Because the individuals' perspectives were meaningful to them, therefore they were also meaningful to this investigation. Human actions and behaviour in a real life classroom group activity were the main investigation interests of this research. Research into human behaviour and complex situations requires the qualitative approach to harness the richness of information and data for analysis (Creswell, 2003; Marshall & Rossman, 1999; Mertens, 1998; Borg & Gall, 1989).

Many studies in learning and cognition have been done at the activity level beginning at the work settings and public places such as how pilots fly planes in their cockpits (Hutchins, 1995b), shoppers do their grocery shopping (Lave, 1988) and young children learning through interactions with their caregivers (Rogoff, 1990). These ethnographic studies into the interactions of the participants in social and learning events offer insights into the way people think and act. In schools, case studies on how children developed a classroom practice (Hall & Rubin, 1998), how laboratory groups increasing understanding over time (Nersessian, Newstetter, Kurz-Milcke, & Davies, 2003), and how students collaborate in their conversations (Greeno & Sawyer, 2008) are several of such studies of learning in activity. This research looked at the learning activity phenomena as a whole in its natural setting, with no pre-determined constructs but rather, recognising as they emerge in the observations.

## 2.2 Extended cognition

Educational practice and theory have long been influenced by psychology and cognitive sciences and especially by the work of Dewey, Piaget, Papert and Bruner (Clancey, 2006, p. 23). The approach of understanding the mind from the socio-cultural perspective has changed the way we view educational practices, especially in the classrooms (Wood, 1998). The popular use of collaborative and cooperative learning activities, as well as classroom practices of active learning and learner centred learning are but some of the several examples deriving from this influence. A new entrant to the study of cognition, the notion of extended cognition has its origins in the socio-cognitive and socio-cultural perspectives and is challenging the way we see cognition in practice (Mok, 2008). The subsequent sections will discuss why this notion is useful in the study of learning in the classroom.

### 2.2.1 Socio-cognitive perspective

The study into cognition as not solely residing in the head has its beginnings in

Wilhelm Wundt and Hugo Munsterberg as the early psychologists in the early 1900s (Cole & Engestrom, 1993) that first recognised a different form of psychology where cognition requires interaction outside the brain. Unfortunately, their writings were not picked up and developed into any recognisable cognitive psychological strands. Subsequently, Leont'ev, Luria and Vygotsky, the progenitors of cultural-historical psychology, sought to mediate basic cognitive tasks to more complex ones with cultural tools, including the use of language. The movement to view cognition beyond the confines of the skull (Clark, 2002; Salomon, 1993) has, over the last few decades, suggested studying larger cognitive systems other than the mind alone (Vygotsky, 1978; Dewey, 1963). Vygotsky's "Mind in Society" (1978) treated society as having mind like properties. By this, he meant to use language of the mind to describe the activities of the group. Vygotsky clearly stipulated that the specific processes of the intra-psychological level can be accounted for from the inter-psychological level (Wertsch, 1991). As such, cognition in the mind, seen with the social activity, began suggesting the very notion that the mind "extend(s) beyond the skin" (Clancey, 1993, p. 90).

In educational psychology, Dewey (1963) warned against treating experience (learning and development) as something going on only inside one's head and that there are "sources outside an individual which give rise to experience" (p. 39). His idea of a learning experience is not primarily an intellectual entity in the head but "an organic anticipation of what will happen when certain operations are executed under and with respect to observed conditions" (p. 109). Cognitive inquiry is not a purely mental phenomenon but involves an interaction between organism and environment to produce real changes in the causal couplings that characterize the situation (Gallagher, 2006). Even in traditional cognitive science, the analogous comparison of the brain to the computer led to studies into the computational representations of how the mind works (Turing, 1950). This computational approach recognised that mental phenomena arose from the operation of multiple distinct processes rather than a single undifferentiated one. Connectionists, who are also concerned about learning, used the "Parallel Distributed Processing" model (Rumelhart & McClelland, 1986) to study cognition that is distributed in a network of computers, believing it to be similar to the neural networks of the brain.

### 2.2.2 Socio-cultural perspective

Key to the conceptual construct of extended cognition is the social origins of cognition found in the writings of Vygotsky emphasising that in order "to understand the individual, it is necessary to understand the social relations in which the individual exists" (Wertsch, 1991, p. 88). Vygotsky's "two planes" of the interpsychological and intrapsychological interplay demonstrate that "social relations among people genetically underlie all higher functions and their relationships" (1981b, p. 163). The interpsychological plane is the interaction between the individual and other, while the intrapsychological is the internalisation of the individual with what was interacted with. In fact, Vygotsky also stated that "higher mental functions…is social" (1981b, p. 164). Higher mental processes are social because of the social origin (Valsiner & Van der Veer, 2000). The social discourse and actions with the teacher and peers in the classroom provide the basis for mental development of the learner. The learner observes, participates and internalises (making sense of what is going on) demonstrating that the cognitive and the social processes cannot be separated.

The social understanding of cognition is further understood in Vygotsky's notion of ZPD where the individual's "actual development level as determined by independent problem solving" and the higher level of "potential development as determined through problem solving under adult guidance or in collaboration with more capable peers" (Vygotsky, 1978, p. 86). Most social scientists are now acknowledging the irrefutability of the social environment that individual cognition is situated in (Valsiner & Van der Veer, 2000; Salomon & Perkins, 1998). In addition, Vygotsky's genetic method of understanding mental processes includes the "social and cultural line" of development (Wertsch, 1991, p. 88). This particular theme of Vygotsky, while criticised being unclearly defined, nonetheless posits the need to understand not just the social others but the cultural elements as well. Higher mental processes are cultural (Valsiner & Van der Veer, 2000) because they involve the use of language and cultural practices that are peculiar to the learner.

Contextually then, any social cognition is highly situated in its local context and cultural environment (Bruner, 2005). This places learning as highly contextualised in its own setting: the human members and artefacts situated in the environment. In a learning activity, the learner uses what he or she has acquired in the history and experience of the learning and classroom practices particular to the learner's culture. This cultural line then, refers to the cultural tools that the learner uses during the learning activity. Cognition, thus, has social and cultural origins.

In seeking to understand mental processes, cognitive science has asked how information is represented in the cognitive system (mind) and how representations are transformed, combined and propagated through the system (Simon, 1981). With much criticism in the singular approach of not being meaningful (Thompson, 1998), the study of the mind can now be understood in a larger, socio-technical system (Hutchins, 1995a; Hatch & Gardner, 1993). This study then, wishes to characterise the behavioural properties of the larger unit of analysis (outside the minds of students) in terms of the structure and the processing of representations that are internal to the system.

### 2.2.3 Situated cognition

The argument for the consideration of the context and environment can be seen in the emergence of situated cognition, where the aim is in analysing "activity systems" (Greeno, 2008, p. 79) that focuses not on individuals only but the "complex social organisations" in the classroom: students, teacher, teaching materials, technological aids and the physical environment. Situated learning (Lave & Wenger, 1991) and situated cognition (Lave, 1988) posit thinking is inextricably connected to the context and environment of the individual not only in the physical sense but also in the semiotic sense. Similar to this concept but not entirely the same, are terms like Suchman's (1987) "situated actions", which began questioning the linear approach to studying computer and human interactions. She argued that human action is situated and therefore finds its meaning in the social and cultural world which cannot be accounted for in terms of "plans" that cognitive science prescribes. For Suchman, thoughts resulting in actions are "situated actions" because the actions are influenced by the situation the individual is in. Similarly, for Lave and Wenger's situated learning (1991), they see learning as dependent to the environment the learner is in. To Vygotsky, "human mental functioning is inherently situated in social interactional, cultural, institutional, and historical context" (Wertsch, 1991, p. 86).

Thus, for Greeno, all actions are situated, not just some situated actions. Hence, all socially organised activities provide opportunities for learning to occur, whether intentional or accidental (Greeno, 2008). Because if all learning occurs in situations (Greeno, 1998) and "is situated" (Billet, 1996, p. 263), then learning cannot be studied solely from the individual perspective but rather as an activity in the environment. Clark (1998) submitted that the mind is best understood as the activity of "an essentially situated brain" (p. 258) in its bodily, cultural and environment context. The social and collective view of cognition as a whole is exemplified by theories such as socio-cultural psychology (Cole, 1991; Rogoff, 1990), activity theory (Engestrom, 1992, 1987; Leont'ev, 1978), embodied cognition (Varela, Thompson, & Rosch, 1992), distributed cognition (Hutchins, 1995a), and the more recent enactivism (Cowart, 2004).

Thus, Vygotsky's goal to "create an analysis of mind that recognises its historical, cultural, and institutional situatedness" (Wertsch, 1991, p. 92), posits learning as highly situated in its socio-cultural environment consisting of the members and cultural tools. Then the notion of the unit of analysis can be *extended* beyond the individual. The activity system is the extended cognition comprising the collective minds of the members within the system. This notion needs to be explored in order for this research to conduct an observational study from the socio-cultural position to understanding how cognition is distributed across the group. Adopting this notion of an extended mind is more than just a philosophical terminology and positioning but has also a significant influence in the method of research (Clark & Chalmers, 1998). In fact, in seeing cognition as extended, "explanatory methods that might once have been thought appropriate only for the analysis of inner processes are now being adapted for the study of the outer, and there is promise that our understanding of cognition will become richer for it" (Clark & Chalmers, 1998, p. 10).

### 2.2.4 Extended cognitive system

What is then, meant by extended cognition? For Clark (1998), minds can belong to systems larger than an individual. There is an active externalising of cognition where a mental activity is only successful insofar as in collaboration with the external components within the environment. In other words, without these external components, the cognition resulting in the behaviour (and action) would not have been possible (Clark & Chalmers, 1998). Extended mind makes sense only when it is situative. Situativeness demands the peculiarity and specificity of the external components in the environment that generate the cognitive behaviour (Greeno, 2008). And each situation is different from the other. In other words, if there are changes in the external components, then the cognitive behaviour (and result) will be different. In a sense then, the cognitive system has no permanence but rather exists for the duration and time for the cognitive behaviour to complete the activity or task.

Thus, the socio-cultural view of cognition would then extend the unit of analysis beyond the individual. This is in contrast to most empirical studies that deal with the unit of analysis comprising of a single discrete task analysis without external aids (Williamson, 2004). The socio-cultural view challenges cognitive science's traditional preoccupation with the individual and the brain as the boundary of the unit of analysis, confining it within the skull of the individual and ignoring the context and the individual's interaction with others and artefacts (Hutchins, 1995a). External elements should not be only treated as stimuli or aids to cognition but rather as equal partners in exhibiting, distributing and generating cognition. An individual's memory by itself is insufficient to understand how memory systems work (Weick & Roberts, 1993). The rich and complex cognitive interactions in a cockpit or a ship's bridge involving the manipulation of artefacts (Hollan et al., 2000) attest to this. To Hutchins (1995a), the coordinating activity of the crew members in the ship's bridge when steering the ship back into the harbour, constitute a group-system as a whole, where the mental states such as remembering how to cooperate, perceiving the information, considering information for decisions and actions should not be treated as separate and single units.

The classic description of how a person requires an external representation by writing the multiplication on a piece of paper when solving a mathematical problem, is evidential to the use of the pen and paper to facilitate the multiplication process (Rumelhart, Smolensky, McClelland, & Hinton, 1986) which was mentally difficult to do. The written algebra is the external symbols used to aid the cognitive activity. This external representation is also known as "extended computationalism" when compared to traditional computation where computation occurs entirely inside the head (Wilson & Clark, 2009, p. 61). The computation of the numbers has been extended to the mathematical symbols on paper. The pen and paper, by providing the extended cognitive properties, together with the individual, constitute the cognitive system for this single activity of multiplication. This "extended computation" provides the basis for extended cognition (Wilson & Clark, 2009). The computation may have begun in the head but because of the extended cognitive properties, we can better understand how the mathematical problem was computed.

Others such as Cole (1991) see cognition as a jointly and socially mediated activity. Pea (1993) refers to this as "off-loading" (p. 69): when humans rely on artefacts to help them remember or compute cognitive tasks. Perkins (1993) sees knowledge as "represented", "retrieved" and "constructed" jointly by the "person plus" (pp. 93-95). Currently, there is a growing consensus that the concept of intelligence should not be confined as a property of the mind (Pea, 1993). For some like Cobb and Bowers (1999), there is no longer any dispute about the individual versus the social collective as the unit of analysis due to the importance of social influences. More radical views are posited by Rowlands (1999), who argued that "with regard to the memory systems possessed by modern human beings, there is no sound theoretical reason for setting up a dichotomy between internal memory processes and external aids to those processes" (p. 121). This notion of extended cognition is also commented as providing a "radical reorientation to working cognitive science" (Rupert, 2004, p. 312). The unit of analysis is now extended to include human agents and non-human artefacts in the environment varying with each different context (Hutchins, 1995a).

### 2.2.5 No extension of cognition

Opponents to this concept of extended cognition have several criticisms on both philosophical and practical grounds. Rupert (2004) pointed out that groups, as an entity on its own, do not really have mental states or capacities. So, when we begin to treat a group as having its own intelligence and cognitive ability, we "lose our bearings" (p. 393) in the study of cognition. However, is it erroneous to consider a group having a tentative group mental state? The group does have an effect on individual thinking and in so doing possesses a thinking that can be contrary to the individual's when thinking alone. Group learning can bring the group to a higher level where the group, as a group entity, learns in parallel to the individual members. The same team would acquire a new level of understanding and would operate differently a second time round. The cohesion of the same members, each knowing the strengths and weaknesses of each other, play to a greater effect in subsequent tasks or challenges it faces as a group. This would change if the group is disbanded or there is a change in member number or composition. Members having a history of working together develop a common understanding with each subsequent group performance. This is where a team acquires a "social entity as a learning system" (Salomon & Perkins, 1998, p. 5) with each succeeding internal rule and coordination having a correlation to cognitive development of the group (Roschelle, 1992).

In fact, we can see instances of the interdependent or relational self-concept of individuals in the relationships with others in group settings (Markus & Kitayama, 1991) where the self-concepts of members within the group are supplanted by the group. In other words, the members are so interdependent and related in a particular setting that they see themselves as one. This research assumes that there is such a group entity whenever a group of students gather together to work on a learning task. So, rather than dismissing or ignoring this notion of extended cognition, this research hopes to use it to understand collaborative learning in the classroom.

Criticisms of the extended cognition have been also tied together with arguments against embedded cognition. There is a distinction to be made between extended cognition and embedded cognition, which is a less radical view of extended cognition (Rupert, 2004). Embedded cognition is hypothesised to depend very heavily on the external elements that exist in the environment for cognitive activity but the boundaries between the individual and the environment are kept separate (Clark, 2009).  Extended cognition suggests that cognition is part of the environment that the individual cognition operates in; thus considering and equating all cognition to be at the same plane within the larger but singular cognitive system. Hence, Rupert (2004) posited that the individual need not maintain any internal mode of information but merely relies on the environment for cognitive activity. To which he felt that extended cognition views human cognition as extended "organismically" (p. 294) to include the "extraorganismic physical environment" (p. 301). Such a view of extended cognition as a neural phenomenon is seen to be preposterous. This is not what extended cognition is advocating: that one relies so heavily on the external aids that internal thinking is absent. After all, human cognition begins internally and connects with the external (Vygotsky, 1981b) and even an external stimulus or representation requires an internal receptor to pick up the information. Extended cognition is trying to look at cognition holistically by including these external interactions without ignoring them as traditional science used to. This research view of extended cognition is that cognition is extended to the environment with the individuals as loci of the larger cognitive system (Hoffman & Woods, 2000). Even critics such as Adams and Aizawa (2009) admitted that proponents of extended cognition “maintain that cognition extends from brains into the extra-organismal world, rather than from the extra-organismal world into the brains” (p. 92). So, the idea of extension is from the brain to the environment, and not the other way round. In addition, as we are using more technological artefacts, we do in more ways than we realise, rely heavily on them. For example, our reliance on calculators has made us less inclined to make mental calculations. In fact, much of the information that we would have otherwise committed to memory are now stored in our personal electronic devices or other artefacts. So, this notion of extended cognition is not as farfetched an idea as it may seem.

In another criticism, Adams and Aizawa (2009) levelled a key insensitivity that extended cognition makes in its main premise. This is the erroneous equation of cognitive processes as causal explanations “connected to the environmental processes” to those that are “constituted by the environment processes” (p. 81). In other words, the causal (cognitive) connections between the individual mind and the external elements are vastly different from those causal connections between elements themselves. So, while admitting that a combination of a human, pen and paper constitutes a system, Adams and Aizawa (2009) argued that the connections between the human to pen and the pen to paper were not the same and therefore should not be considered equal in the cognitive process. As such, Adams and Aizawa clearly distinguished that cognition is “still in the head” and things outside the head have no “mark of the cognitive” (2009, p. 79).

Similarly, a deflationary view of internal cognition is another criticism positing "less representational and computational structure internal" to the individual (Rupert, 2004, p. 397). Rupert argued that the "external portions of extended memory states (processes) differ so greatly from internal memories…that they should be treated as distinct kinds" (p. 311). There are clearly fundamental differences between the cognition occurring in the head and those that are considered occurring in the environment. It very much depends on one's definition of cognitive processes. This study recognises there are distinct differences insomuch as there are varying types of cognition as performed by an animal and a human or for that matter, by a computer and a robot. While there is indeed a difference between cognition in living organisms and non-living things, we should not deny non-living things as incapable of cognition. As much as we recognise a human remembers information, we recognise that a computer is able of storing the very same information albeit in a different way.

This extended cognition concept is crucial in paving the foundation of this research in order to study how students collaborate as a group where the unit of analysis is no longer considering each individual separately but rather each individual is a part of the cognitive system. In other words, we can now theoretically observe cognition in the classroom because the cognition is seen as *extended*. As such, we can attempt to identify the tools, duration and nature of distribution and representation of cognition.

## 2.3 Educational view of cognition

What does this all mean for the educational perspective and especially for this study into learning? Education is primarily interested in teaching and learning in the classrooms and the notion of extended cognition offers not just an alternative approach to view learning, but recognises that learning and development of an individual involves “sources outside an individual which give rise to experience” (Dewey, 1963, p. 39). Dewey, much cited as the educationalist side of situated cognition, rejected the Cartesian approach and advocated the learning experience as very much part of the environment. Consider his point here on the individual: “The idea of environment is a necessity to the idea of organism, and with the conception of environment comes the impossibility of considering psychical life as an individual, isolated thing developing in a vacuum” (1884, p. 280). For him the learning experience is situated, “in actual experience, there is never any isolated singular object or event; an object or event is always a special part, phase, or aspect, of an environing experienced world - a situation” (1963, p. 67). The current plethora of collaborative, cooperative and active learning classes and use of teaching aids suggest that individual learning is inextricably connected with external learning tools and other individuals. The idea of learning in activity is very much similar to and an extension of Dewey's (1963) learning by doing and inquiry. To study these multi-connectivity and many interactions, extended cognition offers a conceptual basis to accurately understand these cognitive processes. Adopting this conceptual picture of cognition will help illuminate collaborative learning, human and computer interactions, and how students multi-task in the classrooms.

Cognition is traditionally understood as “the acquisition, storage, retrieval, and use of knowledge” (Matlin, 1994, p. 2). Others such as Clark (2009) and Rowlands (1999) considered cognition as information processing. While this view has been criticised as being too broad (Adams & Aizawa, 2009), it, however, offers us a functional perspective of cognition that is suitable for our educational perspective. After all, education is about transforming and delivering information to students to increase their knowledge. Cognition is also seen as computational, which is similar to information processing, but following a well-defined model that is expressed in an algorithm, protocol or network topology (Thagard, 2008). Computation is seen as a phenomenon ranging from human thinking to calculations and is usually associated to mathematical language that denotes logic and causality. Thus, for Hutchins (1995a), the team of crew navigating a ship into the harbour, constitutes the extended cognition as a “unit of cognitive analysis” where he applied the “principal metaphor of cognitive science-cognition as computation-to the operation of this… larger computational system” (p. 49). To Hutchins, he studied cognition “in the way cognition has traditionally been described—that is, as computation realised through the creation, transformation, and propagation of representational states (p. 49). So cognition can be seen as the logical and sequential structure of representational states of the cognition.

Similar to the functionalist approach to cognition is the operationalisation of cognition. There are examples of robots performing operationalised tasks, such as finding soda cans in offices or conducting tours (Patnaik, 2007), demonstrating that robots are cognitive because they operationalised a task tacitly. The robot acquired, processed, and acted on information it received, thus successfully performed a cognitive task. These constitute what cognition is, involving "information-bearing structures" in the environment (Rowlands, 1999, p. 147). Thus, cognition is evident where an intelligent activity has been performed. Cognition may thus be broadly understood as things that causally contribute to the production of intelligent behaviour as seen from a functional approach. So, language use and reasoning are such examples that involve function that are evident in humans. Hence, when extended to non-human entities, the term "cognition" can and should be applied to them. This study then, does not take the view that cognition is solely reserved for the human mental activities.

### 2.3.1 This study's view of cognition

This study, then, while epistemologically advocating for an extended view of cognition, shuns the more radical view and embraces the functional perspective where external elements serve as cognitive aids to the individual's learning *within* the extended cognitive activity. This view of extended cognition would not run counter to the issues that Adams and Aizawa criticised that extended cognition lacks a clear definition. This view also does not confuse the neurological cognitive processes with the external. After all, it would certainly be absurd to see extended cognition as a neurological extension of the human brain to the parts in the environment. Such a functional-role approach to cognition seems to be even acceptable to critics such as Rupert (2004) due to the "cognitive" role that artefacts do play. Adams and Aizawa also implicitly accept this due to the fact that psychological explanations may also be explained from the functional analysis point of view (2009, p. 7), a recognised approach to understand psychology from functional analysis (Cummins, 1983). Because it is a study on the activity of acquiring, storing, retrieving and applying information, cognition is also not seen exclusively as a human property alone but rather regarded loosely as activity that performs a cognitive function.

Epistemologically then, this research draws from the socio-cultural approach, the actions and behaviour of these relationships are observed and the conversations analysed. It is therefore not an empiricist, nor rationalist study. Even though this study is concerned with cognition, this is not a cognitive psychological study trying to understand or interpret what is going on inside the heads of the individuals. Neither is it a psychological study on personalities, nor measuring process outcomes of the group. And it is not a social behavioural study, as it did not look at social nor behavioural typologies of individuals. It is, however, an inter-disciplinary study with a socio-cultural approach that aims to understand the cognitive processes of the individuals working in a group.

This research understands cognition in the functional, information processing, computational and operational sense for the purposes of studying learning in activity: an activity that has clear functional-role properties of the actors and tools operationalising the task. The activity of learning involves processing information in logical and sequential structures of computational data. Thus, if cognition can be seen as acquiring, storing, retrieving and applying information, then we can conceptually see how extended cognition provides a holistic picture to studying learning in activity.

### 2.3.2 How extended is the cognition?

One of the difficulties in studying extended cognition is the indeterminateness of the system boundaries. Unlike the traditional cognitive studies where the constructs are clearly stated, ethnographic studies into cognitive behaviour and patterns allow undetermined influences to be considered during the study, including new and emerging influences that interact with previous ones in the cognitive system. These recursive and emerging cognitive relationships can be intriguing. While this is the nature of the study and analysis, the question of limit and termination of the cognitive activity is often left open. While the cognitive system and process is limited by the cognitive task and time taken, the extended boundaries that contribute to the task and duration may be difficult to ascertain due to the dynamic nature of the distribution. Giere (2002) went, in jest, as far as to consider the coalmines in Montana as the boundary of the distribution of his laboratory task. There is certainly an element of unpredictability where there are no controls or exclusion of influences that may "interfere" with the cognition. But it is precisely the reality of such impromptu and unpredictable influences and inclusion of elements into the cognitive system that is not only authentic but also significant to the cognitive activity of the group (Hoffman & Woods, 2000). Admittedly, recognising the need for authenticity to the study of cognition in "natural" settings, we can be besotted with having too many data and considerations, which may lead to an unsatisfyingly open study.

To help us determine the boundaries of the unit of analysis, the notion of the task is important. The nature and collective goal of the task clearly determines the kind of demands placed on the members of a group (Nye & Bower, 1996). Different tasks produce different types of processes involved in a group activity. A reading task demands members to perform a reading process followed by comprehension. When students collaborate in a group to accomplish a task, they use tools to mediate the process, interact with each other, operate with rules and divide the labour *in order* to work towards the objective. From Leontev's activity theory (1978), where the unit of analysis is considered as an activity with an objective and Engeström's social intent (1987), we obtain the notion that an activity has an outcome: the completion of the task. The task provides the intent of the activity and the motivating factor for the members. While this research was primarily process focused, the outcome of the processes helped us to draw the boundaries to the cognitive system. The task and the nature of the task, its purpose and content, is crucial to the cognitive processes and group cognition (O'Donnell, DuRussel, & Derry, 1997). The task determines and terminates the cognitive activity of the students. The unit of analysis for this study is therefore bounded by the nature and outcome of the task: the duration of the social and cognitive processes taken to complete the task.

### 2.3.3 Is cognition observable?

Crucially for this study, can cognition be really observed in an extended system? It seems rather obvious that one cannot perform observations of what is inside the mind, apart from being wired up with mapping sensors in a laboratory. But this study seeks not to observe what is going on inside the head, but rather the cognitive representations that result in the collaboration and actions of members in a group activity. And we have established how the inter-psychological level externalises the intra-psychological level (Valsiner & Van der Veer, 2000, p. 379), undergirding the notion of extended cognition to observe cognition. What do we look for then? In "cognitive ethnography" (Hutchins, 1995a, p. 371), we look for the *external representations* of cognition. This was clearly illustrated in Hutchins' ethnographic account of how he observed cognition as being distributed to other crew members in his description of a ship's log: "Putting calibrating nails into the deck is a way of creating a memory for the lengths between knots in the log line…in this case, the marks on the deck are a memory for distance" (p. 106). Similarly, he observed how the chart the navigator uses to plot the positions of the ship was placed strategically in an area where others can refer to, thus serving as a memory to be shared with others. The marks on the deck and the chart are observed as external representations of cognition that the crew created and are then distributed to others when they refer to these terms to help them compute their tasks. We turn now to a more elaborate discussion on cognitive representations.

### 2.3.4 External representations

Traditionally, cognition is seen as both internal and external representations. Internal representation concerns what is inside the brain while external representations are distinguished as external symbolic organisation of thought. In computational terms, external representation is seen as "the knowledge and structure in the environment, as physical symbols, objects, or dimensions (e.g., written symbols, dimensions of a graph, etc.), and as external rules, constraints, or relations embedded in physical configurations (e.g., spatial relations of written digits, visual and spatial layouts of diagrams, etc.)" (Zhang, 1997, pp. 179-180). Because this was an ethnographic study on the flow of information, the research analysed the external representations of cognition of students. In the social study of cognitive science, cognition can be observed in the external representations across media. The media include any observable medium that transfers, transforms, stores and retrieves information. Categories of such external representations include the conversations between students, coordination of actions and behaviour, and cooperation with each other in order to complete the task. This external representation of communication also include items such as documents and artefacts that students interacted with, to encode, transform, store, propagate, and retrieve information and scaffold knowledge building. The coordination analysed are the processes of social relationships between individuals and between the artefacts. This includes actions and behaviour of students demonstrated to complete the task and those that supported the cognitive processes. Non-verbal communications are also observed as part of such representations.

Because we see cognition as extended and situated, we recognise the strong link between both the internal and external representations. In fact, Zhang and Norman (1994) consider internal representations to rely on knowledge in the world while external representation depends on knowledge in the mind. The internal mental cognition can be assumed to support and retain internal representations of the external representations (Hutchins, 1995a) in the classroom. Even for memory processes, Baddeley (2007) sees memory as "the interface between perception and action" (p. 338) that is, between receiving of information and activity of the individual. Thus, even memory processes, cognitive activities inside the head, are linked with observable actions. This then, suggests a knowledge continuum between external and internal representation as seen in Figure 2.1. External representation is a direct result of internal human cognition and conversely, internal representation is a result of interaction with the external knowledge. External representations are recognised to facilitate processes in group work where they aid memory and provide cognitive supports (and constraints) (Zhang & Norman, 1994).

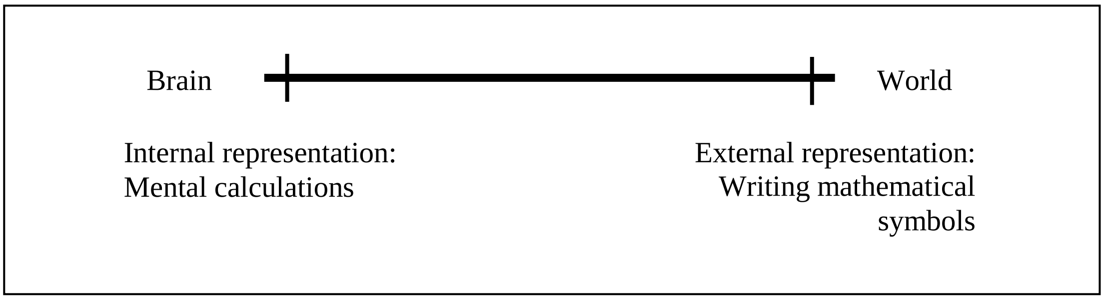


**Figure 2.1 Representation continuum**

### 2.3.5 Informational, teleological and causal representations

There are many types and forms of representations in cognitive science (Rowlands, 2009). Because this is an educational research, we will not go into extensive discussion on the nature of representation that has generated much debate. Instead, we will focus on the traditionally accepted forms: informational, teleological, and causal. An informational representation is where the information is presented in forms that retain the informational value. So for example, when a teacher instructs the class on an assignment verbally and at the same time hands out a printed copy of the instructions, the information is represented in two forms: spoken and written use of language. The teacher's cognition is represented "informationally" in two ways: as a verbal and a written discourse. The discourse is the "vehicle" (p. 116) of the representation with the words in sentences as the symbols. Other vehicles include things that carry the information or content such as notes, or printed paper. The second type or nature of representation is teleological, which shows the “proper function of some mechanism, state or process of what it was designed to do” (p. 121). For example, the computer’s function is to enable the student to access the internet to perform a search for items. The ability to perform the search as displayed on the computer screen is the representation of the cognitive ability of the computer. Likewise, a teacher’s ability to produce intelligible sounds (speech) is another representation in a functional way. Or the paper is a representation that displays (function) the printed words. The third, causal representation refers to the role that the representation plays in guiding an individual’s behaviour (p. 117). In other words, the representation is a cause for an action or behaviour of an individual. For example, the computer prompts the user to enter the password or the waving hand gesture of the teacher causes a reaction from the class. These actions by the computer and the hand gesture are representations that are causal in nature. Similarly, the printed paper *becomes* a causal representation when it is the cause of an action or cognition to an individual. The image or symbol of the paper, not the words that it carries, may cause a thought in the individual who proceeds to an action. For example, when a student sees the papers of another student lying on the desk, he or she may start to take out his or her notes. The symbol of the paper (notes) caused cognition (memory) in the student to take out (action) the notes. So, external representations can be identified by its nature as manifested informationally, functionally and causally. This study looked only into these types that are relevant to the situated activity of extended cognition. Any external representation that receives, stores, retrieves and/or processes information is observed as cognition.

### 2.3.6 Is cognition distributed?

Cognition is seen as distributed (Hutchins, 1995a) because humans "off-load" (Pea, 1993, p. 69) tedious thinking. Also in a socially mediated activity (Cole, 1991), knowledge is "represented", "retrieved" and "constructed" jointly by a "person plus" (Perkins, 1993, p. 93). Intelligence is seen as "distributed" (Pea, 1993, p. 50) to the artefacts alleviating the tedious cognitive tasks that humans have to undertake. Salomon (1993) was more guarded while acknowledging the "joint nature" (p. 112) of distribution but kept the individual cognition as separate while operating together with others in the system. Fearing that distributed cognition may be seen as the only explanation that ignores the other aspects, Salomon was careful not to attribute cognitive powers to non-human artefacts. Because of the over emphasis on "what's outside" the brain, he felt the extreme position was truncated conceptually. While espousing the overall concept of distributed cognition, he pointed out that not all cognition is distributed and suggested the middle road: some cognition is distributed and the individuals are significant "sources" of cognition (p. 111) in the system. So, Salomon, saw the interconnectedness between what was distributed versus the internal solo cognition (p. 113) of the individuals. However, could personal reflection or any other forms of solo cognition be also seen as a consequence of a social interaction? The context and environment we are in surely contributed to the kind of reflection that will be different if we are somewhere else. Subsequently, the cognition is manifested later in some distribution; even though it was not distributed initially.

Whether we can say that all cognition is distributed (Hutchins, 1995a), or partially (Salomon, 1993), there is really "no reliable way of fully externalising… intra-psychological development" (Valsiner & Van der Veer, 2000, p. 379). Clearly, we cannot be absolutely certain on how the learner makes use of the guidance of the peers and teacher. So, for a large part, the inter-psychological representations reveal to us how cognition is distributed between learners, the final part of internalisation may only be revealed in so much as the individual learner may disclose through verbal or written meta-cognition or from interviews. In this research, the concept of cognition being distributed is only observed in the external representations between the members. Interpretative data need to be solicited from the interviews to complete the understanding. The conversations, actions and behaviour of the students are examined. In so doing, it is possible to observe the patterns of distribution of knowledge and information to help us understand how information flows within the group and reveal critical junctures of collaboration.

Cognition is also distributed across time with the earlier events affecting later ones (Hutchins, 1995a). This means that the manner of distribution is time sensitive. The timing and aging of the cognition affects the cognitive process and system. The research examined how cognition has been affected and aged over time. This meant re-visiting the points of cognition and constant monitoring of each member over time. The cognitive trail of the task was also monitored to ascertain the "strength" of the cognition; whether it was "strong" (constantly being accessed), "weak" (neglected) or dead (no longer used or inaccessible). This ethnographic observation of the activity considered the timing and aging of the cognitive processes. We will now discuss what these cognitive processes are for this study.

### 2.3.7 Memory and information processing

Cognitive studies into the mind consider elements of mental processes largely as memory and processing of information ("sensory register...response generator and executive function" (Luckner, 1990, p. 99). Information is processed when it is received, transferred, responded to and manipulated while being temporally stored. The information processing theory is also seen as "symbol manipulation" consisting of "manipulative processes" and "memory organisation" (Simon, p. 151). Following from the information processing of cognition as information, function and causal action (Rowlands, 2009), information processing involves the manipulation of cognition as information pieces. This manipulation results in a function and action.

Since the 1890s, studies into memory processes have long established two types of memory, short term memory (STM) and long term memory (LTM) (Baddeley, 2007); LTM being the more durable and permanent memory of the shorter STM and transference of knowledge. We will not go into the intricacies of what constitutes working memory (WM), STM and LTM but it suffices to recognise the distinct and separate neurological activity of WM when compared with LTM in the scientific community. Considered similar to STM, distinguished by a very short decay (Cowans, 2008), working memory (WM) is seen to be actively involved in processing and has replaced STM in current studies on the brain. Issues arose with this separation and the strict storage nature of STM began in the 1960s with advances in neuropsychological evidences led to the replacement of STM, in some sense, with WM in the 1970s (Baddeley & Hitch, 1974). Educators have long wanted to achieve as much LTM with the students with what is taught in class and scientists are beginning to see that there is no distinct separation between WM and LTM. While some see WM as part of LTM (Cowan, 2008). This study regards WM to subsume STM because STM was traditionally considered as a holding place rather than the current understanding of a more dynamic system that involves cognitive processing.

In Baddeley's revision of his 1986 book on working memory, he now recognises that WM "links both perception and LTM" (2007, p. 338) as a storage system, alluding to the dynamic nature of memory. In fact, a research testing WM with English and mathematics performances among seven- and eight-year-olds resulted in "low WM span having difficulty in following instructions" (p. 208) in the classroom. The same observational studies showed that situations that required simultaneous processing and storage, affected WM which also resulted in forgetfulness.

Thus, in order to study distribution of cognition in the classroom, this study looked at the external representations of cognition: the memory and information processes within the larger cognitive system. This study recognises both WM and LTM and their distinctive and connected roles they play in the cognitive system with information processing.

## 2.4 Affordances and cognitive artefacts

### 2.4.1 Affordances

In order to understand how students distribute cognition, we need to consider the artefacts the students use (SRQ2). Affordances are the functions that can be carried out (afforded) by the properties in the environment (Gibson, 1979), including the human agents. Simply put, art studios afford drawing and computer rooms afford computer work. The type of objects, artefacts, documents and any media determine the nature of affordances in the physical environment. The affordances that the environment has for cognitive activity allow for the students in the group to make use of them to accomplish the task. The properties of the learning environment afford "allowable actions" (Zhang & Patel, 2006, p. 336) of cognitive activity. The range and type of tools are afforded and yet constrained by the physical and social condition of the environment.

Affordances are constrained by the cultural conventions and the differences between perceived and real usability (Norman, 1999). In the classroom, different students face different cultural and perceived challenges in using objects. These affect the distribution of cognition and the interactions in the cognitive system. These perceived challenges were observed and ascertained through interviews. So, at one observable level, the study focused on members' physical interaction and engagement with the affordances in the environment and on another observable level, the cognition that resulted from the affordances. Cognition can be triggered, sustained, propagated or transformed by the affordances. An object, page or even smell can activate a thought or memory in the development of the task. When cognition is afforded from the affordances, the constraints disappear. The cognition afforded by the environment rest solely on the member and is not dependant on the nature of the interaction. So, while an object affords a usable action shaped by cultural conventions and physical usability, the same object can afford cognition to the member, as the member processes it.

### 2.4.2 Artefact mediation

In adopting the extended cognition paradigm, the cognitive system includes what Wilson and Clark (2009) refer to as "natural" and "technological resources" (p. 62). These natural resources are the textbooks, whiteboards, desks, chairs, pens and paper while the technological ones are the computers, mobile phones or electronic diaries. Found in the classroom, such tools were once considered as objects of use (Brown et al., 1989) rather than contributing to the cognitive processes. However, Vygotsky's socio-cultural view of "technical" and "psychological tools" (Wertsch, 1991, p. 90) affords the notion of mediation. This form of mediation with the tools allows humans to perform complex tasks. This includes the use of language and "various systems for counting; mnemonic techniques; algebraic symbol systems; works of art; writing; schemes, diagrams, maps, and mechanical drawings; all sorts of conventional signs" (Vygotsky, 1981a, p. 137). Such "tools" include not only physical implements but also technical procedures (e.g., the algorithms of arithmetic) and symbolic resources (e.g., those of natural languages and mathematical and musical notation). Humans using and later internalising such external aids such as fingers to count or represent counting becomes part of the mental processes that develops the human's higher mental functions (Valsiner & Van de Veer, 2000). As such, tools are more than just for human cognition and tasks. Salomon and Perkins (1998) refer this as "social mediation by cultural scaffolding" (p. 5) where the artefacts are culturally and historically situated such that they form a learning system with the learner. While using a tool (a physical object) may not necessarily suggest a learning system, the act itself, serves as a “secondary learning system” (p. 10). The activity develops not just the learner but also the practice of this activity, which thus becomes a learning system (Hutchins, 1995a).

Vygotsky’s socio-cultural view of mediation of tools in the development of mental processes may then be propositioned to extend collaboration with tools. If collaboration is “joint working”, then would it not be somewhat reasonable to say that humans may collaborate with a robot or even a computer? We may even be working jointly with less intelligent artefacts such as a personal digital assistant or a mobile phone. To write a paper, an intellectual endeavour, in today’s context, I will have to use a word processing software program. The program is intelligent enough to check my spelling and grammatical errors. It has indeed “worked jointly” with me on my paper, although not exactly in the conceptual domain. And if I used the computer to surf the internet for ideas, it would have contributed to my conceptual development, which technically was not solely mine. Such artefacts can be deemed to have a mediating effect in a collaborative activity as “technologies that learners interact and think with in knowledge construction, designed to bring their expertise to the performance as part of the joint learning system.” (Kim & Reeves, 2007, p. 224).

### 2.4.3 Cognitive artefacts

In this research, the documents and artefacts are considered cognitive. A cognitive artefact may be understood as “those artificial devices that maintain, display, or operate upon information in order to serve a representational function and that affect human cognitive performance” (Norman, 1991, p. 17). While it is more commonly associated with technological devices, other types may include drawings on paper, whiteboards, and blackboards: "physical, tangible written objects" such as a notebook, to note "maintain current knowledge through cryptic but well-understood markers, distribute memory among participants, and manage emergent conditions" (Jones & Nemeth, 2005, p. 152). A cognitive artefact is similar to the notion of cognitive tool, having a broader understanding encompassing both technological and non-technological tools. These artefacts provide the "allowable actions" (Zhang & Patel, 2006, p. 336) of the technology in the environment. Jonassen (1994, p. 34) argues that "technologies, from the ecological perspective of Gibson (1979), afford the most meaningful thinking when used as tools".

Cognitive artefacts are cognitive simply because they afford and support cognitive activity. The idea of an artefact being cognitive may be a radical one but it may not be a farfetched notion. Take the common practice of using a personal digital assistant (PDA) to aid our memory by storing the information in its database. Did the PDA help our memory? Did it amplify our recall ability such that we are able to remember it the next time? Although it did not really change our memory, it organised the information we entered in the system so that we can retrieve it at an incredible speed, which humans are cognitively incapable of. The artefact was involved in the cognitive function of organising the information for our quick retrieval. So, the artefact performed a cognitive task: "organising" the input data, and "searching" the required data. The cognitive artefact fits into the notion of extended cognition as Dennett puts it, "minds are composed of tools for thinking that we not only obtain from the wider (social) world, but largely leave in the world, instead of cluttering up our brains with them" (2000, p. 21). In fact, Kaptelinin (2003) further attributes artefacts to improve cognition of the group through the collective use.

Nardi (1996) argued that this notion devalues or restricts the meaning of cognition when there is no distinction made between people and things as cognitive agents. Her contention is that for an artefact to exhibit cognition, it must possess the quality of having the act of or process of knowing, including awareness and judgment. She felt that artefacts are incapable of consciousness and therefore, should not be put on the same level of consideration in a cognitive system. Technically, cognition is any activity that involves the act of recall, comprehension, critical thinking or creative thinking, which involves information processing. As such, any artefact that is capable of this action is performing some form of cognition. Recalling and generating knowledge is not the sole prerogative of consciousness. In fact, air conditioners today sense (know) a drop in temperature and turn up (judge and act) the heating. The full array of consciousness (as humans have) may yet be elusive to the most advanced or powerful machine at present but in the future, such possibilities may become a reality.

Conceptually in this research, the artefacts, as afforded in the classroom, become part of the cognitive system. Artefacts are still seen as different from humans but nonetheless, play a significant and equal role in distribution. They mediate cognition being distributed in the system and are in themselves, representations of cognition. This research is about technology that the classroom affords; what are the devices available and how are they used. Technological and non-technological tools afford the off-loading and distribution of cognition. The notion of affordances is crucial here to identify the artefacts that afford and collaborate cognitive activity in the classroom.

## 2.5 Collaborative levels of interaction

In order to understand the different levels of individual and group cognition within a larger activity system, we turn to Leontev's activity theory (1978) for the conceptual understanding. He proposed that human behaviour cannot be adequately explained by reflexionism alone. The mental processes can best be understood with the activity and social context of shared work actions. Engeström (1987) further developed Leontev's activity theory to analyse social systems, by pointing out the social direction of the individual's activity towards the environment where each individual has a role of play (cognitively) to accomplish the larger cognitive task. Analysing just an individual's activity and cognition bears no meaning. But by analysing the whole activity, and its individual members' cognitive contribution to the whole, it would make sense. It is this social intention of the larger picture that makes each member's cognitive activity meaningful. Engeström saw how the individual cognitive role fits into the larger unit whereby analysing either would be meaningless without seeing the social intent. As such, the tools used, mediate the cognitive activity at both individual level as well as the group level. Engeström's model of activity theory includes rules, division of labour and community of the praxis that undergirds the activity among the tools, subject and object.

However, studying the activity interactions as a whole is cited as a problem for researchers as they struggle to reduce, then aggregate or treat as a whole. Valsiner and Van der Veer (2000) preferred the system to be viewed either as a whole or as analysing the individuals in the system. One of the current debates on the social view of cognition is how the cognitive system is ultimately viewed: as a collective whole with the individuals ("fusion"), as parts of a component of the cognitive system, or each individual is still seen separately but interdependent with the environment ("inclusive separation") (p. 6). Either view recognises the socio-cultural influence as primary in the cognitive process of the individuals but the issue is how each individual is related to the whole. Sfard (1998) compared this problem from the perspective of "acquisition metaphor and the participation metaphor" (p. 5), which distinguishes the kind of learning an individual does. Sfard was careful not to equate this difference to the individual and whole on the social axis of learning but rather either metaphor has both, with just a matter of greater emphasis on one over the other. Perhaps the appropriate approach to viewing this is not that both views are mutually exclusive but rather inclusive with degrees of emphasis.

This is the approach this study takes: looking at the students working in a group, first collectively and later individually as participation structures emerge. This may be similar to what Salomon, Perkins and Globerson (1991), on ways of evaluating intelligence between people and technology partnerships, cite on both "systemic and analytic" (p. 4) when considering both aggregate performance and specific contribution by each member. If human cognition is to be fully understood, it is pertinent to consider the holistic as well as the particular without levying any restrictions or limitations on research. The benefit of collective cognition is as equally important as its significance to the individual. The approach this study takes to understand the collaborative learning will be to consider the learning activity as a whole first and the participation structures of smaller groups of individual. Studying a whole activity system suggests a higher ecological validity to individual studies aggregating in order to understand the whole (Greeno, 2008). Studying groups as a whole revealed interesting positive result where pairs of students performed better than individuals (Schwartz, 1995). This would not have been possible if the reductionist approach was used. In fact, adopting the holistic approach reveals the learning entity or social entity of the group, or even a community.

In order to understand how students collaborate (SRQ3), the cooperation and coordination of actions that has relevance to the distribution of cognition have to be studied (Hutchins, 1995a). Collaboration requires interaction and communication and this is where we turn to the approach of social interactions for learning.

### 2.5.1 Social interactional analysis

Interactional analysis has traditionally been used to analyse teacher-student interactions (Sawyer, 2006). However, instead of focusing on teacher-student interactions used in interactional analysis, this study looked at collaboration between students. This learning sciences' tradition of interactional studies that investigates human behaviour (Greeno, 2008), emerged as an alternative to behaviourism in the 1960s and 1970s, focuses on identifying patterns of coordination of individuals in groups working together.

This interactional approach, while focusing on the whole activity system, looks *first* at the group *before* having to fully understand how individuals participate in the system (Greeno, 2008). An outcome of such an approach will lead to conclusions on “principles of coordination of interactive systems” (p. 82) providing for a more holistic understanding. This approach focuses on an activity system comprising of the group and other systems, this study is not saying that the individual is not important but that the individual is constantly being considered in relation to the others in the system and in the general patterns of interaction. The goal therefore, is to understand “cognition as the interaction among participants and tools in the context of an activity” (p. 82). Considered akin to studies in distributed cognition of activity systems, this perspective, according to Greeno, brings the concepts and methods of cognitive and interactional studies together.

Minsky’s “Society of the Mind” (1986) posited that the language of the group can describe what is inside the mind and human language is seen as a traditional criterion for representations of human cognition (Rowlands, 2009). By examining “thinking-aloud protocols”, Simon (1962, p. 151) believes that we can identify “precisely how the subject holds a particular pattern or concept in memory and precisely what processes are” in the mind. Thus, studying the language structure, a representation of cognition, we can see what individuals are thinking. Group learning involves both extensive verbal and non-verbal communication (Sawyer & Greeno, 2009). Greeno (2008) proposes that the data to be collected are “records of interaction" (p. 85). Thus, settings of participants' activity, their talk, gesture and visible representations as they interact are recorded as data. These data on interaction reveal how the group share, distribute, transform and propagate information. Analysing the communication in the interactions has been the main research method of studies in ethnomethodology, symbolic interactionism, socio-cultural psychology, and discourse analysis (Sawyer & Greeno, 2009).

### 2.5.2 Participatory activity

Another approach that analyses the language use in groups is the participant structures (Phillips, 1972), a turn taking sequence of the conversations. Such structures would reveal the distribution of the "functional aspects of activity, including agency, authority, accountability, leading, and following, initiating, attending, accepting, questioning or challenging, and so on" (Greeno, 2008, p. 82). When we adopt the situative approach to interactional analysis of a collaborative activity, we can modify such participant structures to study the joint activity of individuals in the group. These structures, then, are information that are produced and propagated through verbal and non-verbal communication. Apart from analysing the observable social interaction between members, networks or diagrammatic patterns, such activity can be mapped and analysed to see how and what the students distribute the cognition with. So, instead of just participant structures, consisting of turn taking discourse, they include the actions of the interactions with both humans and artefacts. Such participatory structures exist as both the explicit and implicit rules for engagement in any social or artefact interaction. Such structures are also understood as group or community practices, where one learns to be part of and identify with fuller participation of the community's practices (Lave & Wenger, 1991).

A slight distinction needs to be made between participant structures and participation structures. While some researchers make no distinction between them (Greeno, 2008), this research prefers participation structures where the there is a slight emphasis is on *participatory activity* rather than the *individual*'s participation, in line with the focus on the group systems. At the risk of splitting hairs, the purpose here is to orientate the focus on the *participation* of the students and not the *participant*. Thus, the participation may involve several students for the various number of sub tasks or actions that aggregate to the completion of the entire task. The analysis is not focused from the angle of the individual's dialogical interaction with others, but from the angle of group interaction.

### 2.5.3 Cognitive network

By studying participant structures, we can observe patterns of interactions between student to student and teacher. Using socio-mapping, we identified which student preferred to talk and which student prefers talking to the teacher. A socio-mapping is a graphic representation of social links connecting one person to another. However, the purpose here is not to study the personality preferences or social dispositions, but to identify the interactional networks that represent the flow of cognition. In so doing, we can understand how cognition is distributed between students and the teacher. An example of a cognitive network between students and teacher talking in a group is shown in Figure 2.2. The cognitive network includes not only human interactions but also interactions between human and artefact, as shown in Figure 2.3.

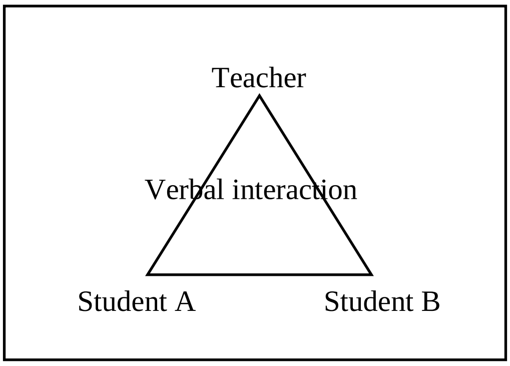


Figure 2.2 Cognitive network A

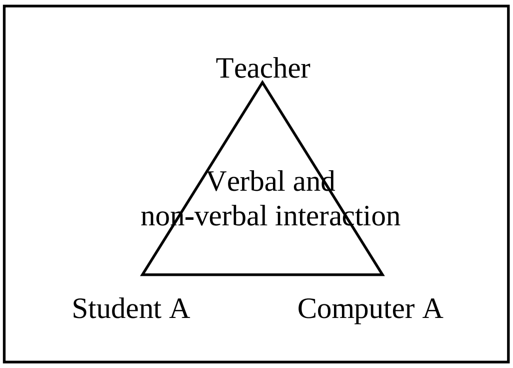


**Figure 2.3 Cognitive network B**

By looking at the participation structures in this study, we can uncover the levels of collaboration and how these levels interact with each other (SRQ3). We can identify the pattern of relationships and activities of the cognitive system. Such multi-layered and interconnected levels of interaction go back to the notion of extended cognition where the system is observed to re-configure itself (Hollan et al., 2000) with sub-systems enjoining in the interactions in the system while accomplishing the cognitive task.

### 2.5.4 Levels of interaction

This research then, considers a few levels of cognitive interaction as depicted in the framework (Figure 2.4) generated for the study. The levels of collaboration are parallel and emerging, both within and outside the group. This results in several interactions occurring at the same time and along the time line to the end when the task is completed. Three levels of cognitive interaction are proposed: the individual (I), sub-group (SG) and group (G). Both individual and group levels occur in parallel and are interspersed with sub-group (SG) and smaller sub-group (SSG) activities. Any number of SSG's interaction can occur and are nestled within the sub-group interactions (e.g. SG1). An emerging character of the cognitive processes in the system consists of $SG_n$ and $SSG_n$. Emergent relationships also occur between groups and sub-groups within ($E\text{-}wg_n$) and outside the unit of analysis ($E\text{-}og_n$). These emergent interactions involve the activity between the mental spaces of the people, artefacts and environment.

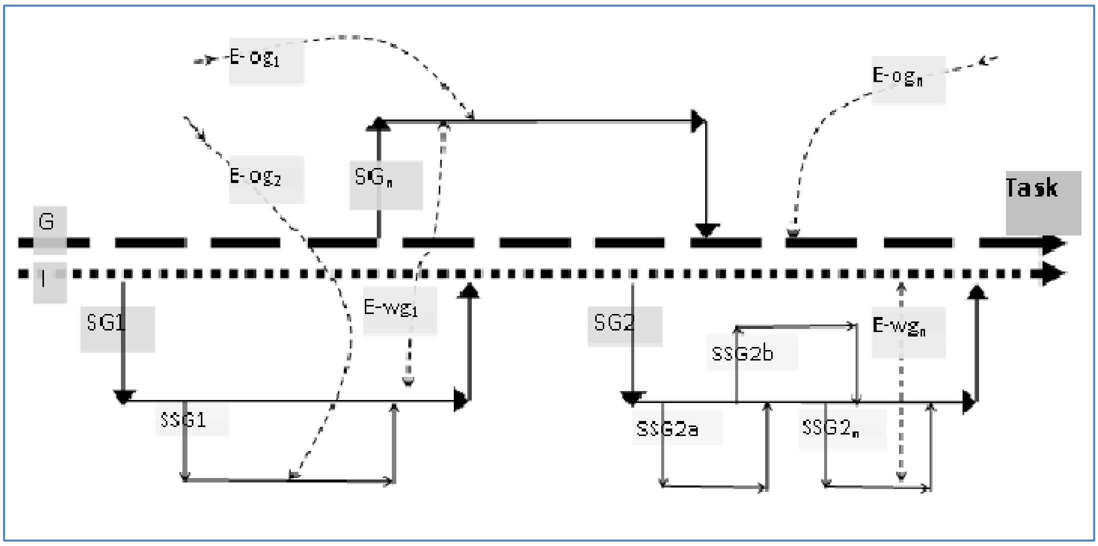


**Figure 2.4 Levels of group activity with emerging relationships over time**

Using this framework (Figure 2.4), this study seeks to answer the specific research questions on the cognitive processes (SRQ 1) and levels of collaborative interactions (SRQ3) in the classroom.

## 2.6 Japanese classroom culture

Because of the social and cultural context of this study, we turn to a brief discussion on the Japanese classroom culture. In general, the Japanese are characterised by having a collectivistic culture (Hendry, 2003; Okawara, 1982), promoting conformity to group goals, with emphasis on cooperation, harmony, and interdependence in social life (Mouer & Sugimoto, 1986). Japanese schools have been seen to "complement...the working order of industry" (Rohlen, 1983, p. 168) and "shaping generations of disciplined workers" (p. 209) where "long-standing Japanese virtues of self-control, dedication and singularity of purpose are admired and rewarded" (Hendry, 2003, p. 94). Even when students are young in elementary schools, students are grouped to be "responsible collectively for various tasks" (p. 85). Order is maintained where duties and privileges are shared equally amongst groups of students. Under such environments, Japanese students are expected to behave in a highly collective and cooperative manner. The goal of communication for the Japanese is "wa" (the Japanese character for harmony) and conflicts or disagreements are conceived as threats to this harmony (Sekiguchi, 2002). Fox (1994) describes the experience in a Japanese classroom: "I used to feel guilty in Japan because I was too critical. In Japan, the teacher teaches, the students take notes. . . . As soon as you ask an interesting question, it's rude. . . . The Japanese are so eager to create harmony. You just can't break the harmony. (p. 56)". Students defer, listen and agree amicably with each other throughout the phases, practising "routinised control" (Giddens, 1991, p. 56) where each member seeks to maintain this harmony.

This group harmony is further accentuated by the notion of intimacy in smaller groups. In his argument that it would be culturally difficult for Japanese to express disagreement in class, Sekiguchi (2002) argued that communication in smaller groups is akin to the "social exchange" conditions of a conversation which Japanese are more comfortable to share in. This "social exchange" is seen as an exchange of one's resources and effort in expectation of reciprocity from the receiver done at a more personal level rather than a business exchange (Moeran, 1984). As part of the harmony mentality, reciprocity is taught from young to "do as you would be done by" (p. 51) where a child is "trained out of its natural selfishness". The discipline of the group in class is "generated by the pressure of peer group" (p. 54) where unacceptable behaviour is publicly discouraged and offenders are made to "feel most uncomfortable" when group norms are threatened. Cooperation is also highly valued over individual endeavour. This research recognises these cultural traits of harmony, "social exchange" and group mentality exist in the classroom.

### 2.7 Summary: framework for unit of analysis

First, the concept of extended cognition is crucial to the main research question of this naturalistic study in setting up a conceptual framework (Figure 2.5) to study how cognition is distributed in the classroom. The concept re-configures the unit of analysis, extending the boundaries of the mind to the environment, to include the students, teacher, and artefacts in the classroom. This framework provides the basis for the study of groups of students collaborating on a task in the classroom. This framework also lets us examine the group cognition phenomenon as a whole rather than the individual as the starting point.

Second, cognition can be observed informationally, teleologically and causally through the external representations of internal cognition. Thus, allowing the possibility of observing the processes of memory and information to study the cognitive processes in the classroom (SRQ1). Third, the approach of interactional analysis permits the analysis of participatory structures, social interaction and

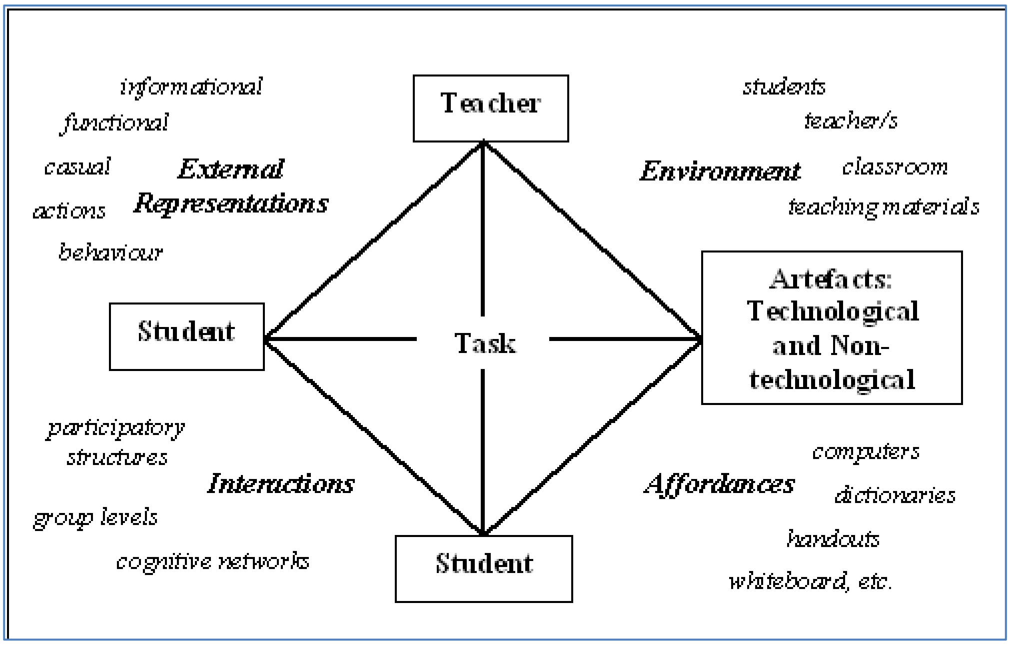


**Figure 2.5 Unit of analysis for learning in activity**

cognitive networks, enabling the study of levels of collaboration (SRQ3). In addition, interactions, both verbal and non-verbal, and as representations, reveal the cognitive processes of the collaboration (SRQ1). Fourth, the environment affords the use of artefacts for collaboration and permits the study of their role in the distribution of cognition (SRQ2). Artefacts are considered cognitive when mediating cognitive processes and are in themselves, representations of cognition, thus revealing the cognitive processes in the collaboration (SRQ1). Fifth, the environment also affords the classroom culture of the participants: the students and teacher, which influences the cognitive processes. The environment also affords the nature and duration of the task that governs the boundaries of the distribution and extension of cognition in the classroom. These theoretical considerations then undergird this study and perhaps, enable it to map the cognitive processes in the extended cognitive system of the classroom.

# CHAPTER THREE

# METHODOLOGY

## Introduction

The aim of this research is to study how students collaborate in a technologically enabled classroom of a college in Japan. This chapter will detail and discuss this research's paradigm and methodology design of data collection and analysis.

This chapter is subdivided into:

3.1 Research paradigm and methodology

3.2 Data collection

3.3 Data analysis

3.4 Rigour of study

3.5 Ethical issues

3.6 Limitations of methodology

3.7 Conclusion

## 3.1 Research paradigm and methodology

### 3.1.1 Interpretivist paradigm

The positivist research paradigm has been dominantly employed in socio-psychological studies that have an educational focus (Creswell, 2003; Borg & Gall, 1989). Only in the last few decades have studies from the interpretive research paradigm gained increasing acceptance. Positivism asserts that universal principles and laws are "out there" and can be known by observing and collecting data objectively. Research using this paradigm is empirical in nature, deductive and theory testing. Due to criticisms that there is no such thing as “theory free”, “value-free” or objective sense making, knowledge and understanding of reality should more accurately seen as constructed, interpreted, and modified by people and the meaning they place on them (Easterby-Smith, Thorpe, & Lowe, 1994). The interpretive research paradigm is also known as discovery-oriented, subjectivist, and naturalistic (Lincoln & Guba, 1985). Its key thrust is that knowledge is understood through interactions between the individual and the world. Instead of seeking to explain, it seeks to understand; instead of testing hypotheses, it builds theories; instead of being an independent observer, it acknowledges that it is part of what is being observed; instead of deconstructing the phenomenon, it looks at it holistically. There were three specific research questions to help answer the main research question, how cognition is distributed across a group of students collaborating on the learning task:

**SRQ1. What are the observable cognitive processes and representations in the classroom?**

**SRQ2. What artefacts are accessed and how are they used?**

**SRQ3. What are the levels of collaboration and how do they interact?**

The research question asks about the students’ lived experience in the discussion group: how they distribute cognition. Human actions and behaviour in a real life classroom group activity are the main investigation interests. Such research into human behaviour and complex situations requires the qualitative approach to harness the richness of data for analysis (Creswell, 2003; Marshall & Rossman, 1999; Mertens, 1998; Borg & Gall, 1989). The data is gathered and understood from the participants' perspective (emic) and observed by researcher (etic). Given the situatedness of human activity and uniqueness of particular actions, this study is naturalistic rather than experimental and does not have a priori theorising or hypothesising.

The data collection was done in a natural setting, not in a controlled environment where subjects are decontextualised from the surroundings and with each of the variables being observed separately. The natural setting meant that there were interplay of confluences and emergent influences. These emerging and unpredictable data are the interests of this research and only qualitative data is able to understand this phenomenon holistically (Creswell, 2003). The primary goal of this study is exploratory in nature and inclusive of the context. Interpretive research is known to uncover little known phenomena (Strauss & Corbin, 1990) as this study aims to do.

### 3.1.2 Researcher effect

As a participant researcher, I am aware that my actions and observations have an influence on the phenomena. The fact that the participants are aware of my presence and that they are being observed will affect their behaviour. The polyvocality of my position as an interested researcher, recognised teacher, occasional friend to the students, experienced educator to undergraduates, employee of the college and a foreigner living in Japan, all would have influenced and filtered my data collection. As a primary instrument in collecting the data, my feelings, impressions, interpretations and invariably my judgments came into play in my understanding of the phenomena (Denzin & Lincoln, 2000). As a researcher in culturally familiar surroundings, I was implicated not just as an insider, teaching in this college for the past three years, but by my field of expertise as an educator, familiarity with classroom scenes as well as my deep interest in the use of technology. I have used computers to teach and have been an avid advocator for collaborative and active learning for the last fifteen years. Such familiarity with the environment would offer deep insights (Hannabus, 2000) for my study. Also as an insider, I was not limited in terms of understanding hidden meanings and achieving a level of trust with the participants (Labaree, 2002) where an outsider would. However, such familiarity would have impaired my sensitivities and rendered my observations less strange to the studied phenomenon when compared to a non-educator and non-technological researcher (Mercer, 2007). Yet, being a non-Japanese, the unfamiliarity with Japanese students may provide the freshness that an ethnographer would like to have, having just been here for the last three years. Another issue was the power imbalance imposed by me as a teacher in the college (Mercer, 2007). Although this may be mitigated somewhat due to my status as an "outsider" to the observed classes belonging to another faculty member, the participants still recognised me as a teacher who would have or might be teaching them in future.

### 3.1.3 Data collection methodology: ethnography and social interaction

In this study, the theoretical concepts of situated and extended cognition provided the basis for an ethnographic study and social interaction analysis. These established theories into cognition engendered the observation of a cognitive phenomenon as whole rather than discrete and separate elements to be studied. The previous chapter has discussed these concepts extensively to undergird this study.

#### 3.1.3.1 Ethnography

Ethnography in education is understood as research using "participant observation and/or permanent recordings of everyday life in naturally occurring settings" (Delamont & Atkinson, 1995, p. 15) in educational institutions. The range of data collected is mostly qualitative with the researcher as the major instrument of research (Gordon, Holland, & Lahelma, 2001). Ethnography is also a common research method in studies that investigate cognition that is socially distributed (Hutchins, 1995a). Ethnographic methods, observation, interviews and artefact analysis are considered common and established methods to study distributed cognition in a group setting (Jones & Nemeth, 2005). In fact, Hutchins coined "cognitive ethnography" (p. 371) to study how cognition is distributed in naturally located systems. Cognitive ethnography studies the processes or activities that effect and or affect work performance in a natural setting. Originating from the anthropological field, ethnographical studies take into account the social and material contexts where the actions are carried out together with the meanings of the social practices that are attached. Ethnography aims to provide accounts of activity as perceived and recognised by the participants present within the setting as participant observers. In the case of cognitive ethnography, the actions and behaviour of individuals that facilitate information flow, social organisation and cultural processes are observed, documented and analysed as a phenomenon. Ball and Ormerod (2000) pointed out that cognitive ethnography has "observational specificity" (p. 151), as opposed to the all encompassing and intensive nature of a typical ethnography. The "observational specificity" meant that I observed by keeping an eye for any action or behaviour that indicated a distribution of cognition. It was not all encompassing because I did not trail the participants before and after the classroom observations. Neither did I spend time in social interaction to collect more ethnographic data. Rather it was intense in the repeated watching of the video recordings of the activity *after* the in-situ observations. Additional on-site observations, which were not videotaped, were made as and when time and rights of access were permitted. And because of its specificity, it was purposive, focusing on properties pertaining to cognition. When studying cognition ethnographically, social factors that determine the meaning for cognitive processes are recognised. By analysing how participants use resources to make their actions meaningful, we can gain a more complete understanding of the cognitive activity being carried out. The goal of this research to study cognition, traditionally recognised to be in the head, seems to be diametrically opposed to an ethnographical studying of disembodied cognition of individuals. As argued in the previous chapter, the notion of extended cognition and its necessity of considering cognition and the context *enabled* a framework to observe cognition outside the head. The notion of extended cognition premises the unit of analysis to include not just the participant alone, but the collaborative activity between several participants situated in the material environment – the tools, documents and artefacts used.

Because this was an ethnographic study investigating the flow of information, the research collected and analysed the external cognitive representations of students. In the social study of cognitive science, cognition can be observed in the external representations across media. The media include any observable medium that transfers, stores and retrieves information. In this study, categories of such external representations included the conversations between students, coordination of actions and behaviour, and cooperation with each other in order to complete the task. The types of coordination analysed were the processes of social relationships between individuals and between the artefacts.

As an ethnographer, field notes were taken for each observation. These field notes are recognised as not a complete, objectively accurate or neutral set of data, but as socially constructed texts, giving a "frozen" description of the observed, from the viewpoint of the ethnographer. Even though I set out to observe and record as accurately as possible, I was keenly aware of my constant selective filtering, reading, encoding of texts and my bias. This position of power, being able to interpret and author the notes into what I regarded as meaningful and of interest, was something I had to contend with in each observation. This bias was mitigated with members checking (section 3.4).

The field notes recorded the time, date, setting of the field. The field notes were made in three ways. First, on-site observation generated general notes about the setting, participants and activity. Categories and codes were also annotated. Additional observations in classrooms and repeated viewing of the videotaped sessions added to the coding. Subsequent observations generated fewer categories due to the saturation. Second, a reflective diary was kept with entries made after each observation. This discussed the concepts, methods and processes that were used and observed. Third, memoing was created to discuss concepts on the creation, propagation and storage of cognition. This constituted part of the analysis, examining emergent data, themes, categories and ideas about the data. This memoing was done contemporaneous, during observation as well as retrospectively, after each observation. There were two types of memoing taken which will be discussed in section 3.3.3. All these three forms of data collection were conducted in tandem with the observations over the time-frame right up to the writing of the dissertation. The observational fieldwork was carried out in the time frame (Appendix A) after agreement with the teachers and students of the classes. Rights of access and ethical issues were duly observed (section 3.5).

#### 3.1.3.2 Social interaction

Social interaction studies are often linked to approaches in classroom research, such as ethnomethodology and symbolic interactionism. Ethnomethodology looks at how "folk" methods are being used to organise the world around them. Symbolic interactionism studies how people make meaning as they relate with each other in everyday situations in schools. These interpretative approaches in social interaction concentrate on the internal life of the schools and close analysis of videotapes of classrooms were extensively used (Gordon et al., 2001). In fact, these approaches have led to a rich and increased understanding of everyday processes in schools. While social interactional studies focus on how the interactions between individuals are constructed from the use of the cultural resources in the classrooms (Hammersley & Atkinson, 1995), this study looked at how the interactions facilitated the distribution of cognitive representations. In other words, I was not interested in how these interactions were formed but how these interactions influenced or facilitated cognition.

The interactional analyses also involved discourse analysis of participants' conversations where information is verbally shared. By studying the language use, considered a representation of cognition, we could see what individuals were thinking. Group learning involves both extensive verbal and non verbal communication (Sawyer & Greeno, 2009). Analysing such communication in the interactions has been a main research method drawing from disciplines such as ethnomethodology, symbolic interactionism, socio-cultural psychology, and discourse analysis (Sawyer & Greeno, 2009). The language use was analysed from participant structures (Phillips, 1972), a turn taking sequence of the conversations that showed how information was shared and distributed. Talk, being a key medium for classroom interaction (Wells, 1999; Cole & Engstrom, 1993; Delamont, 1976), was observed, recorded, analysed and transcribed to show the process of cognitive processes. Transcription made visible the social-interactional activity (Cole, 1996). Strict transcription codings were not observed as the goal of this study was not to study language structure, syntax and use but rather transcribed for the ideas and information flow (Chafe, 1987). The transcription focused on the words used and they were coded, and compared with the coding from the observation and interview. The transcription was influenced by the theoretical issues of this study (Ochs, 1979) and determined which aspects of interaction were attended to and how they would be represented. Being multimodal in nature, and influenced by the site's cultural and social processes (Scollon & Levine, 2004), the interaction was also observed for the non-verbal behavior that represented the cognitive trace. Cognitive representations, such as audible words, readable texts on notes and whiteboard, were observed to see how information flowed between participants.

Interactional analyses of the participatory activity of the participants involved observation in order to understand how cognition is distributed. These participatory activities were the interactions and communication lines between students. When a student was talking to another student, both these students formed a cognitive network that was connected by the audible words (Appendix F). When a student was working on a computer, the visual connection and mechanical movements of the computer mouse and keyboard typing formed another network. These networks were mapped to get a holistic view of the cognitive and social processes involved in the collaborative learning. They were described ethnographically together with graphical description of their relationships. These networks revealed the patterns of distribution of information and cognition.

### 3.1.4 Data analysis methodology: grounded theory methods

Grounded theory methods were used to analyse data derived from observations, participants' interviews and documents analysis. There may be different variations of grounded theory methodology, but they all share certain common characteristics (Charmaz & Mitchell, 2001). In short, grounded theory methodology is an iterative process of collecting, coding, comparing, categorising, and integrating categories in order to develop a theoretical framework from the data. In methodological terms, grounded theory is about conceptualising data and eventually developing a theory or theories from the data to explain a basic social problem faced by a specific group (Strauss & Corbin, 1998). A basic social problem can be understood as any social phenomenon that needs to be unravelled. While seeking to build a theory may not be the primary concern of this research, a tentative theoretical construct was not ruled out. While a grounded theorist would exhaust categories through theoretical sampling and conduct literature review after the data collection and analysis, this research differed in that literature was conducted first to lay a conceptual (not necessarily theoretical) framework to undergird the study (Charmaz, 2006). This study coded what was observed related to cognition in the field and used two of the three phases of coding in grounded theory methods: open and axial (Strauss & Corbin, 1998).

Ethnographic data collection generates so much data that researchers can find it difficult to make connections or find relevance during the analysis (Charmaz & Mitchell, 2001). Grounded theory methods help to focus, structure, and organise ethnographic data by "raising description to abstract categories and theoretical explanations" (p. 162). Seen as a flexible strategy for collecting and analysing data, Charmaz and Mitchell consider it helpful for ethnographers "to conduct efficient fieldwork and create astute analyses" (p. 160).

## 3.2 Data collection

### 3.2.1 The setting and participants

The research was conducted in a small private liberal arts college in Japan. 73.5% of all university students were studying in a private college in Japan (MEXT, 2004, p. 4). This college was unique because it uses the English language as its medium of instruction and all the students were expected to use English when they were in the college. The core educational philosophy of the college was active learning where the students were actively engaged in reading, writing, discussing, and problem solving in their classes. The teacher and student ratio was low at 1:15-20 in the classrooms. The total student population size was about 400 with a gender ratio of one male to three females and an age range from 17 to 21 years of age.

Almost all of the student population had Japanese ethnicity and none had studied overseas prior to enrolling at this college. The courses were liberal arts in nature with majors in humanities and social sciences being offered together with concentrations in English language, world culture and psychology. The sampled students were in their first year of studies and they were in their "general education" course of studies and would be representative of typical college students before going into their specialisation in the second and third year. The participants were college students collaborating on a task in a classroom. The class was of mixed gender and ability. The choice of college and class was based on easy access, ethical issues and costs (Mertens, 1998). Time and scope of study constraints did not permit more sampling of other courses in this study; nonetheless, they should serve as a starting point for more substantive research in future. The college was technologically enabled with a wireless internet connection throughout the campus. Besides having four computer classrooms dedicated for teaching, there were also two study rooms equipped with computers. The student computer ratio was 4:1. Students had little prior group work experience, as they would have just finished high school before entering into this college. Out of the total of 48 students, about 23% had prior group work experience in schools.

### 3.2.2 Sampling

This research, focusing on students' cognitive activity in the classroom, requires a sampling of "groups, settings, and individuals where the processes being studied are most likely to occur" (Denzin & Lincoln, 2000, p. 20). Using a combination (Miles & Huberman, 1994) of two types of purposive sampling (Patton, 2002), typical case and intensity sampling, this study examined deeply into the students' collaborative activity that represented an ordinary case of group work with technology in a classroom.

#### 3.2.2.1 Typical case sampling

Typical case sampling can be informed by statistics to identify “average-like” cases from normal distribution of the characteristics (Patton, 2002, p. 236). The typicality of the sampling centred on the type of class, task, students and teacher.

#### 3.2.2.2 Sampling of class type

The class selected was based on a common subject taken by all students. The subject matter was not crucial as the focus is on how students learn an activity. The sampled classes were core courses that every student was required to take in their first year of studies (Table 3.1). A total of three courses were observed (two English Language courses and one Introduction to Psychology course). In this college, 50% to 60% of the courses, offered to the first and second year students, employed technology in the classrooms. Almost 100% of the courses used some form of group work activities in class. Informed by key informants (Patton, 2002), the teachers who frequently used computers with group work, the typicality of the class grouping was also reflective of the overall composition and size of members in collaborative tasks. The teachers grouped students in fours due to the size of the classes ranging from 15-16 students.

**Table 3.1 Type of classes**

| Class | Psychology | English Class A | English Class B |
|---|---|---|---|
| **Members in each group** | 3-4 | 3-4 | 3-4 |
| **Sessions using technology** | 31 out of 43 | 8 out of 14 | 20 out of 28 |
| **Sessions using collaborative learning** | 40 out of 43 | 10 out of 14 | 23 out of 28 |

#### 3.2.2.3 Sampling of task type

The typicality of the task was reflective of the overall nature of the tasks in the observed classes both in the use of technology and collaborative tasks (Table 3.1). This study was careful to sample tasks of similar nature and collective goals (Nye & Bower, 1996). The tasks that were sampled were of the listening collaborative jigsaw type (Aronson, 2008), where students had to listen for different information before collaboration. The listening task identified for this study was a common task according to the teachers interviewed. They had used this type of group listening task at least five to seven times in the past semesters. The listening task was given to all four groups in each of the observation sessions. A sample of a task is found in Appendix C. The tasks required them to use the computer to access the information. Prior to coming together, they have to listen and understand an audio clip that was different from one another. The different audio clips contained the necessary parts of information that were required for the completion of the task. The worksheet required comprehension, organisation, reassembling and application of information. Sampling a similar type of task facilitated data analysis by "bounding the collection of data" (Miles & Huberman, 1994, p. 27).

#### 3.2.2.4 Sampling of type of students and teacher

The class was an ordinary class comprising the usual grouping of students with mixed abilities. All of them had six years of formal high school education comprising three years in junior and three in senior high. This was reflective of about 98% of the student population. The students had an average score of 355 for TOEIC, an English proficiency test for business English, which reflected the college average of 349. The students in the class were randomly allocated with no deliberate control over abilities or socio-economic factors.

A total of 48 students (31 females and 17 males) were observed working in groups in this study. 81% (39 students) of the students had at least a year of using the computers with about 55% (26 students) having more than four years' experience before this observation. However, there were 20% (9 students) who had less than a year of exposure to computers and 15% had no experience. It was evident that most of them were familiar with use of computers. This percentage was typical and reflective of the 88% of Japanese college students owning a computer in a survey (Mok et al., 2008). In contrast, only 57% (27 students) had been exposed to group work for more than one year with 43% (20 students) having had less than a year and a surprising 35% had no experience. While those who had over four years of experience numbering 15 (29%), learning in groups had clearly not been a prevalent practice. In this college, active learning in groups was the teaching philosophy and the students were exposed to group work from the first day of school. Most of the 20 students that stated that they had less than one year of experience in group learning, confirmed in the interviews that they were only exposed to this form of learning only after they started learning in this college.

All the teachers had an average of ten years of teaching experience. All except for one used group work and IT in the early years of their teaching and thus had considerable experience. They were all exposed to group work since their post graduate days and saw that as their first exposure to the potential and benefits of group learning. Use of IT was a later introduction to their teaching career after being convinced of its potential and necessity in the classroom. All except for one were considered to be highly familiar with IT use in the classroom by their own admission.

### 3.2.3 Data collection design

This research used the two major techniques of collecting qualitative data, observation and interview (Madriz, 2000). Ethnographic studies rely on direct observation as the primary research instrument. In addition, document examination was used. The document examination included all artefacts, both technological (computers, electronic dictionaries, mobile phones and digital audio-visual equipment) and non-technological (notes, paper, whiteboard, text, images and objects). Because the document examination included all objects beyond just paper that were relevant to the group, I will henceforth use "artefact" to replace "document" in order to more accurately describe this part of the data collection.

The data collection began with observation first, followed by interviews and document examination. The observations served as the primary source of data with the interviews and artefact examination as supplementary data. All the observations were videotaped to alleviate the challenges in observing fast movements and balancing between the holistic and detailed descriptions (Marshall

& Rossman, 1999). Repeated viewings of the videos were done for accuracy and for more data to be added to the persistent observation of the participants.

Data from observation informed the interview and vice versa, and subsequent video observation resulting in triangulation of data. Emergent data from the interviews and document analysis pointed to more details in subsequent viewing of video recordings. The observations informed the structure of the interview schedule and questions where there were specific actions to be clarified or discussed. For example, a student was observed mumbling to herself while reading off the computer. This was followed up during the interview session. Interview data also informed further viewing of the video recording and subsequent in classroom observation. For example, after an interview with a group, a student mentioned an action that she did in order to remember a piece of information. That action was viewed again for verification.

### 3.2.4 Observation

Unlike participant observation, the form of naturalistic observation adopted was non-participant, offering full concentration and uninvolved participation in recording field notes to observe the activity. This was because the researcher was observing another teacher's class. This tended to lessen the halo or bias effect of an involved observer where a participant observer would have established some form of a relationship with the students. In some ways, I was like a stranger who was able "to survey conditions with less prejudice" (Simmel, 1950, p. 405). Visual familiarity with the observer was achieved by visiting the class a few times before the actual observation class. Students were told on the days they were being observed. The video equipment was set up in the classroom every time the class met to gain visual familiarity. In order to offset the problem of obtrusiveness, the researcher was positioned outside the zone of activity, at a corner of the room.

Indeed, there was a limit to how long (fatigue sets in) and how much (immense amount of data) I can observe in detail. This limitation was mitigated by the use of video recordings that supported fieldwork in investigating how students "accomplish activities using talk, body movement, objects, artefacts and the physical environment" (Heath, 1997, p. 197). Video recordings, with multiple cameras, provided "access to such complex tasks" which "unpack the interactional organisation of social actions and activities in these technological settings" (p. 197). Moreover, the sequential and interactional organisation of the participants' actions and behaviour is "an important analytic resource for investigating how they themselves are orientating to each other's conduct and accomplishing their activities" (p. 188).

#### 3.2.4.1 Observing cognition

In order to answer the main research question and SRQ1, the tools, duration and nature of distribution, transformation and representation were observed. The observation had an "eye" on cognitive representations. The cognitive representations are the visible and external representations of the flow of the information (Hollan et al., 2000) including emerging qualities in the distribution. The observation began with an open observation on all activity, behaviour, action, communication and interaction between member and artefact within the cognitive system (Clancey, 2006) that had to do with the distribution of information. Later observation from video becomes semi-structured with a focus on activities that were “off-loading” cognition (Pea, 1993, p. 69), amplifying cognition (Hutchins, 1995a) or storing information (Norman, 1991). Repeated viewings of the videos were also done to clarify behaviour and further identify categories. Some of these behaviours were used as questions for the interviews. Because of the importance of the idea of distribution, the latency and duration issues of the distribution (Hutchins, 1995a) were also observed.

#### 3.2.4.2 Observing levels of collaboration, processes and interactions

In order to answer the specific research question on what are the processes, levels of collaboration and interaction (SRQ3), the relationships and activities of the members and artefacts of the cognitive system were analysed. Various forms of coordinative actions and emergent coordinative behaviour were identified in order to make sense of the group interactions. This included identifying and explaining invented visual representations that occurred which possessed meaning and constituted shared cultural models (Liu et al., 2008).

Each phase was described as accurately and as detailed as possible from the beginning to the completion of the task. The observation began from the class to groups, observed as an entity in its relationship with others. Observations then moved on to individuals within the group: the interactions between the individuals in the group, who they were talking to within and outside the group in order to establish patterns or characteristics of configurations of the interactions. These included distractions from within and without. Types of participant interaction levels were identified together with types of participant and artefact levels. The frequency and intensity of each type and level were also observed.

Repeated viewing of the videotapes helped to fill in the gaps missed during on-site observation. The phases of the students' activity such as listening to the teacher, taking of notes, discussion and clarifying the task were sequentially recorded to understand what processes and interactions were involved in the distribution of cognition. The specific nature of cognitive behaviour such as clarifying, organising, generating, integrating and synthesising information were observed and noted. This allowed the researcher to understand what were the intent and outcome of each distribution.

**3.2.4.3 Observation schedules**

Three classes were observed and videotaped twice over the same semester of 14 weeks, 4 to 5 weeks apart (Table 3.2). All these tasks had the similar structure of listening to an audio clip from the computer and working on an information gap group task. Other observations that were not videotaped amounted to another nineteen sessions in order to ensure some form of prolonged engagement. These other nineteen sessions were group work with the use of technology but may not be necessarily similar to the ones that were sampled and videotaped. The observation began at the beginning of class to the end of the group activity. The first observation was done five to six weeks into the semester (Appendix A). Each observation of the group activity lasted from a range of about 45 minutes to 105 minutes.

**Table 3.2 Profile of classes**

| Class | Psychology | English Class A | English Class B |
|---|---|---|---|
| **Year** | 1 | 1 | 1 |
| **Number of groups** | 4 | 4 | 4 |
| **Members in each group** | 4 | 4 | 3-4 |
| **Number sessions observed in detail** | 2 | 2 | 2 |
| **Number of other sessions observed** | 9 out of 31 | 4 out of 8 | 6 out of 20 |

Details of each observation's time duration and specifics are found in Appendix A. Each group had two camera angles trained on opposite sides to minimise blindsiding. Each group was audio taped. The video cameras were positioned high up at the four corners of the room to achieve good vantage points (Appendix B).

### 3.2.5 Individual and group interviews

This research used both individual and group interviews. Group interviews, a key qualitative data gathering method (Fontana & Frey, 2000), were conducted with the students. Individual interviews were conducted with the teachers.

#### 3.2.5.1 Group interviews with students

At the beginning of the group interviews, students were solicited individually for their views on the use of technology and group work (Questions 1-27 in Appendix D). This was done by having the students fill out a questionnaire without any discussion for about ten minutes before the interview began. This short survey allowed the researcher to have a general sense of what each student felt about the collaborative processes in class. Semi-structured questions were used due to the focus on cognition and their flexibility (Mercer, 2006). These included open-ended questioning techniques or "conversations", as opposed to structured interviews

(Marshall & Rossman, 1999, p. 108) were used to elicit students' internal experience (Silverman, 2004). Initial interviews were audio taped but subsequent ones were not recorded due to logistical constraints. All the interviews were conducted in the same classroom and in groups in order to aid in contextual recall, for a safe environment, in the company of similar social, economic, and cultural backgrounds (Madriz, 2000). The objective of these interviews was to clarify concepts, ascertain certain actions, explain ambiguous behaviour, and validate categories and their relationships, treating "respondents' answers as describing some external reality" (Silverman, 2004, p. 122).

The group interviews began with a brief showing of the recorded video clip. An example for the need to elicit and clarify specific information, questions (Appendix D) concerning a segment in the student activity were asked. These segments were identified from the observation. Open-ended questions were also used to elicit feelings and evaluations about certain aspects of the activity. Additional or follow-up interviews were scheduled to clarify the data. In total, there were 15 interviews with three follow-up interviews. Each interview lasted between 30 to 45 minutes.

#### 3.2.5.2 Interviews with teachers

The teachers' interviews were conducted in the researcher's office. Semi-structured questions (Appendix E) were used, focused on the teacher's use of group work and use of technology in the classroom and were sent to the teachers a week in advance. The teachers were asked about their perspective and evaluation of the learning activity with reference to the use of IT and group work. As an individual interview, it offered an in-depth understanding (Silverman, 2004) into the teacher's history of use of IT and group work. As an insider researcher, the greater degree of commonality with the interviewees afforded more candour and less "information bias" due to the low power distance and rapport (Mercer, 2007, p. 8). It also provided an avenue for interpreting culture-based cues in an interview (Haniff, 1985). I was mindful not to reveal any of my own thoughts about the same matter in order not to influence the interviewee (Holstein & Gubrium, 2003). Yet, the interviewees knew of my persuasion towards group work and use of technology and I recognised that the data collected may be unduly influenced (Cresswell, 2003).

#### 3.2.5.3 Interview schedule

The interview schedule began with a quick recap of the learning task via showing the videos of the opening minutes of the observed class. This helped the interviewees to remember and set the focus of the interview. The initial questions were general, respecting participants' views and subsequent questions were built on emergent data (Merriam, 1998). Specifically directed questions with reference to the video recording were asked to determine the reasons and purposes of actions and behaviour. The schedule ended with open-ended comments. The interview schedule is found in Appendix D-E and transcripts in Appendix J.

### 3.2.6 Artefacts

In order to answer SRQ2, documents and artefacts were accessed, the range of tools used in and during the group activity in relation to the distribution of cognition were identified. All artefacts that affected, contributed and stored any representation of cognition were collected and examined (Dwyer & Suthers, 2006).

All artefacts considered to be significant by the participants were collected: some briefly and others more extensively to record their size, location in the room, the functions and manner of usage by the students. These were identified from observation and interviews. The frequency of access and usage was noted together with the functions that each artefact played. Another useful data was each artefact's relationship with information: What does it do to pieces of information? Does it store, retrieve, organise, generate or display information to the user? What were the modes of transmission from input to output?

The issue of timing of artefact collection was an issue as some artefacts were time-sensitive: they deteriorated or changed over time (Hutchins, 2002). While most of the artefacts were collected at the completion of the cognitive task and process, some had to be examined during the actual observation as they changed over time. Examples of these were: a note written on a hand for recall purposes, which were erased over time, or a word that a participant consulted on the electronic dictionary that would not have been possible to retrieve later. As a result various such instances of artefacts were lost or could not be collected during the observation time. As much as possible, all artefacts that had a part to play in the distribution of cognition were collected.

### 3.3 Data Analysis

To analyse data, coding, a formal representation of the data organisation, analysis and induction process (Marshall & Rossman, 1999), is used to organise the data into meaningful information. A coding scheme, considered the "first level of coding" (Merriam, 1998, p. 164), was applied to identify the information about the data. In this study, no pre-conceived codes or categories were used due to the lack of existing literature in this genre. This research looked for categories or themes and patterns that emerged. They were generated during and after data collection (Ryan & Bernard, 2003; 2000).

Two types of coding drawing from the grounded theory methods were used: open coding and axial coding (Strauss & Corbin, 1998). Akin to the constant comparative method, each piece of relevant data was continually compared with others to generate conceptual categories that encompass as many behavioural variations as possible. This comparison was done through asking questions of the data provided by each action or category to ensure there were no similarities.

### 3.3.1 Coding

Open coding involves labelling a characteristic as suggested by the data (Strauss & Corbin, 1998). In this study, an action, artefact, or representation that facilitated cognition was labelled. The labels of the categories have a cognitive theme. Some examples are "transforming from audio to visual text" and "distributing from one to many". These categories were abstractions from the data (Merriam, 1998), conceptual meanings of the cognition being studied that were internally consistent but different from each other (Guba & Lincoln, 1985). The analysis developed categories that were occurring frequently, as well as those that were unique and significant to the research questions. Constant comparing and contrasting of the categories, themes and sub-themes provided the rigour and minimised blind-sides.

Each label captured the meaning or value of the phenomenon observed. By asking questions such as what, who, where, how, when and why, each activity was analysed and broken down into different discrete actions which were then, codified. Each code was assigned an alpha and numeric character with a brief description of the action (Table 3.3). Subsequently, each of these codes was compared and similar codes depicting the same activity or actions were clustered together under a conceptual label. Each group was a concept that was then compared and contrasted further with others to evolve a higher and more abstract level, producing categories. Each category was described by its properties. Precise use of language was crucial in differentiating the categories from others and not to mislead or confuse the meaning. There were 198 open codes recorded in this study.

**Table 3.3 Examples of open coding**

| No. | Codes | Description of action |
|---|---|---|
| 1 | ap | Asking peer |
| 2 | aT | Asking teacher |
| 3 | B | Whiteboard |
| 4 | C | Computer |
| 5 | D | Dictionary |
| 6 | dH | Distributing/receiving handout |
| 7 | dp | Distracting a peer |
| 8 | f | Finger pointing |
| 9 | fA | Pointing to an artefact |
| 10 | fC | Finger (pointing) computer screen |

Axial coding is where the categories and subcategories are examined according to their properties to establish relationships (Strauss & Corbin, 1998). In so doing, actions, their cause and effects, factors that influence and the conditions were explored and developed into main categories. An example of a main category was the “verbal distribution” where subcategories such as “teacher talks to class”, “teacher talks to a group” and “student talks to class” formed the cluster of verbal distribution of cognition (Table 3.4).

**Table 3.4 Examples of axial coding**

| **No.** | **Codes** | **Main activity** | **Main category** |
|---|---|---|---|
| **1** | **Ttc** | T talks to class | **verbal distribution (teacher)** |
| **2** | **Ttg** | T talks to a group | |
| **3** | **TtS#** | T talks to S# | |
| **4** | **TtS#S#** | T talks to 2-3 but not all Ss in a group | |
| **5** | **S#tc** | S# talks to class | **verbal distribution (student)** |
| **6** | **S#tg** | S# talks to group | |
| **7** | **S#tS#** | S# talks to S# | |
| **8** | **S#tS#S#** | S# talks to Ss but not all in the group | |
| **9** | **S#tT** | S# talks to T | |

In this research, data collection, management and analysis were done simultaneously in order to inform each other to coherently develop a full picture of the phenomenon (Miles & Huberman, 1994). Guided by the research questions, this research adjusted and modified accordingly during data collection as and when informed by the analysis.

### 3.3.2 Cognitive maps

Cognitive mapping is a way of structuring and storing spatial knowledge. In cognitive studies, cognitive maps display individuals’ representations of their thinking (Miles & Huberman, 1994) and are one of the many “data displays” (p.

91). They reveal relationships between concepts. In analysis, shared cognition is analysed with such maps (Quinn, 1997), revealing what they "must have in mind in order to say the things they do" (p. 140). Such visual displays are an important part of qualitative analysis (Ryan & Bernard, 2000). Cognition occurs and is distributed spatially in three-dimensional settings. Therefore, this research used several of these cognitive map displays for analysis purposes. The relationships of causality, association, time, changes and part to whole relation were viewed graphically with complementary text description. Each of these maps was coded and compared with those from the observations and interviews. Examples of these cognitive maps that emerged out of the data analysis are found in Appendix F.

### 3.3.3 Memos

Memoing helps to keep track of the categories, properties, hypotheses, and generative questions that evolve from the analytical process (Strauss & Corbin, 1998). Three types of memoing were kept: code, theoretical and operational memos. Code memos were used for conceptual labelling of the categories and activity. Theoretical coding was done during the axial coding where the analysis, labelling and comparing were constantly guided by the theoretical framework. These memos helped the researcher to merge, synthesise, generate and develop categories that made sense of the phenomenon. Operational memos were purely looking at the research methodology design with thoughts on how to collect and analyse the data in more meaningful ways. Some examples of these three types of memos created in this study are shown in Appendix G.

## 3.4 Trustworthiness and rigour of study

All good research must have rigour and meet tests of reliability and validity (Marshall & Rossman, 1999). While this may be true for positivistic research that emphasises repeatability (internal validity) and generalisation (external validity) of the research data, interpretivistic research views validity as "trustworthiness" (Creswell, 2003). The notion of trustworthiness is not similar to reliability for the positivist due to the value of "multiple and constructed" realities of the interpretist, but rather as truthfulness of the findings. Trustworthiness is also understood as credibility (which corresponds roughly with the positivist concept of internal validity), dependability (which relates more to reliability), transferability (which is a form of external validity) and confirmability (Guba & Lincoln, 1989).

In ethnographic studies, prolonged engagement and persistent observation lend credence to the trustworthiness of the data (Hammersley & Atkinson, 1995). The nature of this data collection method, resulting in rich and thick descriptions, allowed not just more believable and more precise data, but also permitted transferability of the findings with the contexts fully accounted for. This ensured the dependability of the findings. The repeated (persistent) viewing of the videotapes not only allowed previous data collection to be "corrected" but also minimised any data that was earlier overlooked. Indeed, because of the huge amount of data is generated by the researcher himself, the weight of integrity and reliability rests on the researcher. As such, trustworthiness of the data was established in the following ways: triangulation of data, member checking, and maintaining an audit trail.

Interviews with the participants and artefact examination were triangulated with the observed data. The artefacts were examined to ascertain the interview and observation data. There was however some data that could not be confirmed by the students due to their forgetfulness or the angle of the camera could not capture what the students said they did. This was one of the limitations of the data collection and analysis. Member checking, regarded as “the single most critical technique for establishing credibility” (Lincoln & Guba, 1989, p. 239), of sample codes and descriptions of the activity observation were done to enhance confirmability. A relevant video clip of the activity together with the codes and description were checked with teachers within one to two months after the video-taping to ascertain the accuracy. Audit trails (Appendix K) of memoing and field notes of the observations were kept. This was discussed under 3.1.3.1 where there were three types: on-site observation notes, reflective diary, and theoretical memoing. Samples of these types are found in the Appendix G.

### 3.5 Ethical issues

A trustworthy research discusses ethical issues early and incorporates them in all stages of the study (Bogdan & Biklen, 2003). This study did do its best to comply with the Revised Ethical Guidelines for Educational Research (BERA, 2004) regarding rights of access and ensuring students’ rights and according to the University of Leicester Handbook. Among the key areas in this guideline, this section will elaborate on voluntary informed consent, deception, right to withdraw, incentives, potential detriment arising from participation, privacy and disclosure. The rights of access were secured with the college’s Dean and President before any of the observation and interviews were conducted.

### 3.5.1 Informed consent

In order to comply with voluntary informed consent, deception and right to withdraw, potential participants were briefed on the purpose and implications of the study: to understand how they behaved in a group learning activity that used technology. This was verbally explained and a two-page written letter, detailing the research aims and observation process was given to them for their perusal Appendix H (2/2). They were informed that under no circumstances, whether they accepted or declined to be observed, would their grades in their course of study be affected in any way. They were also told that at any time during the observation, they could choose to stop the observation without giving any reason. The participants were notified and given the letter of consent a week before the observation dates in order for them to consider and acknowledge on the letter to show their agreement to the research. Participants had to initial on two sheets of paper detailing their agreement (Appendix H, 2/2), each to be kept by both parties. None of the students invited to participate in this observation declined to be observed. However, five students submitted their consent forms after the first observation was done due to their forgetfulness in bringing the forms to college on the observation day. Two students were absent on the day when the forms were handed out and they were separately briefed. The offer to withdraw from being observed was repeated at subsequent observations of the same classes, reminding them of their privileges as a participant.

### 3.5.2 Voluntary

No incentives in the form of extra credit for grades or monetary items were given nor offered. The students participated in this research purely on voluntary grounds.

However, the observation was done during actual class sessions that may pose as an incentive to participate as a student of the class. Arranging for an extra class or outside class hours setting for this research would affect the motivation and behaviour of the students. This was not done.

### 3.5.3 Privacy and confidentiality

In order to comply with privacy and disclosure, no participant was identified as the observation referred to the participants in codes such as S1 (Table 3.4). All notes and analysis labelled the participants in codes rather than actual names. The participants were informed that the findings will be kept confidential and they have the prerogative to request for any of the data. Care was also taken not to provide other detailed information that may lead to identification by others in the group. Any potential publication of the participant’s views, especially those gathered from the interviews, would require participants’ agreement before being released for publishing. This was to ensure that the confidentiality of the participants stayed protected (Bogdan & Biklen, 2003; Kvale, 1996).

## 3.6 Research limitations

One of the limitations of this methodology was the brevity of two years that this data collection and analysis took and in particular the one year of direct observation of the activity in the classroom. In an ideal state of ethnographic studies, a prolonged engagement is required for observing “behavioural” cognition (Marshall & Rossman, 1999). However, the use of repeated video observation somewhat justifies the research design. Notwithstanding, this research recognised that a more intensive and prolonged engagement would be ideal.

The nature of ethnographic data collection through direct and repeated observation of the video recording generated an enormous amount of data that posed a challenge to the researcher's analysis. The research questions served as a crucial guide in determining the relevancy of each piece of the collected data. And because there was filtering in the researcher's analysis, the position of the researcher posed a clear limitation to this study's data collection and analysis. The richness and enormity of the data and emergent data also posed the difficulty in making sense of the many potential influences and multi perspectives to the activity.

The sample type and size, which might have been suitable for a limited study such as this, did present a limitation in the transliteration of this study's findings to other cases. This is due to the uniqueness and particularity of the participants and the college it represented. While it was not the objective of this study to generalise this study's findings, it recognises the potential of its transliteration is limited by the uniqueness the institutional context.

This study recognised the researcher's direct observation and the presence of video cameras compromised the desired intention to observe a naturalistic environment, but this method still offered a close enough situation to an authentic setting. This study also acknowledged that due to the part time nature of this research where the research did not have the privilege of a full time engagement to the research, the data collection and analysis might suffer from maturation of data analysis. At the same time, in the effort to collect as much information as possible, the limited resources in terms of time and human labour, there was an incomplete collection of all the artefacts that were observed. Some were misplaced between the time of observation and interview. Others were lost through maturation and change. And some were simply difficult to collect unless there was an army of researchers to enter the site and photograph the artefact during the observations. Researcher fatigue was a clear limitation in recording the accounts of the observations. I found myself recording less information after subsequent in-situ observations, as well as the repeated viewing of the videotapes.

### 3.7 Conclusion

This chapter has sought to establish the legitimacy of its interpretivist paradigm and qualitative nature in its study on the phenomenon of a situated group activity of students collaborating on a task in a classroom. First, this research is interpretivist in nature, valuing the meaning as seen from the participants as well as the researcher's perspectives. The recognition of the researcher's effect on site, on the participants' behaviour, in both the collection and analysis of the data, undeniably situate this study in the interpretivist paradigm. Second, the main approaches of ethnography, supplemented by social interaction studies were explained from the cognitive perspective. Therefore and thirdly, qualitative methods of data collection were employed: direct observation with video viewing, interviews and artefact analysis. The planning and schedules of observation, interview and artefact analysis were detailed. Fourth, the sampling was purposive: typical and intensive on a frequently observed phenomenon in modern classrooms: groups of students working together on a task using technological devices. Fifth, the methods of analysis were grounded theory methods in the coding of the external representations of cognition from observation, interaction discourse, participant structures and cognitive mapping of cognitive networks. These together with explanation of the types of coding were explained. The trustworthiness of this study was subsequently justified, followed by the detailed adherence of ethical issues. Last, the acknowledgement of the limitations of this study was discussed to qualify this research. In the next chapter, the discussion on the findings of this study will be presented.

# CHAPTER FOUR

# FINDINGS

Chapter Four presents the findings of this study. The main research question for this study is: how cognition is distributed across a group of students collaborating on the learning task. In order to unravel this question, three specific research questions (SRQ) were employed:

**SRQ1. What are the observable cognitive processes and representations in the classroom?**

**SRQ2. What artefacts are accessed and how are they used?**

**SRQ3. What are the levels of collaboration and how do they interact?**

These SRQs are undergirded with the perspective of directly observable cognition in the classroom (observation and artefact examination) and participants' view of the cognitive processes (interview). This chapter begins with an ethnographic description of the processes of the group tasks (SRQ 1) followed by findings on artefacts (SRQ 2), interaction (SRQ 3) and representations (SRQ 1). Observational narratives and interview comments are reported side by side. Words spoken by the students in the interviews are presented within single quotation marks ('') to distinguish them from in-text citations. The chapter is structured as such:

4.1 Listening and collaborating processes (SRQ1)

4.2 Types of artefacts accessed (SRQ2)

4.3 Levels of collaboration and interaction (SRQ3)

4.4 Media of representations (SRQ1)

4.5 Summary

## 4.1 Listening and collaborating processes (SRQ1)

This section covers an ethnographic description of the directly observable cognition involved in the processes for group work in the classroom. The observations followed the students' and teacher's natural course of activity from the beginning to the end of the task. The description covers the account of all the four groups in three classes observed twice over (Appendix A). This report describes all 24 groups observed in general. Two classes (English class A and B) were observed not to have any handouts accompanying the teachers' verbal instructions.

The group task was observed to have five phases: P1-P5 (Table 4.1). All the group tasks have two sub-tasks: listen to an audio clip individually and work on the worksheet collectively. The first sub-task had three phases: the teacher's instructions, students' decision making and individual listening phases. The second sub-task had two phases but four sub-task processes: teacher's instruction, students collaborating, individual listening and final collaborating on worksheet. The collaboration activity required the students to match the appropriate answers, printed on slips of paper, to statements on the worksheet. We shall henceforth refer to "slips of paper" as "slips". An example of the listening-type task is found in Appendix C. The tasks took an average of 44.1 minutes to complete (Table 4.1). Four out of the six tasks had video clips instead of only audio clips. For purposes of standardisation, both the audio and video clips are referred to as "clip".

**Table 4.1 Phases of activity, nature of tasks and the time taken**

| | Phases | Nature of sub-tasks | Average (minutes) | Cumu-lative |
|---|---|---|---|---|
| **Sub-task: Listening** | P1 | Teacher instructing | 1.1 | 1.1 |
| | P2 | Students decision making (group) | 0.5 | 1.6 |
| | P3 | Students acquiring (individual) | 11 | 12.6 |
| **Sub-task: Collabo-rating** | P4 | Teacher instructing | 0.5 | 13.1 |
| | P5 | Students applying (group) | 17 | 30.1 |
| | | Students acquiring and applying | 5 | 35.1 |
| | | Students applying (group) | 9 | 44.1 |
| | | Total Time | 44.1 | - |

### 4.1.1 Before the group task

Before the group task was announced in the class, most if not all the students would have been seated in the classroom and set up their respective desks in preparation for class (see Appendix A for classroom layout). Teachers set up the room and ensured that the computers were in working order and tested all the connections of the projection display before the class. All the students (100%, Table 4.2) would have switched on their computers and logged onto the college's intranet in anticipation of accessing the internet. Many (46%) had their portable electronic dictionary (PED) positioned in front on the desk. About half of the students (55%) would have their notebooks or files on the desk for reference purposes. Many had pen cases (73%) and other miscellaneous items such as water bottles (12%) on the desks as well. All students would have their bags situated close by for easy retrieval of personal items they may need later. Besides having one whiteboard positioned at the front of the class, the teacher had a projector screen connected to the teacher's computer for information display.

**Table 4.2 Students populating artefacts on desks**

| Artefacts present | Before | P1 | P2 | P3 | P4 | P5a-c |
|---|---|---|---|---|---|---|
| **Notes/Files** | 26 (55%) | 33(70%) | 33(70%) | 35(73%) | 35(73%) | 35(73%) |
| **Handout*** | n.a. | 27* (84%) | 27* (84%) | 27* (100%) | 27* (100%) | 27* (100%) |
| **Computer** | 48 (100%) | 48 (100%) | 48 (100%) | 48 (100%) | 48 (100%) | 48 (100%) |
| **PED** | 22 (46%) | 26 (54%) | 26 (54%) | 48 (100%) | 48 (100%) | 48 (100%) |
| **Pen case** | 35 (73%) | 48 (100%) | 48 (100%) | 48 (100%) | 48 (100%) | 48 (100%) |
| **Headphones** | 0 (0%) | 40 (83%) | 48 (100%) | 48 (100%) | 48 (100%) | 48 (100%) |
| **Mobile phones** | 2(4%) | 2(4%) | 2(4%) | 6 (12%) | 6 (12%) | 9 (19%) |
| **Worksheet** | n.a. | n.a. | n.a. | n.a. | 48 (100%) | 48 (100%) |
| **Miscellaneous** | 6 (12%) | 6 (12%) | 6 (12%) | 10 (21%) | 10 (21%) | 13 (27%) |

* Only 32 students had handouts in their tasks.

Table 4.2 shows how many students populated their workspaces with artefacts over time. Artefacts that were observed to be placed on or removed from the students' desktops were recorded for each phase and were recorded as long as they remained in that phase. Once positioned on desks, students did not remove them except to move them to make space for other artefacts. Artefacts that were not introduced will be considered as "n.a.".

### 4.1.2 Listening (P1-3)

In the first phase (P1), the teacher verbally gave the instructions of the task (repeated a few times) with gestures, while walking around distributing the handouts to each student (Figure 4.1). The handouts contained the instructions and steps to locate the clips. Some tasks (four out of the six) had written instructions on the whiteboard, while others (three out of the six) had a computer display in front of the class during P1. The tasks that had no handout distributed, the teacher gave verbal instructions. The verbal instructions (and body language), printed handouts, projector display and whiteboard were the teacher's way to distribute information to the class. Although many students looked at the teacher at least once (81%) during P1, they engaged in a range of other sub-processes (Table 4.3): some clarified with other students (27%) and the teacher with questions (4%). Sub-processes were activities that students engaged in during a main process. The main processes were the sub-task processes such as the teachers' instructions in P1, students' decision making in P2, etc.

The students were observed to engage in receiving instructions, clarifying when necessary and acquiring information. During this acquisition of information, some students made notes (4%), processing and committing information to note form to allow for later access. Almost all students looked at the handout (94%) and their computers (79%) showing the webpage where the clips were at least once to follow what the teacher was saying. The students were accessing these artefacts to clarify what they needed to be sure about. At the same time, some were retrieving their notebooks, files (15%), PEDs (8%) and pen cases (40%) from their bags to populate their desks with artefacts. There were also one or two instances where the teacher had to attend to the technical difficulties in setting up the computer. Table 4.3 shows how many students interacted with which artefact and another person in the phases.

## Table 4.3 Students interacting with other members and artefacts

| **Artefacts** | **P1** | **P2** | **P3** | **P4** | **P5a** | **P5b** | **P5c** |
|---|---|---|---|---|---|---|---|
| Notes/files | 5 (15%) | 0 (0%) | 35(73%) | 0 (0%) | 15 (31%) | 0 (0%) | 0 (0%) |
| Handout* | 30 (94%) | 21(65%) | 26 (81%) | 2 (6%) | 21(65%) | 7 (22%) | 27 (84%) |
| Worksheet/ slips | na | na | na | 26 (54%) | 48 (100%) | 23(48%) | 48 (100%) |
| Computer (set up) | 38 (79%) | 48 (100%) | na | na | na | na | na |
| Computer (headphones) | 38 (79%) | 0 (0%) | 48 (100%) | 16 (33%) | 16 (33%) | 45 (94%) | 0 (0%) |
| Computer (search) | 0 (0%) | 0 (0%) | 12 (25%) | 0 (0%) | 19 (39%) | 0 (0%) | 2 (4%) |
| PED | 4 (8%) | 0 (0%) | 40 (84%) | 4 (8%) | 46 (96%) | 5 (10%) | 25 (52%) |
| Hardcopy dictionary | na | 0 (0%) | 2 (4%) | 0 (0%) | 2 (4%) | 0 (0%) | 0 (0%) |
| Online dictionary | na | 0 (0%) | 5 (10%) | 0 (0%) | 3 (6%) | 0 (0%) | 1 (2%) |
| Mobile phone dictionary | na | 0 (0%) | 1 (2%) | 1 (2%) | 1 (2%) | 0 (0%) | 1 (2%) |
| Making notes | 2 (4%) | 0 (0%) | 25 (79%) | 6 (19%) | 17 (54%) | 24 (75%) | 0 (0%) |
| Looking at whiteboard* | 27 (84%) | 5 (15%) | 6 (19%) | 2 (6%) | 18 (55%) | 0 (0%) | 0 (0%) |
| Looking at screen* | 26 (81%) | 0(0%) | 10 (21%) | na | na | na | na |
| **Other human members** | | | | | | | |
| Talking to student | 13 (27%) | 18 (37%) | 29 (60%) | 5 (10%) | 35(73%) | 3 (6%) | 24 (50%) |
| Talking to other student | 5 (10%) | 4 (8%) | 4 (8%) | 2 (4%) | 5 (10%) | 0 (0%) | 7 (15%) |
| Talking to teacher | 2 (4%) | 5 (10%) | 4 (8%) | 0 (0%) | 9 (19%) | 0 (0%) | 4 (8%) |
| Talking to group | 0 (0%) | 48 (100%) | 14 (33%) | 5 (10%) | 48 (100%) | 6 (12%) | 48 (100%) |
| Looking at teacher | 39 (81%) | 12 (25%) | 31(65%) | 29 (60%) | 0 (0%) | 30 (63%) | 10 (21%) |

* Only 32 students had handouts in their tasks.


**Figure 4.1** Teacher talking about the task (A. Walking and talking; B. Handout)

**Figure 4.2** Using gestures to randomly assign clips

**Figure 4.3** Traditional hand-play - “jan ken pon”

Because the students had to divide the clips amongst the group members, P2 was a decision making phase. Most groups (75%) adopted a straightforward random assignment (Figure 4.2) of clips to watch while three groups used the traditional Japanese decision making hand-play known as “jan ken pon” (Figure 4.3). This Japanese style of hand-play involved students using hand gestures to indicate a symbol, played by thrusting out a hand representing a choice of one of three hand gestures. The hand-play, at each thrust of the hand gesture, eliminates a player one by one. The group played this in rounds until the last two persons squared off. Only the last person who remained could choose the clip of his/her choice. The “jan ken pon” approach was readily played out and students had fun doing the hand-play. This decision making process involved students giving and receiving information from the symbols created by the hand-play. They had to process them by comparing the hand gestures with each other and make a judgment as to who won the round of hand-play. This complex information processing was operationalised within seconds when the hand gestures were played. Students not only processed information but distributed the information by making the hand gestures. During P2, the sub-processes included students clarifying the procedure with the teacher (10%, Table 4.3), with students within the group (37%) and with members of other groups (8%). In the straightforward approach, students deferred to the one who initiated the assigning of clips without any noticeable objections from other groups members. Either method lasted an average of 30 seconds with students showing no conflicts or disagreements.

P3 saw each student quietly listening to the clips (Figure 4.4). Students were referring to information stored by the teacher prior to the class. Several other sub-processes accompanied the listening: Students made notes (79%) with a few writing cryptic notes on their hands (10%) (Figure 4.5). All students consulted a dictionary, whether it was online (10%), hardcopy (4%), PED (84%) or mobile phone (2%). Students also consulted their notes from previous lessons (73%) and cross-referenced the handout (81%, Table 4.3). Students used these artefacts to access stored information to help them clarify what they needed to know. Students acquired and clarified information while accessing the stored information. There were clarifications with the teacher (8%), students within the group (60%) and outside the group (8%). This listening sub-task process involved a complex cognitive process where students not only had to acquire and understand the clips, but also to check with the dictionary for clarification. Soon after, some of the acquired information was transformed from the audio format to a written format. There was an intense level of cognitive processing, distributed between reading (handouts, whiteboard, notes and files), listening (clips) and writing (note making), and acquisition of information from the clips, dictionary and notes. While there were technical difficulties associated with the listening sub-task: headphones compatibility, computer access, clip access and sound production, the teacher attended to all of them successfully. Thus, this first sub-task of listening had three phases of activity. Students generally engaged in main processes of acquiring, clarifying and converting information into notes. Even though each phase had a main process, sub-processes occurred alongside, supporting these main processes.


**Figure 4.4** Listening phase (A. Taking notes; B. Checking PED)

**Figure 4.5** Cryptic notes on hands


**Figure 4.6** Collaborating phase (A. Slips; B. PED)

### 4.1.3 Collaboration (P4-P5)

P4 started the collaborative process on the worksheet when the teacher gave instructions on this sub-task. Similar to P1, the teacher gave verbal instructions while walking around to distribute the worksheet to the groups. Students acquired the new information (instructions) while looking at the teacher (60%, Table 4.3) when he spoke.  Other sub-processes involved listening to the clip (33%), accessing the PED (8%) and mobile phone (2%). Still others converted audio format to written format in making notes (19%). This included interactions with other members in the group (10%), another student in the group (10%) and student in another group (4%). Some students started on applying information with students looking, fiddling with the slips and working on the worksheet (54%) while listening to the teacher. So while students were being introduced to the next phase of the task, they were engaging in several sub-processes.

P5 saw students working intensely to apply the information they had acquired on the worksheet (Figure 4.6). They were observed to look at slips then the notes and back to the slips. In between these actions, the students consulted their artefacts and talked to their groups. This information process was a complex combination of several cognitive sub-processes: recognising, recalling, matching, checking, constructing, clarifying, comparing, contrasting, integrating, synthesising, storing and retrieving information. In performing these cognitive sub-processes, students engaged in social interaction at P5a (Table 4.3): in the group (100%), with another student (73%), with another student from another group (10%) or teacher (19%). This included the individual activities with artefacts at P5a: searching on the internet (39%) and accessing notes (31%) and at P5b: listened to the clips again (94%), making notes (75%) and researched on the computer (19%). Students not only processed information but also distributed and accessed information from artefacts. Students said that they used the artefacts to show what they were talking about to others.

Mid way into the collaborative activity, the teacher interrupted the process by suggesting to the class to listen to the clips again in order to verify their answer (P5b). Some groups took the advice, while others who were already listening to the clips did not. This phase was brief, taking about half a minute on the average for all groups. The next part of this phase (P5c) saw all groups stop listening to the clips and start working on the worksheet (P5c). This was another intense activity of comparing slips to the notes and talking to group members. Students reviewed all the answers where the slips were positioned by the simple process of elimination: students reviewed the empty and remaining gaps and remaining slips. Some groups pasted the slips as they worked on the worksheet while others only pasted them at the end. An example of a completed worksheet is provided in Appendix I. According to the teachers, about 75% of all students achieved full accuracy in their worksheets, while others had a few errors. The teachers explained the answers in the later part of the class. Thus, the second sub-task of collaboration had two phases (P4 & P5) but four sub-tasks processes. The first phase was teachers' instruction and the second was students' collaboration. The second phase had the teacher interrupting the phase, thus creating an additional sub-task process.

In terms of student activities, they collaborated in P2 (decision making) and P5 (worksheet) whereas in P3, they performed individual activities. For the teacher, he engaged the class in P1 and P4, primarily to give instructions. Having reported on the observable cognitive processes, we asked how students felt about these processes they experienced.

### 4.1.4 Students during collaboration

In all the collaborations in P2 and P5, there were no observable serious conflicts or disagreements that threatened to derail or stall group cooperation. Students deferred, listened to, and agreed amicably with each other. Students said when the time came for collaborating, whether in making decisions in P2 or P5, they readily eased into cooperating and working with one another. When asked why they collaborated without any problems, some students talked about the friendship they have with each other in the group; and that they can rely on group members to work well together and complete the task.

When polled at the interviews, students expressed enjoyment working with each other in groups (81%), with none disagreeing (#1, Table 4.4). When asked about what they liked about group work, 35 students gave reasons using phrases such as ‘togetherness with friends’, ‘group discussion’, ‘working together’, ‘group work’, ‘group learning’, ‘fun to work together’ and ‘think together’. In fact, there were at least 18 variations of this concept, with ‘group work” having the highest mention. While clearly, students love group work, eight cited ‘friends’, apparently demonstrating what group work meant to them: being able to learn with friends. A couple of students stated ‘not alone’ indicating a dislike to being alone. In fact, several students asked for more group work in class.

Many students also talked about sharing ideas and how coming to conclusions together was meaningful to them. Others cited learning together helped in their own understanding of the content. 13 mentioned ‘understanding content by group discussion’ and ‘learning together’. Nine felt a sense of accomplishment after completing the worksheet. Overall, many (71%) felt that they learned from group work (#3). This was similar to 84% (#4) saying that they learnt from group discussion, with 40% strongly agreeing.

When asked whether the students enjoyed the learning experience in a group using technology, 87% of the students (#11) responded positively. This corresponded with the 81% (#1) that agreed that group work was enjoyable. This also showed that combining technology with group work in classroom was acceptable and even preferred by students.

**Table 4.4 Learning in a group**

| # | Items | Agree | Neutral | Disagree |
|---|---|---|---|---|
| 1 | I enjoyed group work | 39(81%) | 9(19%) | 0(0%) |
| 2 | I did not mind students talking to one another in my group | 35(73%) | 13(27%) | 0(0%) |
| 3 | I learned from working in a group | 34(71%) | 11(23%) | 3(6%) |
| 4 | I learnt from group discussion | 40(84%) | 7(14%) | 1(2%) |
| 5 | I learned when talking to one other in the group. | 40(84%) | 5(11%) | 3(5%) |
| 6 | I learnt from listening process | 35(74%) | 11(24%) | 1(2%) |
| 7 | I prefer group work over individual work | 22(46%) | 26(54%) | 0(0%) |
| 8 | I did not like some of my group members | 7(15%) | 14(29%) | 27(56%) |
| 9 | I had difficulty working in my group | 5(10%) | 17(36%) | 26(54%) |
| 10 | I minded other group members disturbing my group | 8(17%) | 22(47%) | 18(36%) |
| 11 | I enjoyed the learning experience in a group using technology | 42(87%) | 5(11%) | 1(2%) |

The teachers felt that the students were more reticent as a large group and group work facilitated more interaction. All of them were satisfied with the level of performance in terms of both the processes as well as the results. For the process, the teachers mentioned, ‘students were so engaged’, ‘focused in discussion’, and ‘interested in the topic’. One felt the students started slow but picked up pace eventually. One cited the advantages of having different opinions from peer sharing and learning. Another wanted more peer cooperation and ‘assisting each other’. One teacher admitted that he only started group work when he first came to this college and was later convinced of the college’s teaching approach in active learning. Another teacher owed his approach to the idea of authenticity, as it was ‘part of his generation’ and ‘natural’ to have group work and use of IT in the classroom.

Generally, teachers felt that they had achieved the objectives of both using technology in their group work tasks. Apart from the teacher’s individual learning objectives, all teachers shared similar process goals such as active learning, critical learning and use of IT in tasks. They felt the students’ processes in group work and the use of IT were acceptable and had no issues with them. In terms of the performance, all the teachers felt the students managed to achieve all the main learning points. One teacher felt he has achieved the objective of students being ‘exposed to IT’ and to ‘use IT naturally in class work’. The teachers had no issue with the amount of time taken for their tasks and the duration of each of the separate phases. Thus, students enjoyed and learned from their experience using computers in group work.

### 4.2 Types of artefacts accessed (SRQ2)

In the study of an extended cognitive system such as this collaborative setting, we have included the analysis of artefacts as part of the investigation in order to fully understand how students collaborate with artefacts. This section reports the findings for SRQ2. What artefacts were accessed? In all the tasks observed, the students accessed the whole range of artefacts that was being afforded in the classroom (Table 4.5). We will discuss each artefact separately. The following were observed to emerge with respect to how students and teachers use the artefacts for their cognitive activities.

**Table 4.5 Artefacts and affordances**

| Artefacts | Afforded Functions | Observable Representations |
|---|---|---|
| Computer | Audio/video playback (intranet) | Media player window display |
| | Dictionary and translation (internet) | Dictionary and translation webpage |
| | Information research (internet) | Search engine webpage |
| Whiteboard | Written information | Whiteboard screen |
| Projection screen | Computer screen | Projection screen |
| Handout | Printed information | A4 size printed paper |
| | Note taking | A4 size printed paper |
| Worksheet and slips | Printed information | A3 size printed paper |
| | Application of information | A3 size printed paper and pasted answer slips |
| Notes/files | Written information | A4 size printed paper and handwriting |
| Notebook | Note taking | A4 size paper with handwriting |
| PED | Dictionary and translation | PED display screen |
| Hardcopy dictionary | | Printed paper |
| Mobile phone | | Mobile phone display screen |
| Student's hand* | Note taking | Handwriting |
| | Gestured information | Hand gestures |

* Though technically a student's hand is not an artefact but it was used in a manner resembling an artefact for a cognitive task

### 4.2.1 Whiteboard and projection screen

In classes where the teacher used the whiteboard to write instructions and the computer projector to show where the clips are located, students referred to them to help them remember. The whiteboard, measuring 2.5 by 1.5 metres was mounted at the front of the class (Figure 4.7). Most students were able to see and read what the teacher wrote. However, when some students found the teacher's handwriting to be illegible or ambiguous, they clarified with their neighbours. The students also said that when they could not understand what the teacher said, they looked to the whiteboard for the information (Table 4.6). Others said they referred at the whiteboard to help them remember and clarify what the teacher had said and

## Table 4.6 Artefacts, cognitive processes over phases

<table>
<tr><th rowspan="2">Artefacts</th><th rowspan="2">Afforded functions</th><th colspan="7">Phases</th></tr>
<tr><th>P1</th><th>P2</th><th>P3</th><th>P4</th><th>P5a</th><th>P5b</th><th>P5c</th></tr>
<tr><td rowspan="3">Computer</td><td>Audio/video playback</td><td>M</td><td>M</td><td>D</td><td>D</td><td>D</td><td>D</td><td>M</td></tr>
<tr><td>Dictionary and translation</td><td>Ac/M</td><td>-</td><td>Ac/M</td><td>Ac/M</td><td>Ac/D</td><td>Ac/D</td><td>Ac/M</td></tr>
<tr><td>Information research</td><td>M</td><td>M</td><td>Ac</td><td>M</td><td>Ac/D</td><td>M</td><td>M</td></tr>
<tr><td>Whiteboard</td><td>Written information</td><td>D/Ac</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td></tr>
<tr><td>Projection screen</td><td>Computer screen</td><td>D/Ac</td><td>-</td><td>D</td><td>-</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td rowspan="2">Handout</td><td>Printed information</td><td>D/Ac</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td><td>D</td></tr>
<tr><td>Note taking</td><td>-</td><td>-</td><td>M</td><td>M</td><td>M</td><td>M</td><td>M</td></tr>
<tr><td>Worksheet</td><td>Printed information</td><td>-</td><td>-</td><td>-</td><td>D</td><td>App/D</td><td>App/D</td><td>App/D</td></tr>
<tr><td>Notes/files</td><td>Written information</td><td>Ac/M</td><td>-</td><td>Ac/M/D</td><td>-</td><td>Ac/M/D</td><td>-</td><td>-</td></tr>
<tr><td>Notebook</td><td>Note taking</td><td>-</td><td>-</td><td>M</td><td>M</td><td>M/D</td><td>M/D</td><td>M/D</td></tr>
<tr><td rowspan="2">PED</td><td>Translation</td><td rowspan="4">Ac/M</td><td rowspan="4">Ac</td><td rowspan="4">Ac/D</td><td rowspan="4">Ac/M</td><td rowspan="4">Ac/D</td><td rowspan="4">Ac/D</td><td rowspan="4">Ac/M</td></tr>
<tr><td rowspan="3">Dictionary</td></tr>
<tr><td>Hardcopy dictionary</td></tr>
<tr><td>Mobile phone</td></tr>
<tr><td rowspan="2">Student’s hand</td><td>Note taking</td><td>-</td><td>-</td><td>M</td><td>M</td><td>M</td><td>M</td><td>M</td></tr>
<tr><td>Gestured information</td><td>-</td><td>D</td><td>-</td><td>D</td><td>-</td><td>D</td><td>D</td></tr>
</table>

M: memory; D: distributive; Ac: acquisition; App: application

Bold letter suggests dominant process for the phase

to see if anything new was written on it. Of course, some students said they sometimes looked at the whiteboard without any reason or they were bored at those times. Both whiteboard and projection screen were accessed intensely at P1 but tapered off towards the end (Table 4.3).

The computer display shown on the projection screen was clear to the students and helped them ascertain where to locate the clips. The screen was large enough for all to see and was mounted at the front corner of the room (Figure 4.7). The teacher's computer screen fed off to the projector located in front and projects the display to the screen. Like a computer screen, the projected display allowed for rich colour and complex graphics that a whiteboard could not afford (Table 4.5). Students mentioned that they looked at the computer screen to follow what the teacher was saying and to help them locate the clips. The students felt that the whiteboard and projector screen complemented the handouts in helping them understand what the teacher was saying. The teacher felt the display was useful to direct the students to the webpage without which he would have to move from one student to another to ensure every student managed to locate the clips.

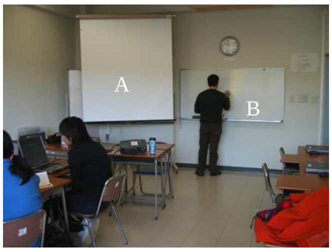


**Figure 4.7** Whiteboard and screen (A. Screen; B. Whiteboard)

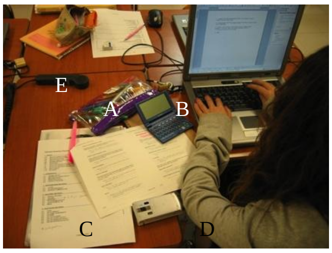


**Figure 4.8** Artefacts on table (A. Pencil holder; B. PED; C. Notes; D. Mobile phone; E: Microphone)

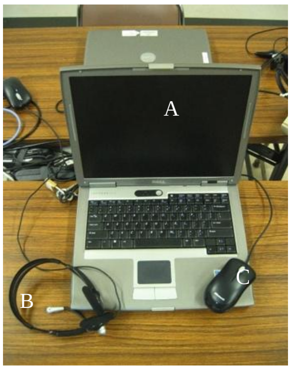


**Figure 4.9** Computer (A. Screen; B. Headphones; C. Mouse)

However, due to the limited space of the whiteboard, the information written earlier would be erased whenever new information was written. Similarly for the projector screen, subsequent display would eclipse the previous one. This meant that the previous information would be lost unless the students either transferred the information to their notes or committed to memory. The teacher had control over the duration the information was displayed on the whiteboard and screen. As long as the teacher saw it necessary for the display to remain, the students could continue to access the information. The teachers interviewed said that the information on the whiteboard was not erased until the end of the class except when they had to put up new information. However, for the computer screen display, the teachers said that they switched it off after sensing that the students had no use for the display after P3.

### 4.2.2 Computer

The students used the computer to acquire and clarify information (Table 4.6). The computers were DELL Latitude D510 notebooks (Figure 4.9), accompanied with a mouse positioned on the right hand side and headphones on the left. The computers ran on a Windows-based operating system, Windows XP, installed with standard Microsoft Office software and connected to the college's intranet. This meant that the students were able to access the clips on the college’s intranet. Due to the size of the clips, the teachers had to upload the files onto the college’s intranet before the class in order distribute the clips to the students during class time. The computer each had a Pentium 1.6GHz processor, 2 gigabyte of RAM and was local area networked. This meant that the computers worked quickly enough to facilitate the general multimedia functions and quick downloading of intranet data. The clips that the students accessed were either audio or video files that were automatically playable on the computer's in-built media players.

The students used the computers to access the clips (P3, 100%, Table 4.3) and obtain the information (P5a, 39%) they needed to work on the group task. The headphones facilitated an individual activity of listening to the clips without noise disturbances to a neighbour or class make. The computer had a broadband speed of up to 100 megabits per second facilitating quick downloading of data from the internet. This meant that the students were able to search the internet for information. As many as 19 students (P5a) used the internet to search for information for their tasks (39%, Table 4.3). The students said that they did that in order to better understand and clarify the topic, as well as to acquire the relevant information (Table 4.6) to complete the tasks. Two students said that they forgot to bring their PED and used the internet's dictionary and translation websites instead (Table 4.3). Another three students used the computer even though they had their PED. When asked, they replied they prefer the quality of the translation in on the internet websites. These websites were book-marked in the computer and students were able to return to them for retrieval of the previous information at a later phase. In collaborating (P5), some students said they not only re-visited the websites for clarification of the information, but also re-accessed the clips for repeated listening. The storage capabilities of the computers enabled the students to engage the information at demand.

The computers on the students' desks afforded the teacher with the use technology in class to distribute information (Table 4.6) to all the students. The teachers said they knew the capabilities of the computers and their affordances for the individual listening activity. Hence, they decided to use them for the collaborative task in class. The teachers said that they used technology to make the class more interesting with students having to listen to a clip mirroring what they would do outside class. By storing the clips on the intranet server, the teacher ensured that the clips could be repeatedly accessed, thus allowing the information to be retrieved at anytime the students needed it. This was evidenced by the repeated viewing of the clip throughout P3 (100%, Table 4.3) and P5b (94%). The teacher used the computer network to distribute information to the students and store information in class where students could individually and repeatedly acquire information together at the same time. The teachers said they would not have been able to do this jigsaw listening group task if not for the computers. Because of the computer multi-functional capabilities (Table 4.5), which afforded several cognitive tasks for the both teacher and students, the computer was used extensively and repeatedly over the phases (Table 4.3).

### 4.2.3 Learning with computers

How did the students feel about using computers in class? Generally, students preferred and enjoyed using computers in class, with some exceptions. When asked which part of the learning activity they enjoyed the most, 15 students mentioned ‘use computer’, ‘watching videos’, ‘listening with computers’, ‘watching video was fun’, and ‘able to use computer’. The remarks, ‘use computer’ and ‘watching videos’, had as many as 10 respondents. Eight said they enjoyed ‘learning with computers’. 81% of the students said they enjoyed using the computers (#1, Table 4.7). In fact, seven students suggested having more activities using the computers.

The overall enjoyment of use of computers corresponded with the 87% that enjoyed learning in a group using IT (#11, Table 4.4). A teacher felt that IT was a powerful tool for creativity and allowed students to make quick changes to their work unlike "low-tech" resources. All the teachers were convinced that use of IT was so commonplace that ignoring it in the classroom would be a disservice to the students.

**Table 4.7 Learning with technology**

| # | Items | Agree | Neutral | Disagree |
|---|---|---|---|---|
| 1 | Enjoyed using computer to listen to clips | 39(81%) | 8(17%) | 1(2%) |
| 2 | Prefer having computers in classroom | 24(50%) | 17(35%) | 7(15%) |
| 3 | It was not difficult to use the computer to listen to clips | 31(63%) | 15(33%) | 2(4%) |
| 4 | It was easy to use the computers | 20(40%) | 15(31%) | 13(29%) |

However, there were 15% students preferring not to have computers in the classrooms and as many as 29% cited difficulty in using the computers (#4). When asked for reasons, some said they were not too familiar with it while others said they did not like using them. Thus, using computers in the classroom had its problems. When asked what some of the problems or difficulties faced were, there were overwhelming responses of 'computer too slow' and 'faster speed'. Seven clarified that not only were the computers slow in being set up; the connection to the intranet where the clips were housed was also slow. Other issues related to the computer were physical, such as the wires being in their way when they worked and the computer screen being too small. 16 voiced for improvements in the physical arrangement. 22 asked for better computer table and chair arrangements as well as bigger workspaces and desks. Five considered the 'computers as obstacles' to the group discussion and wanted to 'move the computers'.

There were technical issues with the use of computers. Several students complained about the headphones being flimsy and inadequate in providing good quality sound. As a result, nine asked for better quality headphones. In spite of this, 63% found it *not* difficult to use the computer to listen to the clips (#3, Table 4.7). Besides these technical issues, five students wanted to have computer skills training. One student complained of having to teach another how to use the computer. Not surprisingly, only 40% found it easy to use the computers (#4). So, about one third of the students actually found it difficult to use the computers. This corresponded with the students' years of computer experience where 20% having less than a year and 15% (section 3.2.2.4) having no experience whatsoever.

The teachers also voiced their concerns when using IT. One teacher felt like stopping the use of IT in his class after a year due to the 'hassle of technical problems'. He said sometimes he lost '10% to 20% of class time to settle technical issues'. Another remarked that technical issues are 'part and parcel' of having IT. As much as 'we embrace the good, we need to accept the bad', according to one teacher. However, overall, the teachers felt that the benefits outweighed these concerns, as IT has been a powerful tool for their classroom teaching.

### 4.2.4 Handout

The handout was an A4 size set of printed papers (Figure 4.1: B), with the task's instructions and additional information about the task. An example is provided for in Appendix C. Students referred to it (94%, Table 4.3) for clarification or affirmation when the teacher was giving the instructions verbally. Students said that they referred to it also whenever they needed to clarify their thoughts on the task (Table 4.6) and to measure their progress. The handout acted as a distributive artefact and it was accessed throughout all the phases (Table 4.3). The handout was a procedural and instructional artefact that accompanied the teacher's verbal instruction. The additional information was directional information for the students to locate the clips, as well as website links for more information on the topic being introduced in class. Besides highlighting or underlining the words, some students used coloured pens to make markings on the handout for emphasis or particularity. Students made additional notes (both Japanese and English) on the handouts that became the students' reference points during the progress of the task.

The teacher said they used the handout as an additional information tool for students to refer to not only during the verbal instructions but also throughout the phases. They felt that their verbal instructions alone were insufficient to convey the information to the students. The teachers said they used the handouts as a form of distributing information.

The handout took on another function as a note taking tool when the students used the handout (Figure 4.4: A) to make their notes while listening to the clips (79%, Table 4.3). The students said that they wrote on the handout out of convenience and the information on the handout served as a frame for them to make notes. The unprinted spaces on the handout afforded the note making and some students added blank sheets of paper to the note making. Note making tapered off towards the end of the P5. The handout was transformed to a memory artefact when the students made notes for later retrieval (Table 4.6). Thus, the handout acted as an additional artefact for teachers to distribute information and as a reference for the students when they modified it, turning it into notes.

### 4.2.5 PED and other dictionaries

The PED was one of the most frequently accessed artefacts during P3 (84%, Table 4.3; Figure 4.4: B) and P5 (96%, Figure 4.6: B). It was accessed primarily for dictionary and translation purposes. All students possessed one and though there were different models, all PEDs had the dictionary and translation capability. The PEDs were portable and small in size (Figure 4.8: B) when compared to hardcopy dictionaries. It was one of the first few personal artefacts to be placed on the desks (Table 4.2) and was interacted with when students started collaborating in P3 and P5a (Table 4.3). Hardcopy dictionaries were rarely used (4%) as only a few students brought them along to classes. Online dictionaries were also rarely used (10%).

The students used the PED and other dictionaries to search for meaning of words they wanted to clarify both in the English and Japanese language (Table 4.6). They said referring to the PED was very natural and they have been doing this 'all the time' in their school days. In fact, some of them said they use it in regular Japanese instruction medium classes to 'check on difficult (Japanese) words'. Some students were observed showing the PED display to other students in the group during their discussion. They said that the action was to support what they were saying or to show others, saving them the effort in checking on the same word. Thus, these artefacts allowed students to acquire information and clarify words they were unsure of. They were also used to distribute information (Table 4.3).

### 4.2.6 Notes or files

The notebook and files contained information that was either provided for by the teachers or notes made by the students in the previous classes. They were usually A4 sheets either bound in a file or as a notebook (Figure 4.8: C). Notebooks or files were one of the first few personal artefacts to be placed on the desks (Table 4.2). Interestingly, some students prepared for easy and quick retrieval by positioning the files and notebooks on their desks just before the task began. Others retrieved them from their bags during P3 and P5. Some students did not refer to the notes at all. They interacted with the notes when students started collaborating in P3 (Table 4.3). Students accessed them because they wanted to refer to some information they believed would help them clarify or help them with the task at hand (Table 4.6). Students said that they would check the information in the notes with what was being discussed at that moment to see if what was being said matched up. Others referred to the notes for information acquired in the past (Table 4.6). Yet others, while explaining or elaborating during the group discussion, used the notes as a reference and showed the handwritten text to the group or other group members. Students said they wanted the group members to see what they wrote to serve as evidence of what they were saying. Others showed the notes to enhance clarity. These notes were accessed more frequently in P3 (73%, Table 4.3) and P5 (31%). Thus, notes were used for clarification and distribution purposes (Table 4.6).

### 4.2.7 Worksheet

The worksheet was an A3 sheet where students needed to work as a group to complete gaps of information as a group. Students applied what they had heard from the clips individually by discussing with others and selected the appropriate answer slip and pasted them on the worksheets (Figure 4.6: A). The students said that they had to recollect what they had heard and match the answer to the question. They did this by comparing and contrasting, integrating and organising information (Table 4.6). The teachers said that they had designed some simple comprehension questions followed by more difficult integrative questions where students needed to compare and contrast with each others' knowledge and integrate in order to arrive at the correct answers. For the teachers, the worksheet served as the assessment and practice tool for the performance of the collaborative learning. The worksheet was an application artefact (Table 4.6) where students applied recently acquired knowledge on the questions or problems stated in the worksheet. It was also distributing information to the students.

### 4.2.8 Mobile phone and others

Mobile phones were rarely used even though all students had at least one in possession. There was only one student that used the mobile phone as a dictionary and the reason was because he had forgotten to bring his PED to class. When used as an alternative dictionary, the mobile phone was used in a similar way as the PED. A few students placed their mobile phones on their desks (19%) but did not use them for the task except to look at it occasionally for email and social network updates. Mobile phones did not populate the desks (Table 4.2) nor were they used before and during the group collaboration (Table 4.3).

The other artefacts that were present in the system: pen cases, headphones, slips of paper and glue sticks played supportive roles to the various cognitive tasks (Table

4.6). Pen cases provided for writing and highlighting tools for students to make notes and mark for emphasis. Headphones were used to connect with the computers to make listening possible. Slips of paper and glue sticks were the mechanics for students to perform the application of knowledge on the worksheet. Miscellaneous artefacts such as water bottles and towels provided for psychological and physiological support during task. Artefacts were clearly used for the processes of memory, information and distribution of cognition throughout the phases (Table 4.6).

### 4.2.9 Cultural artefacts

As observed in P3 and Figure 4.5, three students (6%) used their hand as a writing surface for some cryptic words and symbols (Table 4.5). When asked, the students said that the notes were some ideas and key words they thought were important and useful for subsequent use. However, one student confessed that her hand notes were unrelated to the task and it was to remind her of a task after class. Students said that they practised this note taking on their hands because they did this from their childhood days. Though the human hand is not normally considered as an artefact on its own, but because of its use to store information, it can be considered as one. Although only three students were observed to use the hand for note taking, it was a unique activity that had Japanese cultural origins. In P2, 25% of the groups used the traditional Japanese hand-play, “jang ken pon”, to process a decision making activity (Figure 4.3). This is a group interaction, as narrated in section 4.1.2, with the use of hand gestures devoid of verbal discourse to facilitate a higher-order thinking activity. This hand-play was also uniquely Japanese.

## 4.3 Levels of collaboration and interaction (SRQ3)

Understanding the levels of collaboration will help us illuminate how cognition is distributed in a group activity. Drawing from the ethnographic report in 4.1, there were evidently various instances and types of interactions between the students, as well as with the teacher all throughout the phases. Teachers would address the class as a whole or a group of students or an individual. Teachers reported in their interviews that they enjoyed group work because they had the opportunity to engage students at both the group and individual levels. Students would talk to each other in and outside the group. Whenever students could not understand what was going on for example, what was written on the whiteboard or shown on the projector screen, students would ask a neighbour, teacher or someone outside the group for clarification. Students reported in their interviews that they enjoyed group work because they had the opportunity to talk to friends and classmates in a group. Cognitive networks were observed and analysed showing a range of different configuration of interactions (Appendix F). A total of 56 configurations were observed.

### 4.3.1 Class, group, sub-group, individual, and sub sub-group interaction

After comparing and contrasting, five categories of main levels of interactions emerged: class, group, sub-group, and individual. These levels were seen to emerge and be sustained for periods of time during the phases (Figure 4.10). Each block within the phase shows a representative sustained amount of time (though not necessarily the same) where a level exists independently.

Class level interaction was observed between one person and the whole class, where each person was considered as an individual and not part of a group. In P1, the teacher talked to the students individually in class, not yet as groups, introducing the task. Most class level interactions occurred whenever the teacher had to talk to the class (P1, P4 and P5b). Class interactions were brief, less than a few minutes and constituted about 7% (Table 4.1) of the time taken for the task. In P2, the class level disappeared as the group level took over.

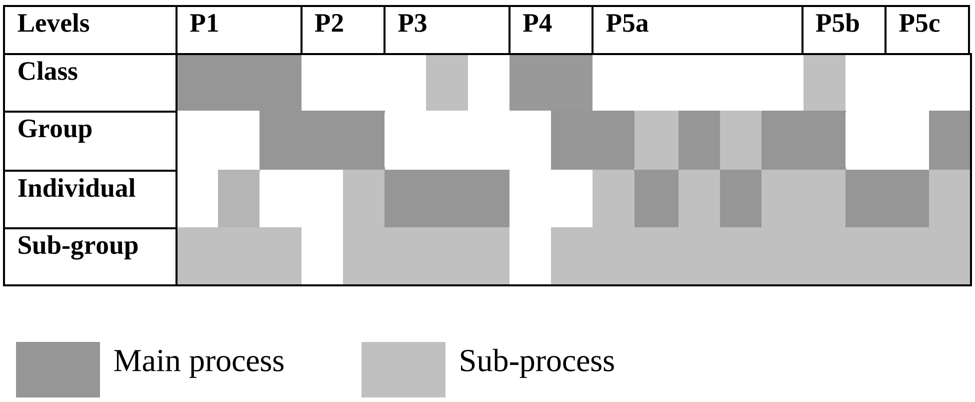


**Figure 4.10 Levels of interaction over phases**

There appeared to be a clear progression from one level to another, with one level dominating the activity as a main process. There were other interactions supporting the main process. In the tasks observed, they all began with the class level as the main process but quickly changed to the group level (P1 to P2) and individual level (P4 to P5). The main task processes were listening and collaborating (Table 4.1) activities.

Group level interaction was observed between members in groups where all the members were paying attention to what was happening within the group. Group level interactions became the main processes for P2 and P5. Group interactions commanded about 62% (Table 4.1) of the average time taken for the task.

Individual level interaction was observed where the student was working on his or her own without any interaction with other humans. This was evident in P3 and P5b where the students were listening to clips on their own. The individual level in P3 was a main process. Individual activities included consulting dictionaries, notes and handouts. Individual activities also included times of inaction, moments of self-reflection, thinking or even daydreaming. The occurrence of individual activity showed that even in group work, students engaged in individual actions. Individual interaction commanded about 36% (Table 4.1) of the average time taken for the task.

Sub-group level interaction was observed where a student engaged in discussion or activity with another student(s) or teacher *while* the core process was going on. For example, in P1, a student raised a hand to ask a question, or students engaging in a conversation with another within the group while the teacher was talking. The teacher did not plan for these interactions, but they emerged. They occurred during the group interaction phase (P2, P5a or P5c) where students asked a question to the teacher, showing or handing over an artefact to another member *while* the group was in discussion. Sub-group interactions also occurred with artefacts within and outside the group. In P3, students referred to the dictionary or whiteboard during the listening process. Sub-group interactions were sporadic and widespread, occurring concurrently at class, group and individual levels. They appeared to support the core interaction level. Sometimes, when all the students were giving undivided attention (P4) or were engaged in group interaction (P2), sub-group interaction did not occur (Figure 4.10). When asked why the students engaged in sub-group interactions with certain members of the groups, they mentioned that they are closer to them in terms of friendship.

As seen in Figure 4.10 and Table 4.3, group level interaction was very much supported with sub-group interaction. When asked if the students minded such side activities, 73% (#2, Table 4.4) did not mind students talking to one another separately during group interaction. Students also showed much acceptance towards sub-group interaction during group interaction. The teachers said they did not mind such sub-group interaction as long as they did not hinder the main group work that they had intended for the students. They were surprised by the amount of sub-group interaction, but surmised that they occurred when students were 'left on their own'.

Sub sub-group interactions were short interactions that were resolved quickly. Sub-group interactions were sometimes interrupted by an interaction with another person or artefact. Such interruptions or initiated interactions can be seen as sub sub-group interactions. In P5a, a sub-group interaction between two students was interrupted by another member asking for something only for the sub-group to resume once the interruption was over. This extended or "branching out" of the interaction constituted a sub sub-group interaction.

### 4.3.2 Students prefer interacting with others over individual learning

Students felt they learned when talking with other group members. 84% felt they learnt, with 30% (#5, Table 4.4) strongly agreeing they learnt when they engaged in sub-group discussion with another member. One student cited that 'talking friend in same group' contributed to learning. In the same token, when asked to choose between group work and individual learning in class, 46% (#7) preferred group work and *none* chose individual over group work. When asked for suggestions to improve group work processes, 11 students suggested changing group members because of 'more' and 'different' ideas and viewpoints. Five asked to work with different people and five asked for mixed ability and gender grouping.

The teachers felt that the group work increased students' participation in class. They liked the fact that students were more engaged and 'active' when compared to doing individual tasks during class. Sub-group interaction contributed to students' learning.

### 4.3.3 Group work has its problems

However, there were concerns regarding group work. One of the concerns was the dislike of a group member. When asked what some of the problems or difficulties faced were, 'uncooperative person' and 'difficult to work with one person' had five students making these comments. Although 15% of the students did not like some of their group members, 29% were indifferent and 56% (#8, Table 4.4) did not cite any dislike. This corresponded with the 10% that found difficulty in working in groups with 54% (#9) stating no difficulty. Although the numbers were small, it is noteworthy. Recognising that students may provide politically correct responses to such sensitive questions, the minority voices can sometimes demonstrate the reality of these concerns. When pressed further as to the nature of these difficulties, students cited personality and personal differences and were reluctant to elaborate further.

The teachers too, had their reservations on group work. Two teachers were concerned about ‘difficult’ or ‘lazy’ students in the group, and students who were loners or had a ‘totally different way of thinking’. One was concerned with situations where one student was dominant in the group processes, not allowing others to equally share in the learning. However, the teachers remarked that in spite of these concerns, these were the very same issues the students will face in the workplace in the future. So they believed that an early exposure to these problems would be good experience.

Another concern was the annoyances caused by other groups such as disturbances created by other members talking to the group. 17% (#10, Table 4.4) minded other group members disturbing their own group. While there were indeed some who minded, the majority did not. With 36% (#10) not minding other group members disturbing their group and 73% (#2) did not mind talking by fellow members within the group; this suggests students were tolerant of their own members’ disturbances, indicating the group culture mentality tolerated the annoyances.

Contributing to the concerns about group work, five students were concerned with grades and equal amount of workload, suggested awarding separate grades and asked for equal workload for each member. Interestingly, four asked for an increased number of members in the group. Eight mentioned issues like 'slow members need help', 'need to teach others', 'how to use computer' and asked for consideration to those 'who has no computers at home'. While group work is preferred, there are inherent issues to contend with. Thus, in spite of the general preference of group work, there were concerns with group dynamics involving individual responsibilities, disturbances, equity in workload and member compatibility.

### 4.3.4 Sharing cognition and interaction

Students and teachers were observed in their interactions at the five different levels to not only distribute information, but also to process and help to remember information. Students shared cognition, specifically in acquiring, clarifying and applying knowledge during these interactions. The following transcripts illustrate examples of the cognitive activities that students engaged in while interacting. These transcripts are translations from the Japanese transcripts and were transcribed for the ideas and information flow (Chafe, 1987) of the discourse rather than following technical transcription codes in line with the principles of conversation analysis. The purpose of these transcriptions was to observe the information processing that took place in the discourses. This study recognises that the transcription is done selectively to represent the flow of information as influenced by the theoretical issues of this study (Ochs, 1979). However, this transcription also recognised that translating the transcription in the original language will move further away from the original emic voice of the participants. But, because this study was written solely for the English speaking audience, the presentation of the original language will not be meaningful. In the interest of accessibility and readability of the transcripts presented and this was not a study in discourse analysis, ambiguous words and unintelligible utterances were not transcribed.

The transcripts are illustrated in such a way as to highlight the half-second action that took place. As such, the behaviour and discourse are presented with each line showing what each student was doing at that moment simultaneously. Each alphabet denotes a student and the teacher is label as T. "…" indicates a pause of a few seconds. Some actions overlap the lines and there could be more than an action in that line, but the reflected actions are to demonstrate what the students are primarily doing at that time. Blank spaces in the boxes suggest that the student was waiting and continuing with the previous behaviour. The lines do not suggest a time line in equal division but rather showing a sequence. Table 4.8 is an example of a class level interaction where the teacher is talking to students at P1.

**Table 4.8 Class level interaction: distribution and memory**

| # | T | A | B | C | D |
|---|---|---|---|---|---|
| **1** | (Looking at the class) Discuss in your groups and decide who will watch which clip. | (looking at T) | (looking at computer) | (looking at T) | (looking at T) |
| **2** | (walking towards and looking at a group) Between the four of you (gesturing), choose one clip… | (nodding) | (looking at computer) | (nodding) | (looking at handout) |
| **3** | | Group interaction to choose clips | | | |
| **4** | (10 seconds later, looking at the class) Remember to listen to only one clip…Each person in the group listens to one clip. | (looking at handout) | (looking at computer) | (looking at computer) | (looking at computer) |

| | | | | | |
|---|---|---|---|---|---|
| **5** | (looking at a group) Did you discuss and choose the clips? (pointing to the projection screen) | (looking at T) | (looking at T) | | |
| **6** | Here…four clips… (looking at C) Ok… | (nodding at T) | (nodding and looking at screen) | (nodding at T) | (looking at handout) |

In this interaction, the teacher reminded students of the instructions a few times (#2, #4 and #5). Perhaps to ensure the students understood the information, the teacher not only addressed the class but also talked to individual groups. He also used the projection screen (#5) that mirrored his computer screen and the handouts that he had distributed earlier. The gesturing to the projection screen was the way for the teacher to ascertain that the students were looking at the right intranet site for the clips. Students, in turn, not only looked at the teacher (#4) but also looked at the handout and computer to confirm the information. Again, we see the interaction with the teacher and students was combined with the interaction with artefacts. Also, we see the constant interaction with several artefacts during discourse: computer, handout and projector screen. We see distribution of information to class (#1 and #4), group (#2 and #5) and individual (#6) student. Memory was accessed via projector screen and handout (#5 and #6) by teacher and students and unsolicited memory was offered (#4–6). #1 was an instance of cognitive network where the teacher was networked to the class (Appendix F(F1)) and #2 and #5 (Appendix F(F6)) were examples of networks between group level with the teacher.

Table 4.9 is an example of a group level interaction where students were deciding on the answers during collaboration at P5a. The students were applying the information they have learnt.

**Table 4.9 Group and sub-group interaction: acquiring information**

| # | A | B | C | D |
|---|---|---|---|---|
| **1** | What kind of story is yours? | (looking at computer) | (looking at handout) | (looking at handout) |
| **2** | (looking at B) | Pigeon. (glancing at notes). | (looking at B) | (looking at B) |
| **3** | | They were giving food to pigeon (looking at A). | | |
| **4** | | Then later, there was no food given but the pigeon tried to peck to get food (gesturing). | (showing handout to and looking at D) | (looking at C) |
| **5** | | (looking at group) Then food was given to the pigeon. | (looking at D) | (looking at C's handout) |
| **6** | Is that learning? (looking at B) | | (looking at group) | (looking at group) |
| **7** | | Or "experience"… (looking at A and then the group) the feeding means to experience eating the food when they peck. | | (looking at computer) |
| **8** | (looking at C) | (looking at C) | Or is it causing them to remember what to do when they peck? | (looking at C) |
| **9** | This word (pointing to a slip), is it here (pointing to a space in worksheet) or there? | (looking at worksheet) | (looking at worksheet) | (looking at worksheet) |
| **10** | (looking at worksheet) | I feel it is "experience" (looking at group). | | |

*A* was asking *B*, the contents of the clip that *B* had listened (#1). *B* shared the information (#2). *A* proceeded to test his understanding on the subject by asking, "Is that learning?" (#6) and was countered by *B*'s answer (#7). *C* entered the clarifying process by offering a possible explanation (#8). *A* wanted to connect the brief discussion to the worksheet and slips of answers by asking if what they were talking about fitted a conceptual word that he was looking for when *A* was pointing at it (# 9). *B* made a case for the answer at the end (#10). We see acquiring for information in #1 and #9; clarifying in #2-5; comparing in #6 and #8.

The glancing at the notes (#2) is a common practice (Table 4.3) and an instance of accessing memory from an artefact. *B* was explaining to the *A* and the group but looked at her notes to make sure that she was saying the right information. We see a sub-group interaction between *C* and *D* in #4-5 where *C* had shown *D* something on *C*'s handout. *C* said he wanted to show *D* some information that he wrote as notes. This was an instance of a cognitive network of a sub-group between two students and the notes (Appendix F(F7)).

The pointing at the slip and worksheet (#9) demonstrated how the individual and group are interacting consistently with the artefact: affording the cognitive processing of comparing and contrasting. When looking at the group (#6), students looked generally at the space at the centre of the group with occasional shifting of the attention at the students across the table. Students seldom looked at the students next to him or her.

We see how group interaction involves interaction with artefacts. Students in this group chose "experience" (#10) as the answer. Even though there were slight disagreement and questioning by *A* and *C*, *B* proceeded to conclude the final answer as "experience". This lack of strong disagreement or easy acceptance of the answer from members in the group reflects the general notion of harmony and smooth process of the collaboration.

Table 4.10 is an example of a group level interaction at P2 where students used the straightforward approach to decide on what clip to listen to.

**Table 4.10 Group and sub-group interaction: memory**

| # | A | B | C | D |
|---|---|---|---|---|
| **1** | You do "a" (gesturing to and looking at B), | (nodding and looking at computer) | (looking at A) | (looking at computer) |
| **2** | you do "b" (looking at C) | (looking at computer) | Uh (nodding and looking at A) | |
| **3** | you do "c"… (gesturing to and looking at D) | | (looking at computer) | (nodding and looking at computer) |
| **4** | (looking at computer) | | | (looking at computer) |
| **5** | | | | (looking at A) What's mine? |
| **6** | "b" (looking at D) | (looking at D) | | (looking at A) |
| **7** | (looking at B) "a"… | (looking at computer) | | uh… |
| **8** | (looking at computer) | (looking at computer) uh… | | (looking at computer) |

In what seems to be a straightforward decision making process where a student made suggestions and the rest agreed upon without fuss revealed a series of memory and information processing processes. *A* took the initiative and delegated clips to the rest of the group via group interaction (#1-3). Gesturing, *A* looked and pointed at each of the members and voiced the clip label. Through this interaction, *A* distributed the clip labels to each of the members. *B* was busy looking at the computer and uttered a response without looking at *A* (#1). *D* asked for his clip's label (#5) either because he missed hearing it the first time, had forgotten or was confused. The student when interviewed said he could not remember the reason. *A*, thinking that *B* may not have listened earlier and may have missed noticing *B*'s nodding, reminded *B* of his clip's label (#7). Whether *B* needed to be reminded or that it was unnecessary, *B* received a reminder. As a result, B received the information about the clip twice. We see distribution of information in #1-3 by *A*; *D* asking for information (memory) in #5; *A* giving unsolicited memory in #7. When interviewed about this, the students stated that the preference of clip did not matter to them and they were happy to be assigned a clip at random.

Table 4.11 is an example of a group level interaction at P2 where students processed information using "jan ken pon". This is an interaction composed fully in gestures and facial expression after the verbal "jan ken" by A. "jan ken" is an abbreviated verbal form for "jan ken pon".

**Table 4.11 Group interaction: decision making**

| # | A | B | C | D |
|---|---|---|---|---|
| **1** | (looking at the group) Jan ken? | (looking at handout) | (looking at A) | (looking at handout) |
| **2** | (smiles) | (nodding while looking at handout) | (nodding, smiles) uh | (looking up and at A) |
| **3** | (raises hand in anticipation) | (looking up at group) | (posturing in anticipation) | (nodding, smiles) |
| **4** | (facing B, makes a hand gesture: paper) | (facing A, makes a hand gesture: paper) | (facing D, makes a hand gesture: stone) | (facing C, makes a hand gesture: paper) |
| **5** | (facing B, makes a | (facing A, makes a hand | (grimaced and looks | (smiles in victory and |

| | | | | |
|---|---|---|---|---|
| | hand gesture: scissors) | gesture: stone) | at the other pair) | looks at the other pair) |
| **6** | (grimaced and looks to other pair for face off) | (smiles in victory and looks to other pair for face off) | (posturing in anticipation, smiles) | (posturing in anticipation, smiles) |
| **7** | (facing C, makes a hand gesture: paper) | (facing D, makes a hand gesture: paper) | (facing A, makes a hand gesture: stone) | (facing B, makes a hand gesture: paper) |
| **8** | (smiles and looks at computer) | (facing D, makes a hand gesture: scissors) | (smiles and looks at computer) | (facing B, makes a hand gesture: stone) |
| **9** | (looks at computer) | (smiles and looks at computer) | (looks at computer) | (smiles and looks at computer) |

*A* started by suggesting "jan ken" and with the agreeing members, they swiftly went into the hand-play in pairs in #4: *A* with *B* and *C* with *D*. The pair that finished earlier waited for the other pair in #6, looking to the next round. The winners and losers of each pair faced off in #7. After coming on top of the hand-play, *B* looked at the computer for the clip "a" in #9. It is interesting that the hand-play merely decided who takes the first clip on the list and not exercising the right of choice. When interviewed about this, the students stated that the use of the hand-play was a natural way for them to decide who gets to have the first preference to choose the clips. The issue was to have some fun while deciding who gets to choose first. This interactive gesture hand-play, while devoid of verbal discourse, performed a decision making process while at the same time, distributed information as to who should choose what clip.

Table 4.12 is an example of a group interaction where students were deciding on the answers during collaboration at P5c. The students were applying the information they have learnt and working to decide on the answers on the worksheet.

**Table 4.12 Group and sub-group interaction: Applying information**

| # | A | B | C | D |
|---|---|---|---|---|
| **1** | (looking at group) Is it right? Because one is "memory" and the other one is practical. | (looking at worksheet) | (looking at worksheet) | (looking at worksheet) |
| **2** | (looking at B) | Learning behaviour equals reflection. | (looking at B) | (looking at B) |
| **3** | (looking at worksheet) | (looking at worksheet) | (looking at worksheet) | I'm getting lost. |
| **4** | | (looking at C) | For me I choose this one. (pointing to "memory") | (looking at worksheet) |
| **5** | Why? (looking at C) | (looking at handout) | (looking at PED and handout) | |
| **6** | (looking at C and worksheet) | | (showing the PED to A) Memory is remembering what you learnt and the child remembers... | (looking at others) |
| **7** | (looking at C's PED) uh… | Saliva comes after sound, is it reflection? | (looking at B) | (looking at others and gesturing) |
| **8** | (looking at worksheet) | (looking at C and worksheet) | It is "memory". | (looking at handout) |
| **9** | | (looking at C) really? | (looking at group) | |
| **10** | (looking at C and worksheet) | (looking at C and worksheet) | (looking at B) I don't know but I think this is the answer for now. | (looking at worksheet) |

*A* was verbalising to the group about the choice as he compared between the concepts of "memory" and "practical" for the answer (#1). *B* offered an explanation and gave an alternative answer (#2). *D* appeared confused (#3) and did not participate verbally in the later stages but looked at the artefacts (#4 and #8). *C*, having heard *B*, appeared to make a decision (#8). He repeated the answer twice (#6 and #8) even though *B* thought otherwise (#7). *B* persisted a while in his answer (#9) but *C* maintained his position. Here we see comparing and contrasting between two answers with the group having to consider different views and choosing one answer at the end. Although there were queries and slight disagreements, the solution was quickly settled, deferring to the student who appeared to know and therefore said more. We saw a student (*D*) not getting involved except by being in the group. In fact, *D* engaged in a sub sub-group interaction and with another group's member for a short while (#6 and #7). Handouts and PED play a part in the information processing of application, being accessed for memory and distribution. We see asking for information in #1, 5 and 7; clarifying and integrating information in #2 and #9; comparing information in #1 and #7; making a decision in #8 and #10.

The above transcripts demonstrated how students and teacher distributed, processed information and accessed memory via the five levels of interaction. The levels of interaction and instances of interaction are captured and tabled in Table 4.13 indicating what observable cognitive processes took dominance (in bold) during the phases.

## Table 4.13 Interaction, cognitive processes over phases

| Level | Interaction | Phases | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | P1 | P2 | P3 | P4 | P5a | P5b | P5c |
| **Class** | T giving instruction to cl | **D** | | | **D** | | D | |
| | T reminding cl | WM | | | WM | | | |
| | S talking to cl (T) | Ac, Cl | | | Ac, Cl | | | |
| | T talking to cl | Ac, D | | | Ac, D | | | |
| | A "talking" to cl | D | D, WM | | | | | D |
| **Group** | T giving instruction to gp | D | | | D | | D | |
| | T reminding gp | WM | | | WM | | WM | |
| | T talking to gp | Ac, D | | | Ac, D | | | Ac, App, D |
| | S giving instruction to gp | | **D** | | | D | | |
| | S reminding gp | WM | | | WM | | | |
| | S talking to gp | | **Ac, D** | Ac, D | | **Ac, Cl, App, D** | | |
| | A "talking" to gp | WM | | Ac, Cl, WM | WM | Ac, Cl, WM | | |
| **Indivi-dual** | T messaging cl in webpage | | | Ac, Cl, D, | | Ac, Cl, D, WM | | |
| | T messaging gp in webpage | | | WM | | Ac, Cl, D, WM | | |
| | T messaging S in webpage | | | WM | | Ac, Cl, D | | D |
| | S messaging S in webpage | | | D | | | | D |
| | S messaging gp in webpage | | | D | | | | D |
| | S short messaging S | | | D | | | | D |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | on mobile phone | | | | | | | |
| | A "talking" to indiv and sg | WM | WM | **Ac, Cl, WM, LTM** | Ac, Cl | Ac, Cl, App, D, **WM, LTM** | | |
| **Sub-group** | S giving instruction to indiv | | D | | | D | | |
| | S reminding indiv | WM | | | | WM | | |
| | T giving instruction to indiv | D | | | D | | | WM |
| | T reminding indiv | WM | | | | | WM | |
| | T talking to indiv | Ac, D | | | Ac, D | | | Ac, App, D |
| | S talking to indiv | Ac, D | | | | Ac, App, D | | |
| **Sub sub-group** | S talking to sg | Ac, D, WM | | Ac, D, WM | | Ac, D, WM | | |
| | S talking to another gp | Ac, D, WM | | Ac, D, WM | | Ac, D, WM | | |
| | S talking to indiv with A | | | Ac, D, WM | | Ac, D, WM | | D |
| | A "talking" to S | | | D | | D | | |

WM: working memory; LTM: long term memory; Ac: acquire; App: apply; cl: class; gp: group; in: indiv; sg: sub-group; T: teacher; S: student; A: artefact; Bold letter suggests dominant process for the phase

## 4.4 Media of representations

In seeking to understand how cognition is distributed, external representations of cognition reveal the nature of the distribution (SRQ1). Whether at the artefact or interaction level, each of the observable representations was observed to be represented in a medium they were distributed in. Nine categories were identified (Table 4.14) revolving around audio and visual texts and images, and physical properties. High tech representations involved digital formats from electronic artefacts (#1, #5 and #6) while low-tech were the traditional pen, paper, and human voice (#2, #7 - #9). The nature of the medium has implications to the strength of the representation and therefore how long it can remain in the cognitive system. The longer the representation remains the longer the time the students and teachers can access the representation. The strength (length of time it remains) was observed to be determined by the permanence and frequency of the representation.

**Table 4.14 Representations, medium and strength**

| # | Medium | Representations | Permanence | Frequency |
|---|---|---|---|---|
| 1 | Audio digital text | Computer audio clip | High | High |
| 2 | Audio low-tech text | Student talk | Low | Low |
| | | Teacher talk | Low | Low |
| 3 | Physical presence | Hovering | Low | Low |
| | | Walking pass | Low | Low |
| 4 | Physical touch | Pat on the back | Low | Low |
| | | Accidental bump | Low | Low |
| 5 | Visual digital image | Computer display on projector screen | Semi | High |
| | | Computer screen video | Semi | High |
| | | Computer screen dictionary website | Semi | High |
| | | Electronic dictionary display screen | Semi | High |
| 6 | Visual digital text | Computer display on projector screen | Semi | High |
| | | Computer screen video | Semi | High |
| | | Mobile phone display | Semi | High |
| | | Electronic dictionary display screen | Semi | High |
| 7 | Visual low-tech handwritten text | Written notes | High | High |
| | | File | High | High |
| | | Words on whiteboard | Semi | Semi |
| | | Notes | High | High |
| 8 | Visual low-tech image | Facial expressions | Low | Low |
| | | Gestures | Low | Low |
| | | Glue stick | Low | Low |

| | | | | |
|---|---|---|---|---|
| 9 | Visual low-tech print text | Handout | High | High |
| | | Slips | High | High |
| | | Worksheet | High | High |
| | | File | High | High |
| | | Book (dictionary) | High | High |

Representations were observed to have either temporary or permanent properties depending on the medium. Representations such as handouts, computer clips and worksheets were observed to be highly permanent as they remained and persisted in the system for long periods of time. Others such as speech, gestures and physical touch were temporary. They disappeared after listening, viewing and feeling. They did not remain in the system and appeared to be irretrievable. Highly permanent representations, on the other hand, were stored and could be frequently retrieved at will by the receiver. There were some semi-permanent distributions that persisted for a certain amount of time but disappeared in the course of the task development. Examples were the writings on the whiteboard or computer display on the projector screen. The writings were erased or replaced by another set of writing. Similarly, the computer screen displayed another page or was switched off.

Representations were also observed to either occur frequently or less frequently. A highly frequent distribution was one that was repeatedly sent by the sender. Examples were when the teacher repeated the instructions in P1 or suggestions in P6. The reoccurrences of the representation sought to ensure effective communication. In subsequent interviews with teachers, they felt that they had to be clear in their instructions and often repeated them in order to send the message across. Table 4.14 shows the range of strength of each of the representation in the medium that distributes the cognition. Certain media clearly showed higher or lower permanence and frequency.

There is a relationship between representations that are more permanent and high frequency. Some highly permanent representations such as clips that afford repeated listening or handouts that afford repeated referencing have a high frequency property (Table 4.14). Permanent representation could thus also be seen as frequent. The writings on the whiteboard or computer display on the projector screen were examples of semi-permanent distributions that were frequent (Table 4.14) as they were accessible by sight. As the images were constantly being "shown" to the class, all the students had to do was to look at the whiteboard or screen to retrieve the information. Thus, the permanence and frequency of the representation largely depended on the medium of the representation.

## 4.5 Summary

The observable representations of discourses and body displayed during the interactions with others and artefacts allowed us to examine and understand how artefacts and interaction were used in collaboration in an extended cognitive system. As such, this study discovered several findings: First, in the group task comprising the two sub-tasks of listening and collaboration. The classroom witnessed the populating of artefacts, mainly PEDs, notes and files on the students' desks in preparation for the task. Each of the sub-tasks has a different number of distinct phases of processes. Second, students interacted with each other in the classroom at five levels: class, group, sub-group, and individual throughout the phases, with each phase having a different dominating level. Individual levels were discovered not so much as a solo activity but rather an interaction with either an artefact or another human member of the cognitive system. Third and importantly, throughout the phases, the study discovered students accessed memory, processed and distributed information by interaction with others and artefacts. These memory, information processing and distribution processes were performed separately as well as together, demonstrating they were inter-connected. Fourth, the study also discovered that a range of artefacts was accessed during the phases and they were used to perform memory, distribution and information processes. The high-tech artefacts could perform more cognitive functions. Students were discovered to populate their desks with artefacts in preparation for learning. Fifth, through the transcripts, the study realised that the interaction also accessed memory, processed and distributed information. Sixth, cultural elements were discovered to emerge at both the artefact and interaction levels. Seventh, the strength of distribution was reflected in the medium of the external representations and its quality that determined the permanence and frequency of the representation in the distribution. Lastly, issues were raised from the students' and teachers' perspectives on the group work and use of technological artefacts that gave us a fuller picture of the collaborative nature. Chapter Five will discuss these key findings in detail.

# CHAPTER FIVE

# DISCUSSION

## Introduction

This chapter will present the discussion on the main research question: how is cognition distributed in a collaborative classroom in a Japanese college. Drawing from the findings from each of the specific research questions (SRQs) and literature review, the discussion is structured as follows:

5.1 Observable cognitive processes (SRQ 1)

5.2 Artefacts (SRQ 2)

5.3 Collaborative levels of interaction (SRQ 3)

5.4 Representational media (SRQ 1)

5.5 Cultural considerations

5.6 Mapping the extended cognitive system of a classroom

5.7 Summary

## 5.1 Observable cognitive processes (SRQ 1)

From the descriptive ethnographic account of the processes in the collaborative learning, what are the directly observable cognition involved in the processes for group work in the classroom? In applying the extended cognition notion, the classroom *is* seen as the larger cognitive system where the cognitive processes can be observed between members exhibiting external representations (Zhang & Norman, 1994; Perkins, 1993). This observable cognition is seen in the behaviour and activities of the students and teachers - that is their interactions with each other and with the artefacts. As a result, the study observed that the processes of memory, information processing and distribution that occur are consistent throughout the task processes. The classroom, students and teachers remember, process and distribute information with cultural overtones, are observable at the levels of interaction and use of artefacts. Recognising that there are internal representations of these processes inside the students' minds that are still not observable, this study interviewed members to reveal what was on their minds. The next section will elaborate on the processes.

### 5.1.1 Remembering, processing and distributing information

Students engage in *memory* processes when they access and store information on artefacts and via interactions. Through discourse, students solicit for memory as well as receive unsolicited memory. LTM is accessed from information stored in artefacts (notes and files from previous classes) and interactions. WM is accessed from information stored in artefacts (notes, handouts and the whiteboard during class) and interactions. WM stores information temporarily and are accessed regularly to support the processing of cognition (Baddeley, 2007) during the collaborative task. Via these observable memory processes, we can map this extended cognitive system (Figure 5.1) and see how the classroom "remembers" information via the artefacts and students and teacher interaction.

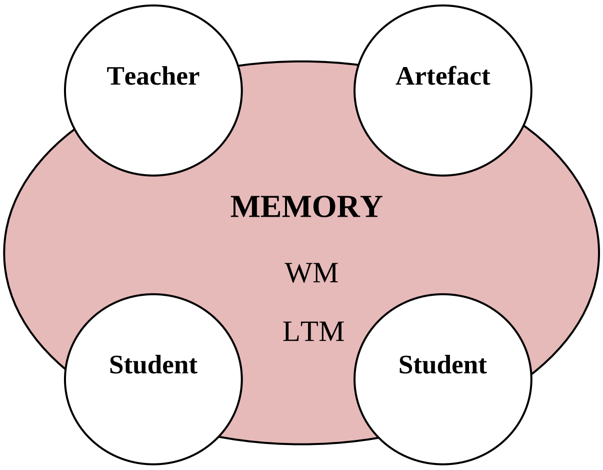


**Figure 5.1 Memory process in classroom**

The WM becomes LTM when students store the information in class and access it later after class. WM and LTM can be also seen as a continuous process (Cowans, 2005). Students and teachers transform such information from WM to LTM by making notes or do a "save" function on the computers to remember the pages visited. Likewise, online or mobile interactions are automatically remembered in the artefacts.

Students engaged in *information processing* at the discourse level of interaction and activity with artefacts. Two types of information processing emerged: acquiring and applying. In acquiring information, students perform a cycle of sub-processes: receiving, clarifying and remembering the information. These processes were directly observable and correspond with the elements of the information processing model (Luckner, 1990) where students receive ("sensory register"), clarify ("response generator") and remember ("memory") (p. 100) information. Students receive information from the teacher or clip, clarify with artefacts (dictionary), other students and teacher (questions) and store information in artefacts (note making) and with other students (verbal reminders) for later processing.

Applying information is more varied with more sub-processes: clarifying, comparing, contrasting, integrating, synthesising and remembering of information. Students, in collaborating on the task, perform a combination of recognising, recalling, matching, checking, constructing, clarifying, comparing, contrasting, integrating, synthesising information and accessing memory in order to make decisions on the worksheet. And these sub-processes involve interaction with artefacts, other students and the teacher in the classroom. All information processing involves manipulating, organising and remembering symbols of information (Simon, 1962).

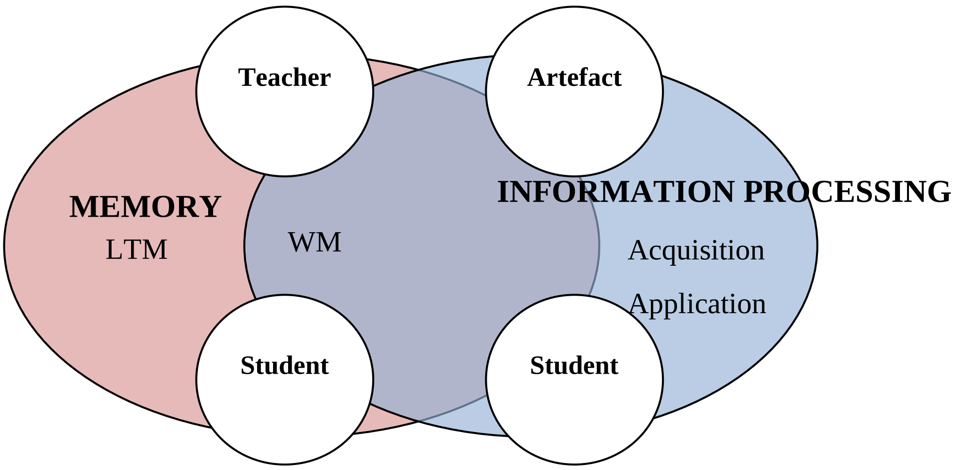


**Figure 5.2 Information processing in classroom**

In either of these types of information processing, memory process is the final processing stage, forming WM and eventually LTM (Figure 5.2).

In *distribution*, students and teachers transfer information using *both* interaction and artefacts creating a complex network of distribution. Information is distributed primarily at the class, group and individual levels, with the sub-group and sub sub-group levels complementing the main distribution levels (Figure 5.3). Students talk to the group (group level) complemented by interactions with group members, other students and teacher (sub-group level). Sub sub-group interactions may interrupt but are beneficial to the students. Students also use artefacts such as handouts, notes and PEDs (individual level) to complement their verbal distribution for a stronger representation or distribution. Artefacts are also used to clarify, emphasise and repeat certain information. Because distribution of information is the heart of co-ordination, communication and cooperation in collaboration (Engeström, 1987), this complex network of interaction levels facilitates the organic and effective flow of collaboration.

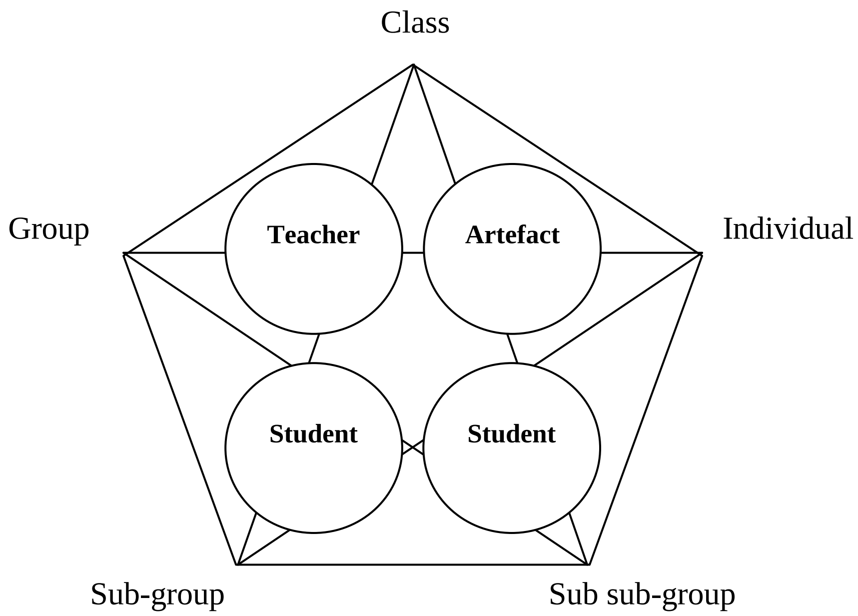


**Figure 5.3 Network of distribution**

The representation at both artefact and interaction levels are observed at different media types used. Nine different media types of representation are used to distribute cognition and the strength of the external representations depends on the properties of the media type. At class level, teachers usually use more than one media to distribute important information such as instructions or key information about the tasks. Teachers give verbal instructions together with a handout, written instructions on whiteboard and projection display. Because spoken words are temporary in nature, teachers repeat important information two to three times. Verbal instructions are repeated and projection displays are deliberately not removed to ensure a more permanent representation or distribution. Because the teachers need to distribute to a class, artefacts such as whiteboard and projection display are used. Thus, the strength of the distribution is dependent on not only the type of media used but the use of both interaction and artefact.

These processes of *memory* and *information processing* are connected via the *distribution* channels of artefact and interaction levels (Figure 5.3). Students process information via distribution while accessing memory; students access memory via distribution while processing information.

### 5.1.2 Cultural overtones

Group-work affords learning with peers in the classroom and allows sub-group interaction to emerge. These affordances are very much preferred among the Japanese students. This study discovered that Japanese students prefer to work in groups and with friends, frequently engaging in sub-group interactions with friends or preferred members in the group. This sense of belonging among friends supports the environment of trust and reliance on each other, a cultural trait of harmony culture (Hendry, 1987; Okawara, 1982) among the Japanese. This explains why there are no observable serious conflicts or disagreements that threatened to derail or stall group cooperation (Sekiguchi, 2002) during collaboration where members seek to avoid conflict (Mouer & Sugimoto, 1986). While there may actually be some competition or disagreement as expressed by students' annoyance at some personalities and work ethics in the group, such feelings are kept in control (Giddens, 1991). In this self control, students do whatever is necessary to facilitate a harmonious and successful completion of the task. The study is also mindful of the researcher effect and video recording that may conjure this harmonious effect. Apparently, the fondness for being in a group and with friends reveals this cultural trait of avoidance of conflict and maintaining harmony mentality that the Japanese students bring into the classroom.

Importantly from the learning perspective, Japanese students not only enjoy group-work but also learn as a result of it. Cited as key reasons, the sharing of ideas and coming to conclusions based on these shared ideas are what Japanese students value in group-work. This preference to share ideas at smaller group levels is related to the practice of harmony at the "social exchange" level (Moeran, 1984, p. 254) where different opinions and feelings are shared at private or closed settings with close friends and more familiar acquaintances (Befu, 1987). In this study, the prevalence of sub-group and group interaction affords this cultural conversational type of interaction at the "social exchange" level where students are not only comfortable in sharing but also give willingly in expectation of reciprocity. The combination of these social exchange and harmony traits in group relationships is perhaps engendering the Japanese collaborative culture in the classroom. And in a way, the harmony trait and group-work affordances breed and seed on the trust and cooperation the collaboration seeks, thus making group-work a highly preferable classroom style for the Japanese students.

## 5.2 Artefacts (SRQ 2)

In this study's consideration of the artefacts in the extended unit of analysis, the mediation by such cultural tools and artefacts, involved cognitive properties that aided the cognitive activity of members. The mediating by the artefacts is seen in the mediating of the memory, information processing and distribution processes as observed in the classroom. Thus we see artefacts mediate as "tools" (Wertsch, 1991, p. 90) in the development of mental processes, bridging the Vygotskian "two planes" of the interpsychological and intrapsychological in both the social and cognitive levels (Wertsch, 1981, p. 163). This mediation can be seen in the leveraging of artefacts for higher cognitive activity and development. Whether high-tech or low-tech, cognitive artefacts perform memory, information processing and distribution processes as we shall discuss in the following sections.

### 5.2.1 Artefacts leveraged for WM and LTM tasks

Teachers and students use artefacts to help them remember information in the classroom: to access and store information (Table 5.1). Both low-tech to high-tech artefacts afford this memory aid (Norman, 1991), but it is how the artefacts are used that determines the scope of access. The "allowable actions" (Zhang & Patel, 2006, p. 336) of the artefacts can be manipulated and extended by the students to increase the number of functions, thereby increasing the scope and strength of access. The different features of the artefacts' properties allow leveraging to achieve the desired scope and nature of the memory process. This, however, is limited to the familiarity with the affordances. Students cited unfamiliarity to the computers as a reason for the lack of usage of some of the computer functions. The artefacts then, can and only afford (Gibson, 1979) as much as the user is familiar with.

**Table 5.1 Artefacts and cognitive processes**

| Type | Artefacts | Cognitive tasks observed | Cognitive processes | | |
|---|---|---|---|---|---|
| | | | **Memory** | **Information processing** | **Distribution** |
| HT | Computer | Teacher uploaded audio clips to share with class | WM, LTM | | cl; in |
| | | Student searched for a word in online dictionary | WM | Ac | in, sg |
| | | Student searched for a concept in search engine | WM | Ac | in, sg |
| LT | White-board | Teacher wrote information to share with class | WM | | cl; in |
| | | Student looked for information | WM | Ac | |
| HT | Projection screen | Teacher displayed information to share with class | WM | | cl; in |
| | | Student looked for information | WM | Ac | |
| LT | Handout | Teacher printed information to share with class | WM, LTM | | cl; gp; in |
| | | Student wrote notes on handout; shared with group | WM | | gp; in |
| | | Student looked for information | WM | Ac | in; sg; ssg |
| | Slips/ worksheet | Teacher printed information for class | WM, LTM | | cl; gp |
| | | Students worked on worksheets with slips | WM | App | cl; gp |

| | | | | | |
|---|---|---|---|---|---|
| | Notes/files | Students referred to previous class' notes | LTM | | in, sg |
| | Notebook | Student wrote notes on notebooks shared with group | WM, LTM | | gp; in |
| | | Student looked for information | WM | Ac | |
| HT | PED | Student searched for a word in PED | WM, LTM | Ac | in, sg, ssg |
| LT | Hardcopy dictionary | Student searched for a word in hardcopy dictionary | WM, LTM | Ac | in, sg |
| HT | Mobile phone | Student searched for a word in online dictionary | WM, LTM | Ac | in, sg |
| LT | Student's hand* | Student wrote notes on hand | WM, LTM | | in |
| | | Student gestured with hands | | App | in, gp, sg |

WM: working memory; LTM: long term memory; Ac: acquire; App: apply cl: class; gp: group; in: individual; sg: sub-group; ssg: sub sub-group; HT: high-tech; LT: low-tech

When the classroom is viewed as an extended cognitive system, the artefacts are seen to perform both WM and LTM processes within the larger cognitive system. Examples of WM are: handout, notes, computer display, whiteboard and projection screen (Table 5.1). These artefacts are considered as WM artefacts because students and teachers access them to help them remember information that is critical for the cognitive processing *during* the task. Examples of LTM are previous class notes, files and clips. The notes and files are information stored *before* the task began and are considered as memory stored long term. Similarly, teachers introduced the clips as stored information on the intranet before the class, making them part of the LTM of the larger cognitive system. These types of memory artefacts can be considered as LTM artefact since they are information stored before the task. The notebook and files are being leveraged for memory, as well as to support the processing of information necessary for the worksheet.

### 5.2.2 Artefacts leveraged for acquiring and applying information

Teachers and students use artefacts to help them acquire and apply information in the classroom. *Information processing* artefacts help human cognition by processing the information at a faster speed and with richer detail. High-tech artefacts such as computer and PED are leveraged for specific cognitive processes and sub-processes (Table 5.1). The computer is used by the students to acquire and clarify via informational websites for further reading on the topics they worked on. The worksheet, when designed for application of information, is leveraged by the teacher to let students process information with it. While processing information happens inside the head, the visual comparing and contrasting of slips with the notes facilitates the sub-processes with external representations. In other words, the leveraging of the visual texts of the slips and notes help the mind to perform the cognitive process of comparing and contrasting. However, the worksheet demanded rather than afforded cognitive processing on the user. There was no leveraging of cognition from this artefact type but rather the worksheet facilitated the application of knowledge.

### 5.2.3 Artefacts leveraged for simultaneous and repeated distribution

Teachers and students use artefacts to distribute information (Jones & Nemeth, 2005) in the classroom. When distributing to class, teachers use more than one artefact to supplement the verbal instructions. When distributed in such a way, the distribution of the same information is repeated via the number of additional artefacts. Distributions via artefacts tend to supplement or complement verbal distribution. Similar to the written text or symbols on sticky paper for others to see (Xiao et al., 2001), the notes written on the handouts and worksheet and information on the whiteboard offered wider distribution. The list of artefacts used for distribution is found in Table 5.1.

### 5.2.4 High-tech artefacts are more powerful

High-tech artefacts afford higher capabilities than low-tech ones. Teachers use high-tech artefacts such as the computer screen to distribute complex images that cannot be produced with low-tech ones such as the whiteboard. The projection screen is crucial in showing what the teacher wants to distribute to the students without having to explain with many words as well as trying to draw on the whiteboard. The computer, whiteboard and projection screen are powerful memory artefacts because they can be used to access memory on demand and for a wide distribution at the class level. The computers are also able to distribute information to individual students at their desks for personal, customised and on-demand access. Students are able to access at their own time repeatedly and customise the length and size of information. This simultaneous and repeated nature of distribution is arguably the most ideal form for an information seeker or learner, free from constraints or limitations of the distributor. The repeated listening of the clips allowed the students to have multiple exposure to both the information and language, fulfilling the learning objectives of the teacher. This would not have been possible if the teacher had not used a classroom afforded with computers for individual use. High-tech artefacts such as the computers offer wide, individualistic and repeatable distribution.

Students use artefacts to distribute in groups or one-to-one interaction. Either high-tech or low-tech artefacts are used based on convenience and familiarity. The use of artefacts is to complement or supplement the verbal interaction. *Distributive* artefacts allow humans to use these artefacts to distribute information in the manner suited for ideal and desirable purposes that would be difficult otherwise to do so.

We have established how artefacts are cognitive in that they amplify cognition (Hutchins, 1995a) and "affect human cognitive performance" (Norman, 1991, p. 17) when they allow the user to represent or process information which the human mind is unable to or finds it too tedious to perform (Pea, 1993). This cognitive nature of the artefacts allows us to map the role they play in the extended cognitive system.

## 5.3 Collaborative levels of interaction (SRQ 3)

Because collaboration can be understood from the perspective of social interaction of members (Sawyer, 2006) within the system, studies into interaction reveal how members share information through language (Rowlands, 2009) and functional aspects of activity (Sawyer & Greeno, 2009; Greeno, 2008). This study reveals a complex network of interaction that process memory and information and distributes cognition. This interaction network can be understood from the five levels of class, group, sub-group, individual, and sub sub-group. *While* interacting primarily at the class, group and individual levels, students *also* interact at the sub-group and sub sub-group levels, complementing the main levels. These interactions are the same as the distribution levels in Figure 5.3. Sub-group interactions occur when a student engages in another interaction *during* main processes. They involve a student with another (student or teacher) or an artefact within or outside the group. Sub sub-group interactions are interruptions by a student or artefact. The emergence of these two levels makes the interaction complex and yet natural in how information is negotiated and distributed in the classroom.

### 5.3.1 Individual level as a sub-group activity with an artefact

In reality, what may appear to be an individual level activity is really an interaction with an artefact. It is not an "individual" activity suggesting no interaction. It involves an interaction either with an artefact or with another member. Whether the student was making notes or listening to a clip, the student is actually interacting with the handout or computer. We see how an individual interaction is really a sub-group activity with an artefact. The existence of sub-group interaction shows how individual level is actually an interaction with an artefact and *not* a non-interactive activity. Although this study does not exclude introspection or any self reflective process, the external representation assumes the internal representation of the mind: the unobservable internal state of mind. If Vygotsky's socio-cultural view of the social interaction is afforded by "tools and signs" (Wertsch, 1991, p. 90), the interaction with an artefact *is* an interaction indeed. The inter-psychological and inter-psychological level of social and mental activity now involves not just another more competent person but also the artefacts used. Equally important, then, and argued for in Chapter 2, the notion of extended cognition of an individual is an extension of the thinking collaboratively *with* an artefact. Individual activity, therefore, cannot be simply understood as a solo cognition anymore.

### 5.3.2 Interaction leveraged for solicited and unsolicited memory tasks

Students access memory via interactions with others. They access WM when they ask others in the group what they have forgotten or missed out when information was shared. Via discourse, students access the memory of others to support their own processing of information. Students reminding another student or a teacher reminding the class are examples of unsolicited memory access. WM is "accessed" in the sense that the recipient is accessing the same information in the WM again. Such unsolicited memory access is another form of interactional access of memory in the classroom. Students are using interactions at group, sub-group and sub sub-group levels to access memory while the teacher uses the class level to distribute unsolicited memory access.

### 5.3.3 Interaction leveraged for information processing tasks

The acquisition and application of information can be observed in the interaction during the collaboration (Table 5.2). Students use interaction at group, sub-group and sub sub-group levels to acquire and apply information. Following from the transcripts (section 4.3.4), these interactions proved to be useful for students to clarify, acquire and apply knowledge. Students clearly not only prefer group interactions but also learning in groups. In a collaborative setting, these afforded interactional levels allow a varied way of supporting the acquisition and application of knowledge.

**Table 5.2 Interaction and cognitive processes**

| Level | Interaction | Cognitive activity | | |
|---|---|---|---|---|
| | | Memory | Information processing | Distribution |
| **Class** | Teacher giving instruction, reminding, talking to class | WM | Ac | cl |
| | Student talking to class (teacher) | | Ac | cl |
| | Artefact "talking" to class | WM | | cl |
| **Group** | Teacher giving instruction, reminding, talking to group | WM | Ac | Gp |
| | Student giving instruction, reminding, talking to group | WM, LTM | Ac, App | gp |
| | Artefact "talking" to group | WM, LTM | Ac | gp |
| **Indivi -dual** | Teacher messaging class, group, student on webpage | WM, LTM | Ac | cl, gp, in |
| | Student messaging another student, group on webpage | WM, LTM | Ac, App | in, gp |
| | Student short messaging another on mobile phone | WM, LTM | Ac, App | in |
| | Artefact "talking" to individual | WM, LTM | Ac, App | in |
| **Sub-group** | Student giving instruction, reminding, talking to individual | WM, LTM | Ac, App | sg, in |
| | Teacher giving instruction, reminding, talking to individual | WM | Ac | sg, in |
| | Artefact "talking" to sub-group | WM, LTM | Ac, App | sg, in |
| **Sub sub-group** | Student talking to sub-group, another group | WM | Ac | sg, in, ssg |
| | Student talking to individual with artefact | WM | Ac | sg, in, ssg |
| | Artefact "talking" to student | | | sg, in, ssg |

**Memory** WM: working memory; LTM: long term memory

**Information processing** Ac: acquire; App: apply

**Distribution** cl: class; gp: group; in: individual; sg: sub-group; ssg: sub sub-group

Students process information by building on the sharing of information, a socio-construction of knowledge (Lave & Wenger, 1991) via social interaction to attain “higher mental functions” (Vygotsky, 1981b, p. 164). And this is done primarily through discourse, a language tool (Rowlands, 2009) and a “cultural scaffolding” (Salomon & Perkins, 1998, p. 5).

### 5.3.4 Interaction distributes at *more than one level* and *simultaneously*

Given that there are five levels of interaction, it follows naturally that students and teachers distribute information through these levels using discourse. While usually distributed at one level in the beginning, discourse is often complemented with another representational media (Table 5.2). This is because spoken discourse is temporal and needs to be strengthened with more permanent and frequent representations. As a result, teachers employ more than one level to distribute information to the students. From class level to group and individual level, teachers engage the students at these levels with the same information. Students distribute to group as well as individual levels.

Group work setting affords interaction with other students that would otherwise be absent in non-group work classrooms, where only one student can interact with the teacher one at a time. In group classroom settings, students can interact not just with others within the group but also outside the groups. The students are not restricted by turn taking as a whole class when these interactions can take place simultaneously in their groups throughout the phases, even when the teacher is talking. There were occurrences of different students interacting with one another throughout all the phases *simultaneously*. These additional interactions afford alternative clarification processes for students to attend to their immediate knowledge gaps and not having to wait for their turn to speak to the teacher or be left behind to have doubts clarified. The clarification process is necessary for students to adequately understand the task demands, process and completion of the task. The clarification process is also necessary for the acquisition of knowledge. The students' preference for learning in a group setting clearly presents an environment for these learning interactions to engender cognitive development.

## 5.4 Representational media

The quality and nature of medium of representation determines how permanent and frequent the representation remains in the cognitive system. The more permanent and higher the frequency of the representation, the stronger is the cognition in the system. Students and teachers use different types of medium to distribute cognition whether it is audio low-tech or visual high-tech. High-tech artefacts, such as the computer, have proven to be capable of high permanence and high frequency. Some low-tech ones, such as notes, are equally capable. High-tech artefacts are also capable of distribution on demand (permanent) where the representation can be repeated (frequent). While the kind of artefacts specifies the type of medium that they afford, what is clear is the strategic use of the types of medium of representation to ensure effective communication. And high-tech artefacts do offer a stronger cognitive representation.

## 5.5 Cultural considerations

This research has argued for the consideration of "ordinary practices of the culture" (Brown et al., 1989, p. 34) in any authentic study into cognition and not to shy away from including cultural influences (Hatch & Gardner, 1993) in the unit of analysis. The following are three cultural considerations that are considered in the extended cognitive system of the Japanese classroom.

### 5.5.1 Cultural practice: populating artefacts

Students and teachers prepare for the class with a host of artefacts. Teachers set up the computers and any other artefacts necessary for the class. Students populate their respective desks with personal artefacts in anticipation of the class. Populating the desks with artefacts facilitates easy access and convenience for later use. This strategy of populating artefacts is perhaps a cultural practice for the Japanese in the classroom. All these artefacts that students and the teacher set up in the classroom are part of the larger cognitive system that facilitates learning. Besides the usual paraphernalia such as pen cases, files and notes, Japanese students populate their classroom desks with PEDs before the class begins to be ready for the cognitive processing. While this may be somewhat expected in an English as a foreign language (EFL) class where students bring their dictionaries to class but the prevalence of a high-tech dictionary is considered to be highly peculiar to Japanese students (Chen, 2010).

### 5.5.2 Cultural artefacts: hand and PED

Japanese students use cultural artefacts to access memory, process information and distribute cognition. They exhibit a cultural aspect of the memory process: making cryptic notes on their hands. This is cultural not only because the notes are written in linguistic symbols but it is a practice peculiar to them. Humans have long used the hands as a memory aid by writing on them (Sherman, 2001). Notes written on hands become WM during class and LTM after class.

The artefact, PED, considered as a traditional practice (Kobayashi, 2008) for Japanese college students and a cultural trait for East Asian students in EFL classes (Chen, 2010), is used extensively for memory processes, especially LTM. It is also considered by researchers to be one of the many “mnemnotechnical strategies” to distribute memory with written text (Tribble, 2005). In fact, studies comparing the use of writing with other memory aids in a healthcare environment (Reason, 2002) have been conducted.

The strong preference to leverage with PED is cultural as all Japanese students grew up with such a device in their formal secondary education. In fact, Japanese students are known for their PED accessories in EFL classes, having a much higher incidence than students in other East Asian countries (Chen, 2010).

Most if not all Japanese students, in their mandatory second language classes, are armed with a PED and the natural reliance on this device to clarify ambiguous English vocabulary was more than evident in this study. Other forms of dictionary or translation help are rarely seen and are used only when students had forgotten to bring their e-dictionaries. In fact, in the two or three instances where the students used the online dictionary, the students had to be introduced by the teacher to this resource online. In other words, they were ignorant of such alternatives. Despite the concerns of suitability and effectiveness of PED by both researchers and teachers (Chen, 2010), the prevalence of such devices are evident not just in this study but also in many parts of East Asia (Chen, 2010).

### 5.5.3 Cultural interactions: "jan ken pon"

"Jan ken pon" - the decision making hand-play is more than a simple hand-play that has social and cultural applications. Observed in daily Japanese life not just among children but among adults, "jan ken pon" is seen as a cultural activity that legitimises decision making (Chen & Rand, 1994, p. 46). It is also seen as a relationship bonding mechanism amongst the players that demonstrates the closeness and homogeneity of the group. The "jan ken pon" is used both for processing information in decision making and distribution process. As a low-tech artefact, the use of the hand as a "social and cultural line" (Wertsch, 1991, p. 88) is considered as "arising from the socially and culturally structured world" (Lave & Wenger, 1991, p. 67) due to the practices peculiar to the learner (Valsiner & Van der Veer, 2000). We clearly see how Japanese culture is participating in the cognitive processes and distribution of cognition in the classroom.

## 5.6 Mapping the extended cognitive system of a classroom

The situative approach to study such interactions (Greeno, 2008) allows us to see the "principles of coordination of interactive systems" (p. 82) and we can see how that students collaborate using these five levels of interaction. We now see how these levels explain the interaction with artefacts and members in the system and how they process memory, information and distribute cognition. Such structures that would normally reveal the distribution of the functional aspects of activity (Greeno, 2008) have, in fact, also revealed the cognitive activity of the extended cognitive system (Hollan et al., 2000) of the classroom where the system includes also the materials, teaching and learning aids in the classroom (Wilson & Clark, 2009). This study's findings resulted in mapping the classroom as an extended cognitive system where students, teachers and artefacts together with their interaction store, distribute and process information (Figure 5.4).

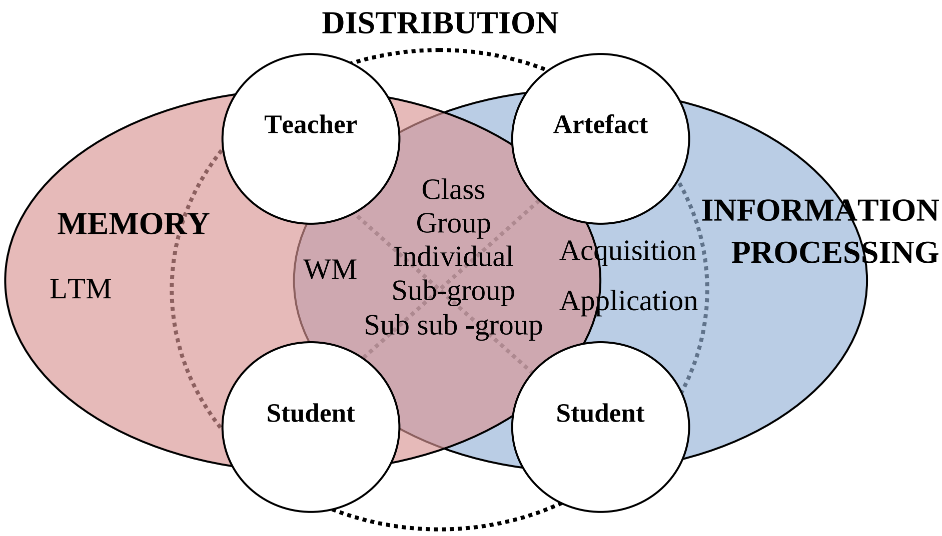


**Figure 5.4 Extended cognitive map of a classroom**

This study has shown that not only the teacher, students and artefacts perform memory, distribution and information processes separately, but they are inter-connected. Memory is accessed at both WM and LTM with information being processed at the acquisition and application cycles with WM. Information is distributed via the interaction cognitive network of the teacher, students and artefacts at the five different levels of interaction.

## 5.7 Summary

With the extended cognition notion applied to this study of classroom collaboration, the observable cognitive processes of memory, information processing and distribution are seen in the external representations via different media. As a result, the classroom remembers, processes and distributes cognition via the use of artefacts and interaction. The classroom accesses the WM and LTM from its members, including the artefacts and from the interaction. WM is seen as a continuum to LTM and also involved in information processing. The classroom acquires and applies information via the interaction and use of artefacts. The acquisition and application cycles involve sub-processes of recognising, recalling, matching, checking, constructing, clarifying, comparing, contrasting, integrating and synthesising. The classroom distributes cognition via the interaction levels and artefacts. The distribution via interaction involves five levels of class, group, sub-group, individual, and sub sub-group and nine media types of representation. The classroom has cultural aspects to the remembering, processing and distributing cognition. There is a coalescing of the cultural aspect of group mentality, harmony, students' preference for group work and the group work affording many levels of interaction. This enhances the learning experience and supports collaboration engendering cognition development thorough interaction and use of artefacts.

The artefacts and interaction levels, then, perform the memory, processing and distribution of information. Artefacts store and support both WM and LTM with high tech artefacts being able to perform more cognitive processes, when compared to low-tech artefacts. The interaction afforded by the group work format, is a complex network of levels, offering more than what is currently perceived in collaborative classrooms. The individual level is also seen as an interaction with an artefact. Interaction can distribute at more than one level and with many levels at the same time. Memory processes can be both solicited and unsolicited through interactions. In facilitating information processing, interaction affords cognitive development in groups. There are cultural aspects of artefacts as well as in interaction. The cultural artefacts are the notes on the hand and PED, a traditional artefact of the Japanese in classrooms. The “jan ken pon” is a traditional hand play interaction to facilitate a decision making process. Finally, with the coalescing of all these conclusions of the findings, this study is able to map the cognitive system of the classroom as illustrated in Figure 5.4, which shows how cognition is distributed in the classroom.

# CHAPTER SIX

# CONCLUSIONS, IMPLICATIONS AND RECOMMENDATIONS

## Introduction

This chapter concludes the study by providing the conclusions, implications and recommendations of the research. First, this chapter presents the outcomes of the main research question after a brief review of the reasons, concepts and research methods of this study. Second, this is followed by the discussions on the implications of these conclusions. Finally, recommendations are made to improve the teaching and learning and suggestions of further research. The chapter is structured as such:

6.1 Conclusions

6.2 Implications

6.3 Recommendations

## 6.1 Conclusions

The conclusions will provide a summary of the main conceptions and investigative process of this study with the conclusions discussed in tandem with the specific research questions and literature review. This section is subdivided into:

6.1.1 Reasons for the study

6.1.2 Conceptual considerations

6.1.3 Investigative processes of the study

6.1.4 Outcomes of the study

### 6.1.1 The reasons for the study

As an avid user of group work and IT in the classroom, I had observed how students naturally turn to their electronic gadgets and computers while collaborating to complete a classroom task and noticed how teachers readily use computers in their classrooms. My interest was to try and understand what exactly is going on during group work especially when IT is used. So, on one hand, there is the nature of collaborative activity, and on the other hand, the natural use of technological artefacts, typecasting a modern learning phenomenon seeking to be understood. The lack of microscopic studies into these modern learning contexts, a result of the increasing use of technology and group activities into our classrooms today, heightened my curiosity and need to understand how students collaborate and use IT at the same time. This study was a result of this interest and the aim was to develop a conceptual understanding on how college students collaborate with IT in group tasks in a classroom setting. The following main research was used to achieve this aim: How is cognition distributed across a group of students collaborating on a learning task in a technologically enabled classroom in a Japanese university? Driven by the main research question, three specific research questions (SRQ) were employed to understand the students' collaborative activity with each other and with the artefacts in the environment. This understanding was further supported by interpreting both the students' and teachers' perspectives on the collaborative task.

### 6.1.2 Conceptual considerations

In order to frame the study, socio-psychological concepts were used to undergird the interpretive nature of the research as well as the basis of the investigative methods to the main research question. The notion of extended cognition (Clarke, 2005) and the interplay of interpsychological and intrapsychological planes of cognition and human actions (Vygotsky, 1981b) validate an ethnographic approach to study cognition as a whole involving students, teachers, and artefacts within the classroom as the unit of analysis. It studies how observable cognition is distributed across a group, seeking to understand the processes of cooperation and connectivity between the members of the system in accomplishing a task. In order to do that, external representations of cognition (Zhang & Norman, 1994) are observed in the collaborative activity of co-ordination, communication and cooperation (Engeström, 1987) in the classroom. The study thus, engages in cognitive ethnography (Hutchins, 1995a), a recognised form of ethnography into distributed cognition: using participant observation, interviews and artefact analysis. This study does not attempt to study the psychological issues nor seek causal relationships for the distribution of cognition, but rather focuses on the interpretive nature of observation and interviews of the students and teachers. Thus, the interpretive research paradigm is the philosophical and epistemological basis of the investigative process, rendering it meaningful to both the researcher as well as the reader of this study.

### 6.1.3 Investigative process of the study

Data was primarily collected from participant observation in three classrooms, consisting of two observations per classroom of 15 to 16 students. A total of 24 group observations were videotaped for further repeated review. Another 12 unrecorded observations were also made of the same classrooms for a more prolonged engagement. The observational data was supported with group interviews with all 48 students and individual interviews with three teachers. In addition, the relevant artefacts found within the group activities in the classrooms were analysed. The students were typically selected based on the random placements and gender mix of a typical classroom in the college. The classrooms were selected based on the availability and willingness of teachers to participate in this study. Together with these primary data collection methods, coding, theoretical and operational memos (Strauss & Corbin, 1998), diagrams and cognitive maps (Miles & Huberman, 1994) were kept to supplement the data.

The data was analysed using the constant comparative method (Strauss & Corbin, 1998), where questions were asked and constant comparisons were made. Grounded theory methods were used insofar as open and axial coding to categorise and make meaning of the data. Codes were generated from observation of the students' activities and were compared and contrasted across the six groups. After the axial coding where categories were created from related and associated open codes, the categories were corroborated with the codes from the interviews and artefact analysis. From these categories, a conceptual framework was developed for this study.

### 6.1.4 Outcomes of the study

This section draws conclusions on how cognition is distributed across a group of students collaborating in a Japanese classroom (RQ). The conclusions are derived from consolidating the findings of the three specific research questions (SRQ) below:

**SRQ1. What are the observable cognitive processes and representations involved in classroom?**

**SRQ2. What artefacts are accessed and how are they used?**

**SRQ3. What are the levels of collaboration and how do they interact?**

#### 6.1.4.1 Observed cognition in activities and processes - SRQ 1

In applying the extended cognition notion to the classroom, this study discovered three main cognitive processes that students and teachers engage in to perform the collaborative task: memory, information processing and distribution. External representations (Zhang & Norman, 1994; Perkins, 1993) of memory, information processing and distribution are observed at both the artefact and interaction levels. In memory processes, students and teachers decode stored information from long term memory (LTM) and access working memory (WM) for processing in class (Baddeley, 2007). In information processing, students acquire and apply information with sub-processes. In acquiring, the sub-processes are receiving, clarifying and remembering information while in applying, they clarify, compare, contrast, integrate, synthesise, store and retrieve information. These sub-processes of information processes (Luckner, 1990) involving manipulating, organising, storage and retrieval of information (Simon, 1962) constitute the extended cognitive system of the classroom. In distribution, students and teachers share information at class, group, individual, sub-group and sub sub-group levels via different media of representation that facilitated the co-ordination, communication and cooperation in collaboration (Engeström, 1987). From these cognitive processes of memory, information processing and distribution, this study is able to map the extended cognition of the classroom with the teacher, students and artefacts as illustrated in Figure 5.4.

#### 6.1.4.2 Artefacts - SRQ 2

Students and teachers use artefacts that are afforded (Gibson, 1977; Zhang & Patel, 2006) in the classroom for memory (off-loading (Pea, 1993)), information processing (amplification (Hutchins, 1995a)) and distribution (Jones & Nemeth, 2005) to complete the collaborative task. In particular, they store and retrieve information in WM for information processing and in LTM for retrieval after class. Similarly, students access LTM with their notes made from previous classes. Students use high-tech artefacts such as the computer and PED for specific information processing. Teachers use powerful high-tech artefacts for simultaneous and repeated distribution. Thus, cognitive artefacts are leveraged for WM, LTM, acquisition, application and distribution of information (Figure 5.4). Artefacts were used by teachers at the class level and students at the group and individual levels. High-tech artefacts are able to perform more cognitive functions, making them more versatile and powerful. In the mapping of the classroom cognitive system in Figure 5.4, we can see how information stored in WM is not entirely separate (Cowans, 2005) from LTM when they become LTM after the class.

#### 6.1.4.3 Interaction - SRQ 3

Students and teachers interact freely, sharing information through language (Rowlands, 2009), in the classroom in order to complete the collaborative task. This study discovered five levels of interaction where teachers and students use to store, process and distribute information: class, group, individual, sub-group and sub sub-group. Class level means one person is interacting with everyone in the classroom. Group level means the students are interacting in their own groups. Individual level means a student is performing a solo activity; interacting with an artefact or another person. Sub-group level is interaction activity between the individual and another person during the class, group or individual interaction time. Sub sub-group interactions are interruptions to sub-group interactions. This web of interaction is leveraged for memory, information processing and distribution of cognition). Memory, when leveraged by interaction, comes both solicited and unsolicited. Distribution via interaction can be simultaneous and at more than one level.

#### 6.1.4.4 Culture considered

This study discovered that students bring their culture into the classroom. Japanese students have a strong preference for group work and engage in sub-group interactions with friends. Underlying these preferences is the implicit trust and harmony (Hendry, 1987; Okawara, 1982) that sees the collaborators' avoidance of conflict (Sekiguchi, 2002; Mouer & Sugimoto, 1986) and self control (Giddens, 1991). These preferences, in part, are also a result of the affordances of "social exchange" (Moeran, 1984, p. 254) at the sub-group interaction and inter-reliance on each other (Hendry, 1987; Okawara, 1982) in a group interaction. These cultural inclinations are brought into the classroom and incorporated into the cognitive processes.

This study discovered that Japanese students practise populating artefacts, in particular the PED, on their study desks prior to classroom tasks. Together with other relevant materials, the PED is a common (Chen, 2010) and even considered traditional (Kobayashi, 2008) artefact in Japanese classrooms. There is also a cultural artefact, a student's hand (Figure 4.5) that performs the cognitive activities of memory (Sherman, 2001) and distribution (Tribble, 2005) when written. Another cultural practice is leveraged for a complex and higher cognitive activity of decision making process via a cultural interaction, "jan ken pon", a traditionally legitimate decision making hand-play (Chen & Rand, 1994, p. 46). This cultural artefact differentiating from other artefacts is culturally a Japanese tradition, "arising from the socially and culturally structured world" (Lave & Wenger, 1991, p. 67) as practices peculiar to the learner (Valsiner & Van der Veer, 2000). Embodying "the social and cultural line" (Wertsch, 1991, p. 88), these cultural artefacts, interaction and harmony mentality not only engender the extended cognitive system but are part of the specific cognitive processes.

### 6.1.5 Cognitive leveraging – Main Research Question

In answering the main research question, I applied the extended cognitive system (Gallagher, 2006; Clarke, 2005) to study how a Japanese collaborative learning classroom distributes cognition. I not only learned that students and teachers access memory, process and distribute information across the artefacts and human members in the classroom (Figure 5.4) but also how they perform these cognitive activities. Members do these by leveraging their cognitive activities with tools that amplify their performance and complete the collaborative task. These tools are artefact, interaction and culture. I shall label this process of using these three tools to enhance their cognitive activities as "cognitive leveraging" (Figure 6.1). Perhaps, similar to the concept of "mediating tools" (Wertsch, 1991, p. 90) in Vygotsky's socio-cognitive mental development, students and teachers leverage their cognitive activities with tools to attain a higher level of performance. I also discovered that in a Japanese collaborative learning setting, all three: artefact, interaction and culture are leveraged *together* for an effective group process.

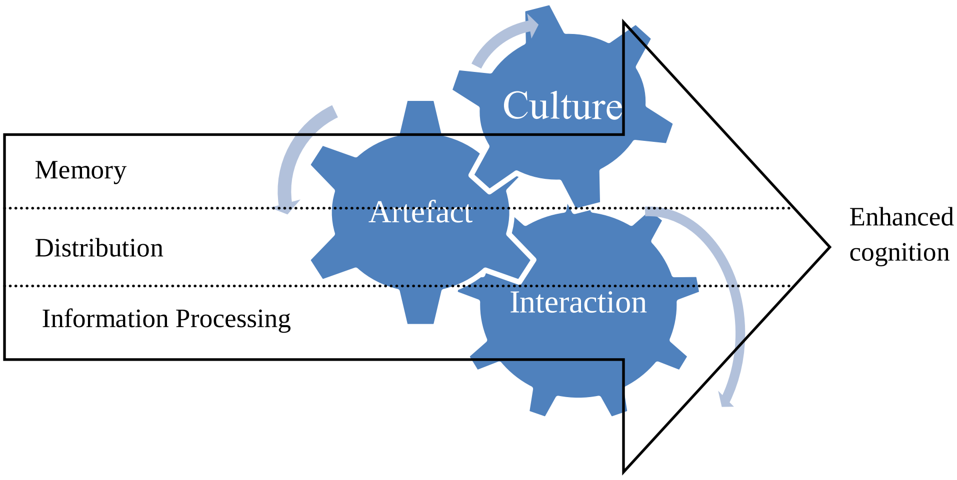


**Figure 6.2 Leveraging artefact, interaction and culture**

The following sections will show how the leveraging is done in the context of the extended cognitive system.

### 6.1.5.1 Cognitive leveraging for memory

Using artefacts and interaction, students retrieve crucial information from WM when they need or when they cannot remember on their own. Students, in trying to remember, extend this effort of remembering by leveraging on stored information on an artefact (whiteboard) or interaction (asking questions). Notes written on hands become WM during class and LTM after class. Culturally, Japanese students tend to populate their desks with artefacts to support their cognitive processes.

Thus, students access the WM of the larger cognitive system and enhance their own cognitive tasks by accessing artefacts and interacting members (leveraging).

Teachers, having the control over the classroom, leverage the cognitive task of memory by storing the clips as LTM in the intranet before the class. This storage of information as LTM in the extended cognitive system from the teacher, being part of the system, allows students to access during class. Via interactions (verbal and online) with the class, teachers remind and repeat students of the task, instructions and suggestions serve as WM for the system. Online interactions become LTM over time once stored in the computer. Because WM and LTM are such integral part of the cognitive system, members employ tools to leverage these essential memory processes.

#### 6.1.5.2 Cognitive leveraging for information processing

In acquiring information students extend this acquisition process onto artefacts and interaction to enhance the cognitive process of acquiring. High-tech artefacts such as the computer allow the students to extend this acquisition over to the internet search or the PED to seek for the meaning of a difficult word. The availability of group members affords peer interaction for students to also extend this acquisition by asking for information. Through verbal discourses, students acquire and apply information and perform complex cognitive activities such as decision making, integrating and synthesising of information.

Some of the interactions have cultural overtones. In a decision making process, students engage in a Japanese tradition of hand-play, “jan ken pon”, not only to distribute information but process information. This extending and improving of the cognitive performance via high-tech artefacts and interaction are examples of cognitive leveraging. Students also perform cognitive sub-processes of clarifying via artefacts and interaction levels. As an integral part of the cognitive system, the information processing is enhanced by the leveraging of the tools.

#### 6.1.5.3 Cognitive leveraging for distribution

Students and teachers use artefacts and interaction to leverage the distribution of information at class, group, individual, sub-group and sub sub-group levels. The group-work affords a complex network of interaction levels to facilitate distribution. Members leverage on this network to distribute simultaneously and at more than one level. Teachers use discourse together with high-tech artefacts to distribute at class level at the same time and to group and sub-group levels. Students use discourse and artefacts at group and sub-group interaction. Nine media of representations are used to distribute with each media possessing different strengths. Students and teachers leverage on the strength of these media to set the degree of permanence and frequency of the external representations of the distribution. Teachers store information on the projector screen and computer for repeatability, retrieval on demand and customised distribution.

What this study has discovered that is significant are tools (artefact, interaction and culture) are being leveraged by students and teachers to enhance cognitive processes of memory, distribution and information processing in the classroom. These tools not only are leveraged individually for the specific cognitive process but are leveraged for more than one at the same time. Information is also distributed through these tools in order to connect with members in the system. This interconnectedness of accessing memory, processing information and distribution reveal how intertwined mental processes are within the larger cognitive system as illustrated in Figure 5.4.

**6.1.5.4 Tools may not leverage**

As much as I have argued that students can leverage the three tools to enhance cognition, these same tools can hamper when not managed properly. When not adequately familiarised with the artefacts, especially high-tech ones, students spend more time familiarising with the artefact rather than leveraging. High-tech artefacts may bring about powerful functions, but also technical difficulties at the same time. Culturally and personally, some students may find an aversion to high-tech artefacts due to their complexity. The artefacts, though afforded in the classroom, may be underutilised. Artefacts can also interrupt cognitive processes when they diverge (Simon, 2005) or distract (Young, 2006) students from the task, such as spending extended time on related and unrelated internet surfing and attending to personal emails.

The affordance of multiple interaction levels can also distract students from the task – through interruptions from fellow members in the group as well as from outside the group. Annoying or difficult members have proven to be an issue in effective group work and even a hindrance. Sub-group interactions can be distracting and interfere with group interactions when an outside member interrupts the group or when a side discussion on issues unrelated to task takes place. In spite of the benefits of learning interactions, there are these issues to contend with.

Culturally, the preference for harmony within the group and class can be leveraged for effective group work and enhanced cognition. However, there are potential pitfalls. The preference for group harmony can lead to too much deference to groupthink (Brady, 2000), a group bias that devalues individual thought. As with issues of group dynamics, being with friends becomes a problem when a member prefers to interact only with the friend rather than others in the whole group.

However, what can be positively established in this study is that the three tools (Figure 6.2) can be leveraged for higher cognitive performance. Many modern classrooms are clearly leveraging them in learning environments that embrace technology and collaborative learning.

## 6.2 Implications

This study aims not only to produce a conceptual understanding about the distribution of cognition in collaborative learning with technology in the classroom, but also to provide insights for practitioners, including students, teachers, researchers and policy makers in college education. Just as the effective use of technology necessitates that "most everything in the classroom needs to change in a way that makes curriculum, learning activities, teacher's behaviour, social interactions, learning goals, and evaluation interwoven into a whole newly orchestrated learning environment" (Salomon, 1990, p. 51), this study's conclusions have implications to teachers, students, policy makers and research.

### 6.2.1 Implications for teachers

The extended cognition framework provides a different and fresh approach to classroom teaching and learning. The mapping of the cognitive processes in the classroom, when seen as a larger cognitive system, allows educators to see how and where these processes take place. Accordingly, there are implications to the distribution of information in the classroom as well as where memory and information processing can be facilitated. These have implications to the teachers' curriculum design, delivery and assessment of cognitive activity as well as achievements in the classroom.

Especially for the classroom design, the teacher has to consider the artefacts to be provided in order to facilitate the targeted cognitive processes and interaction of the members in this extended cognitive system. In other words, the teacher needs to deliberately design for group, sub-group and individual levels of interaction with artefacts and with others. This has implications to the teachers' attitude towards collaborative learning, the many levels of interaction with human members and artefacts.

In the delivery, there are implications for the media of representation, the characteristics of strength and intent, ways of distribution, distributive networks and the potential transformation of the representations in the classroom.

### 6.2.2 Implications for students

The learning in the classroom is a composite, complex and connected cognitive system that affords and allows its members to process memory, information and distribution. From the learning perspective, because students leverage artefacts and interaction for cognitive activity, there are implications for the learners' memory, information and distribution processes in the classroom.

### 6.2.3 Implications for future policy making

The notion of an extended cognitive system in the classroom, the leveraging of artefacts and interactions for cognitive processes has implications for the way policies are upheld in schools adopting this collaborative learning with technology approach. As such, there are implications for the classroom and teacher culture where there may be an impact on the hiring and training of teachers. In addition, the infrastructure and resources in the classroom have to be reviewed and supported.

### 6.2.4 Implications for the research community

Because this was an investigative study, it was first and foremost a research piece, primarily to add knowledge to the existing body of collaborative learning. By adopting the relatively new notion of extended cognition, this study took a different approach to study classroom behaviour and in so doing, developed new conceptual frameworks regarding collaborative learning. These new conceptual frameworks open up new directions of further research in the continual pursuit of a fuller understanding of collaborative learning with technology. Thus, while this study can only unearth an early understanding, more studies clearly need to be conducted in this direction which will be described in the subsequent section on recommendations.

## 6.3 Recommendations

This study proposes a number of recommendations to address the implications for practitioners of collaborative learning and the use of technology in the classrooms; policy makers and research community.

### 6.3.1 Recommendations for teachers

In designing for collaborative learning, teachers must consider technology a common feature in modern classrooms, and strategically put in place high-tech artefacts in the classrooms under careful pedagogical considerations (Fried, 2008) relevant to the cognitive activities that the teachers want students to engage in. When seen as a larger cognitive system of teacher, students and artefacts in the classroom, the design of the task enlarges to include the consideration of the placements of artefacts in the classrooms, the students' vicinity, familiarity and needs to the task and sub-tasks. Because higher technological artefacts afford more cognitive functions for students, teachers need to consider the type of technological artefact for higher human cognitive performances (Norman, 1991). The familiarity and needs of the students with respect to the technological artefacts have implications for the use of such artefacts in a classroom. Technical issues and unfamiliarity with high-tech artefacts should be mitigated with practice for training for teachers and students. Attitudinally, teachers should be open to students bringing in personal artefacts to classroom, thus allowing consultation with multiple sources of information that serve as memory sources. This permissiveness facilitates the seeding for the cultural practices that students naturally turn to for memory and information processing. Teachers should also consider the interactional processes that can be leveraged for cognitive processes by designing for group work or allow students to discuss freely in class. Here, due to the multi-levels of interaction, the teacher needs to have a mindset change to allow the "messy" interplay of interactions and trust the students to facilitate the required processes to complete the task.

The mapping of cognitive processes lets educators design the flow of information in class. Teachers can locate and plan for sources of memory access and information processing in the artefacts and interactional levels for optimal distribution and cognitive activity. The notion of information on demand is a useful concept for such a mapping where students are provided with artefacts to obtain information from the teacher on the task, knowledge to tackle the task and feedback. Another notion is the unsolicited memory processes where students are given the critical instructions and knowledge of the task at regular intervals to ensure they keep to time and stay on task. Yet another notion from this study suggests the flow of information from WM to LTM where students are provided with a reservoir of information to store and retrieve for later classes. Clearly, the use of artefacts and interaction as the means to cognitive processes posit the notion of ample use of these two tools in the classroom.

Finally, in the delivery of the task, the teacher can no longer rely on what comes naturally: speech, to convey instructions and trust that in speaking, the students would have received the messages. The teacher can plan the number of representational media and leverage on the strengths and intent of each media to effectively distribute and engender a distribution that is constant and self-referencing. Media that allow representations to be constantly accessed or frequently distributed will ensure a good distribution of cognition for students to stay on track and access information when required. This means the provision of different distributing representational media that has high strength and intent. For teachers, the conscious selection of representational media according to its strength and intent for critical incidents may ensure a more effective delivery. For example, the teacher may repeat (frequency) his instructions at intervals to remind and help students to stay on task, or provide a more permanent visual text display of the reminder on the whiteboard.

A combination of all the above considerations will engender an environment of learning for students where information is distributed organically and when needed to accomplish the learning tasks.

### 6.3.2 Recommendations for students

Because the students leveraged both artefacts and interaction to process their cognition, students should be made aware that they can take advantage of them for their learning in the classroom. New and more artefacts should be encouraged not just by the teachers but students, who may tend to be more technologically savvy, may contribute and introduce new ways of leveraging high-tech artefacts. With the students' contribution in the classroom, this will certainly become more of a learning community (Lave & Wenger, 1991) where the teacher is not the only source of learning. Thus, just as users populate their computers with relevant and useful applications or programs, students should be encouraged to populate their desks and learning environment with artefacts that they can leverage with.

The extended cognitive environment will help the students to see the classroom as a learning community (Lave & Wenger, 1991) where they are part of the learning process rather than individuals coming to class to learn. This mindset change will enable students to view learning from multiple sources, peers and artefacts, as well as contributing to the whole via interaction.

Distributional ways for representational media can be taught to help students make informed choices when selecting which media are more effective and appropriate for distribution. For students, the knowledge of this media enables an informed choice of which representational media will strengthen the supporting processes they engage in. For example, a student may use a more permanent visual text display of critical information via an artefact positioned in the vicinity for quick referencing. Or a student may use an audio timer in a mobile phone to help monitor the time of the completion of task via (frequency) audio at intervals and visual (permanent) time notifications. Being familiarised in the different representational media and different ways to distribute cognition will not only increase the transformation and therefore strengthen communication, but add to cognitive performance. These may entail additional orientation classes prior to the collaborative tasks.

### 6.3.3 Recommendations for policy makers

First, the extended cognitive system and leveraging of the artefacts and interactions suggest to curriculum planners the need to review their classroom philosophies where such communities of learners can be engendered (Brown & Campione, 1990). If collaborative learning and use of IT are the emphasis, then not only should teaching and learning philosophies need to be realigned but also the resources and funding to support these approaches in terms of training and IT equipment. This may involve recruiting teachers who are open in their thinking and who are more inclined to the use of technology and group work, especially for institutions that embrace the goals of collaborative learning and IT use. This would gather like-minded teachers to foster communities of learning of this nature. And for existing teachers, training and exposure to success stories would encourage more to adopt the approach of engendering learning through group work and use of IT.

Second, the organic nature of the interaction between levels suggests that adequate space be given to group and individual activities where it is flexible for students to shift from one to the other. Planners need to consider the furniture arrangement and provision of artefacts to cater for this organic form. This means having classrooms with moveable furniture and adequate provision of artefacts for students' collaboration.

### 6.3.4 Recommendations for researchers, college and university

Studies into other types of collaborative tasks and across other colleges and universities classrooms can test, refine or confirm this study's preliminary findings.

In the direction of the classroom as an extended cognitive system, studies into the WM, LTM and types of information processes will further add to this research. Of immediate interest is to further investigate whether there are any more tools that students and teachers leverage in the classroom. This study has identified three from its setting and perspective, perhaps other case studies may reveal more. Equally intriguing will be the identification of other cognitive processes that may be present in *other* settings to complement what has been discovered here. One interest would be the range and types of information processes that support the types of memory and vice versa. This will help educators focus on what, how and when to facilitate these cognitive developments of students.

In the direction of interaction levels, a discourse and activity analysis of the levels and how the interplay affects the distribution of cognition will shed more light into the efficacy of each level. The actual amount of individual activity and how they are related to the collaborative learning may be quantified across different types of settings. From the perspective of group entities, studies into their effect within the group and interaction with other groups will reveal the dynamics of dealing with groups.

In the direction of studies on artefacts, the access criteria and the types of cognitive functions may be further expanded or consolidated. Studies into high-tech artefacts, their functions and how they actually add to the cognitive performances of the students are worthy to be pursued. Perhaps a future study can be done to conduct a criteria rating for each of the memory artefacts and compare them to the frequency use of the artefact.

Last, in the direction of distributive media and representations, there are many to be explored. Studies into the different types of representational media and their relationship to the characteristics of intent and strength will yield a theory on how representations can be effectively distributing cognition. Certainly too, one would like to know if there are more categories to be identified other than the nine in this study and more characteristic continuums to be added to the nature of the representations.

Indeed, this study is only just beginning to understand the complexity of collaborative learning from the distributed cognition viewpoint. As such, this study recognises the limits the data can yield and conclusions made, and where there are more questions only which further research can answer.

Finally, while more recommendations can be made for practice, policymaking and further research, these recommendations are made in the light of this early study into how cognition is distributed in collaborative learning with technology. Adopting this fresh perspective of extended cognition to examine classroom learning, this study is all but a start into unearthing data about today's modern learning environment in our colleges. The notion of leveraging tools in our environment is pushing the boundaries of the way we learn and enhance our cognitive processes and abilities. This leveraging of tools in an extended cognitive system that is mapped by the extensional relationships with artefact and human sources of cognition lets us see how information and indeed cognition flows and connects with a world that is beyond the self, group, class and even the school, the students and teachers are in. These relational interactions are endangering cognition distribution and therefore learning in new ways that we are only just beginning to understand. Perhaps, these conceptual frameworks introduced in this study may inspire theories and hypotheses that will give us a fuller and richer picture of extending collaborative learning in today's ever advancing digital world.

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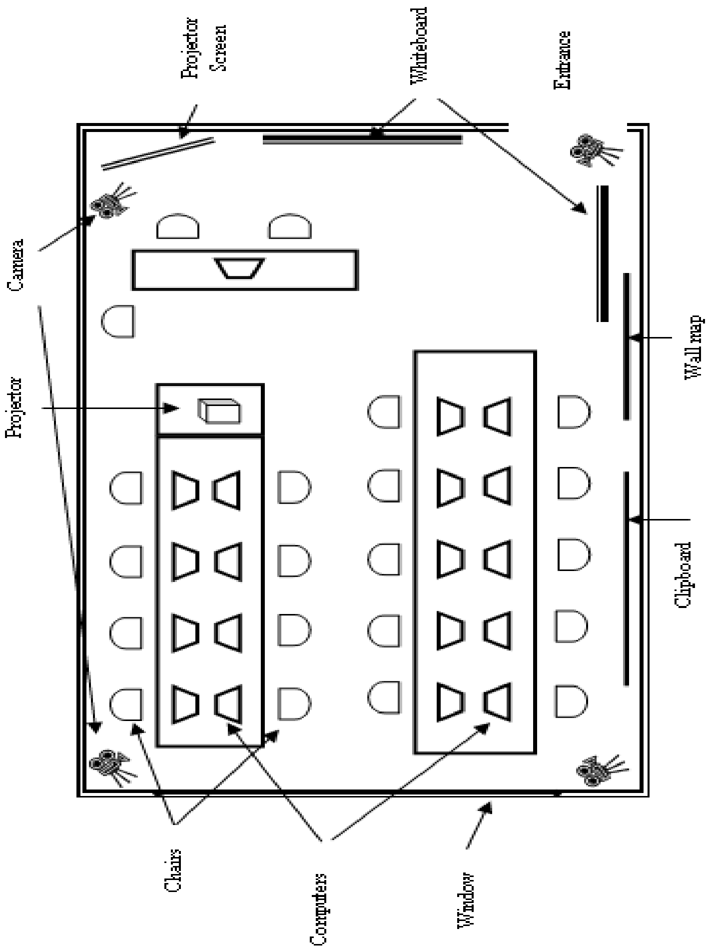
**Appendix A**
**Observation schedule**

| Class | Psychology | English Class A | English Class B |
|---|---|---|---|
| **Semester and year** | Spring 2009 | Spring 2009 | Autumn 2008 |
| **1st recorded observation** | | | |
| **Dates** | May 8th | June 1st | 24th Sep |
| **Duration** | 1 hour & 6 minutes | 1 hour & 12 minutes | 1 hour & 18 minutes |
| **Time of day** | 9am | 1.40pm | 1.40pm |
| **Number of students in class** | 16 | 16 | 16 |
| **Gender** | 4 males: 12 females | 7 males: 9 females | 6 males: 10 females |
| **2nd recorded observation** | | | |
| **Dates** | June 26th | July 8th | Oct 20th |
| **Duration** | 1 hour & 3 minutes | 1 hour & 15minutes | 1 hour & 3minutes |
| **Time of day** | 9 am | 1.30 pm | 1.30 pm |
| **Number of students in class** | 15 | 16 | 15 |
| **Gender** | 4 males: 11 females | 7 males: 9 females | 5 males: 10 females |

All the classrooms have computer notebooks on the desks and each student has access to one notebook each with a few spare ones. Each of the classrooms has a projector and a screen in front together with a whiteboard. Each classroom has also an extra whiteboard on rollers.

**Appendix B**
**Classroom layout**



**Appendix C**
**Sample of a learning task**

**Unit 5 - Social Psychology**

**Listening/ Watching Audio Video Practice**
**(40 minutes)**

You will listen and watch a clip on a topic in Psychology. You can watch as many times as you like. Listen and write down notes in this space. You do not need to have the correct spelling yet. You will be given a chance to make the necessary corrections later. Just write the notes and get the main ideas.

There are four videos found under "Videos for Unit 5 – Social Psychology" in MOODLE. Log in to get the videos. Each student in the group will watch ONE video clip. Take notes and after everyone has watch one video, discuss as a group what you saw. After 15 minutes, your teacher will give you a worksheet for you to complete the missing information as a group. Submit the completed worksheet to your teacher once you finish.

**Your Notes:**

**Topic: ________________** **Date: _______________**

## Appendix D
## Interview guide for group interviews

Questions for Group E1 Time: 11 am Duration: about 45 minutes

<u>Generic questions</u>

1. Before this learning activity, how many years have you been using computers?
2. Before this learning activity, how many years have you been experiencing learning in groups?
3. Did you enjoy listening to and watching a video via the computer?
4. Did you enjoy the group activity working together to complete the task?
5. Did you enjoy using the computer for group work?
6. Did you find it difficult to use the computer to listen and watch the videos?
7. Did you find it difficult to work together as a group?
8. Did you find it difficult to use the computer?
9. Did you find it annoying that students talk between themselves within my group?
10. Did you find it annoying that students from other groups disturb my group, for example they were noisy or they talked to my group members?
11. Did you learn about subject matter e.g. psychology/ English after the group activity.
12. Did you find that you learn most when the teacher talking and giving instructions or
13. When you were listening and watching (and taking notes) about the videos, or when you were discussing with one member of the group, or when you were discussing together as a group?
14. Do you prefer to learn individually as opposed to a group?
15. Do you prefer to learn using computers instead of not using computers in class?
16. Do you prefer NOT to use computers when learning in a group?
17. Do you like you group members?
18. Which group members did you like working with?
19. Did you find the classroom environment to be conducive for learning?
20. Overall, did you enjoy the learning experience of working in a group and using computer?
21. What did you enjoy the most about the activity (which part)?
22. While you were working in the group, did you find any disturbances or interferences? If yes, please describe briefly.
23. Could you suggest some ways to improve the use of computer in a group? E.g. able to move computer aside, faster computer?
24. Please suggest some other IT gadgets you would like to see being made available for use in classroom.
25. Could you suggest some ways to improve the process of working together? E.g. group with people I like, better sitting arrangement?
26. Could you suggest some ways to improve the learning activity? E.g. clearer instructions, shorter video time, better headsets, bigger paper?
27. Please suggest some ways to improve the classroom conditions for learning? E.g. bigger tables, bigger classroom, more equipment, more whiteboards?

<u>Specific questions</u> pertaining to sections of the video clip

1. At 3:40, how did you decide on who to watch which clips?
2. At 10:01, S1 held the headphone to the ear, why did you do that?
3. At 25:28, S3 pointed at the computer, why did you do that?
4. At 29:20, S1 showed a note to S4, why did you do that?
5. At 29:56, S2 held up a paper, why did you do that?
6. At 34:00, what was S2 showing to S1 and asking S1?
7. At 35:00, why did S3 started to glue the pieces of paper? Were you all ready, made a collective decision or you had to wait until everyone to agree?
8. Before 37:00 did you watch other videos?
9. At 20:00, how did S2 put the pieces together?

<u>Open questions:</u>

10. What were some of the problems you faced while watching and trying to understand the video?
11. Describe how you use the computer for retrieving of information.
12. Describe how and why you use the electronic dictionary to retrieve the information.

**Appendix E**
**Interview guide for teacher interviews**

Questions for Teacher Time: varies Duration: about 30 minutes

Please answer these questions with direct reference to the learning task that you gave to your students in the class (last week). We shall focus on this particular group of students.

1. Questions on task
What is the purpose of this task?
What are the learning outcomes of this task?
Tell me whether you think the students have achieved the outcomes and your aim?
How typical is this task compared to all of your other tasks?
Where are the collaborative features of this task?
How would you rate the difficulty of this task?
Would you consider the students to have taken the appropriate steps to perform the task given? Please elaborate.

2. Questions on cognition
Where do you expect the students to access for information?
Where would you think the students should spend more time on?
How would you rate the performance of this group?

3. Questions with reference to video

Please look at this section of the video, and explain your action/s.
Why did you do what you did?
Tell me if you think the student got your message.
Why did you talk to this student?
Why did you use that tool(s) to communicate to the student/s?

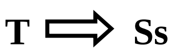
4. Other questions

How long have you been using group work in your classes?
Why do you use group work?
How long have you been using IT in your classes?
Why do you use IT?

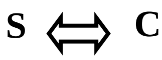
5. Are there any other comments you like to add?

**Appendix F**
**Examples of cognitive maps**

At one to one levels:



F1

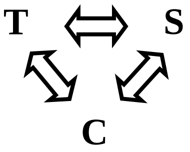


F2

F3

F4

At sub group levels:



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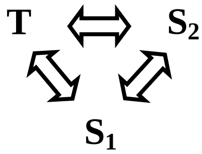
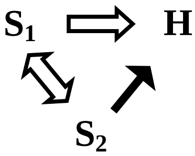


F6



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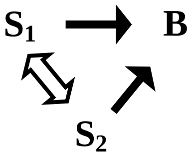

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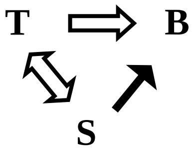

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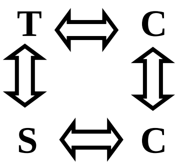
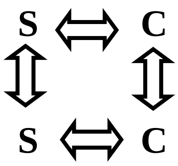
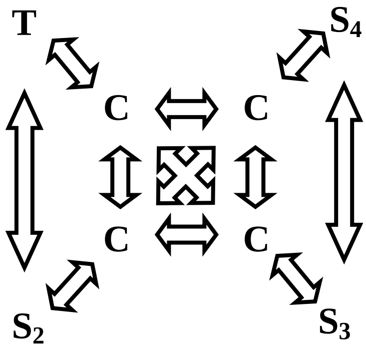


F10

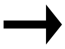


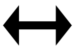
F11

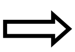


F12

Key:

 One way receiving or giving information; ONLY 1 medium of distribution. E.g. reading, looking, listening

 Two way receiving or giving information; ONLY 1 medium of distribution. E.g. writing,

 One way receiving or giving information; More than one medium of distribution. E.g. listening and looking

 Two way receiving or giving information; More than one medium of distribution. E.g. talking, looking and listening

**B** Whiteboard
**C** Computer
**H** Handout
**T** Teacher
**S** Student
**$S_{\#}$** Specific student e.g. $S_1$

## Appendix G
## Example of Operational Memo

Observation No: P03
Location: Computer Classroom
Date: 23/07/09
Time: 11am
Coding and operational Memo:
Self reflexivity:
When students share a document with another, how much information do the other party receive? Should I go into such detail as to question them how much and what did they look at. Even if I asked in the interview, would they remember? Or does it suffice to acknowledge that they do receive some information and that is enough to establish a "link" or distribution of cognition. Is establishing a link enough or should such a link be measured in terms of intensity during that time span? And do repeated occurrences of such a link suggest a degree of strength for this link? Or should the length of time spent on an artefact during the distribution be a measurement of the strength? But then, how do we know the conscious attention to the artefact is a concentration of the student in receiving the information and not thinking about something else whilst looking at it? Without neuroreceptors in a controlled experiment, we can never see what's inside the head! Should strength be an issue here?

The efficacy of the link is clear when the student acknowledges and responds cooperatively to the student distributing the information. But should we measure this effectiveness of distribution? Perhaps this is for another research project.

--------------------------------------------------------------------------------------------------------

Observation No: E05
Location: Computer Classroom
Date: 5/09/09
Time: 2pm
Coding and operational Memo:
Self reflexivity:

Because of the affordance of a computer and its easy access positioning right in front of the students, the Ss tend to refer to it all the time, even though sometimes, it is not all that necessary. For instance, when a student wanted to get check the definition of a difficult English word, he looked at the computer for a while, searching for the meaning but he eventually turned to the electronic dictionary for an answer.

The constant relationship of C and the S is a dominant r/s. There is a regular checking back and forth and occupies almost 80% of the group activity time. Group interaction is less compared to the time spent on the computer. Looking at C occurs between attention to other artefacts, making it the most attended to artefact when compared to the rest.

The dominant r/s with C is due to the nature of the task; esp one that requires them to use C. But which task affords the most dominance? Do tasks matter? If so, which type of tasks? Of all the tasks, which tasks generated the most attention? Do this measure up to the anticipation of the teacher who designed the task? Should C dominate in collaborative activity such as these or should they talk more? Would it be natural to leave Ss on their own or engineer more social interaction, from the teacher's lesson plan? The process befits the tasks given.

The easy access and affordance also allows the C to be a distraction. Ss surf other sites during group activity. Such distractions suggest that they are comfortable with the setting for them to boldly doing other things besides the task; this in a way, suggests low power distance between researcher and participants (even with teacher). Such distractions are not restricted to C; talking to and looking at members of other groups, checking mobile phones and listening to music were others but C was most dominant. Which distractions constituted the most? What was the range of distractions that were afforded?

**Appendix H (1/2)**
**Consent form for students to be observed and interviewed**

**University of Leicester, United Kingdom**
**Doctor of Education Programme**
**Thesis research**

**Information and consent form for students**

Title of research project: A case study into how students distribute cognition in a learning task using technology in a Japanese university

You are invited to participate in a study into how students learn collaboratively while using technology. The purpose of this study is to observe, examine and elicit opinions and beliefs of students about the way they learn by way of distributing cognition in a group while performing a learning task that involves the use of technology.

This study is conducted by Jeffrey Mok, Doctoral student at University of Leicester and a teacher at Miyazaki International College, Japan. This research is being conducted to meet the requirement of the degree of Doctor of Education at University of Leicester, Leicester, England, under the supervision of Professor Clive Dimmock (Director of the Centre for Educational Leadership and Management, University of Leicester)

Should you decide to participate, you will be:

1. Observed in class learning collaboratively in a group on an assigned task by your teacher. Your group will be video taped throughout the duration of the class of about 90 minutes.
2. Asked to contribute in an interview about your opinions and beliefs regarding how you learn and what you did during the observation in class. The interview will not exceed 90 minutes in duration and you will be provided with snacks and drinks at the end of the interview. The interviews will be audio taped throughout the duration of interview.
3. Asked to provide any personal items or electronic devices that you have accessed during the observed period of time in class for the researcher to examine and collect data.

The content of the video and audio tapes will be used by the researcher to assist in remembering what was observed and discussed. All the data collected from you during the course of this study will be kept confidential. None of your names will be identified in any publication of the results or in any other form. All the content will be securely kept and used only for research purposes. Only the researcher and his thesis advisor will have access to the data collected.

If you decide to participate, you are free to withdraw from further participation in the research at any time without having to give a reason and without any consequence. You may contact your teacher, researcher or his supervisor for this purpose.

Once the research is completed, the researcher is happy to provide you with the summaries of the results or copies of any publication arising out of this study. Please request this information by email at jmok@miyazaki-mic.ac.jp. The researcher's phone number is 85-5931, extension 716. The researcher's thesis supervisor's telephone number is +44 (0) 116 229 7500, email at cd47@le.ac.uk. Please feel free to ask or contact the researcher or his supervisor for any further clarifications you may have regarding this research.

**Appendix H (2/2)**
**Participant's copy**

I, ______________________ have read and understand the information above and any questions I have asked have been answered to my satisfaction. I agree to participate in this research, knowing that I can withdraw from further participation in the research at any time without consequence. I have been given a copy of this form to keep.

Participant's Name: ____________________________

(in block letters)

Participant's Signature: _________________________

Date: ___________________

Researcher's Name: ____________________________

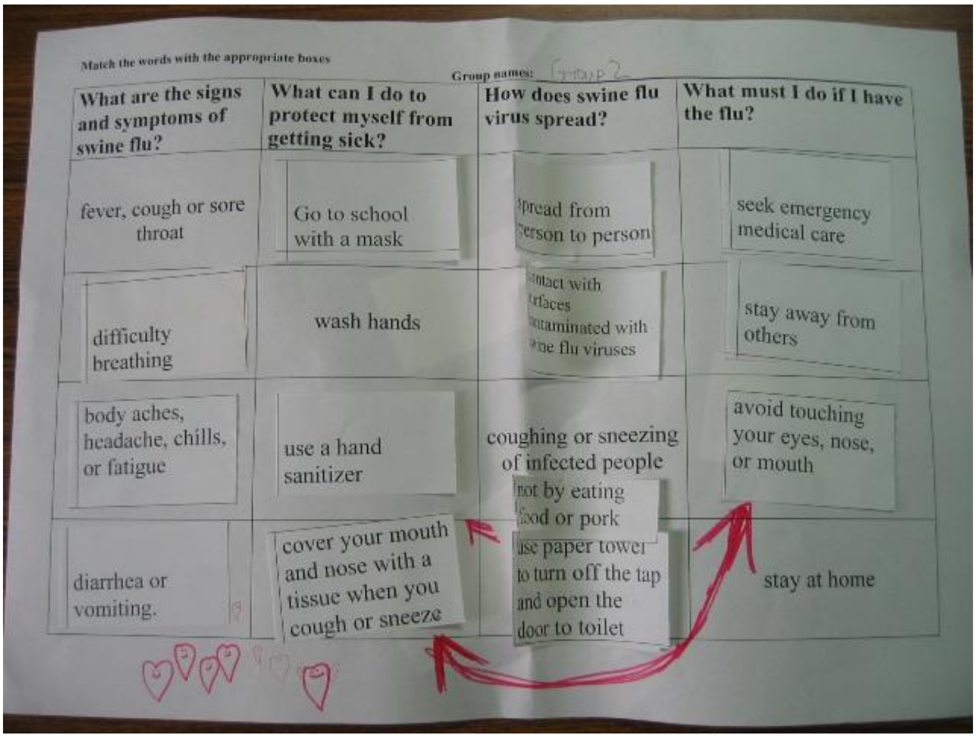
(in block letters)

Researcher's Signature: _________________________

Date: ___________________

The ethical aspects of this study have been adhered to with respect to the research ethical guidelines as prescribed by the Committee for Research Ethics, University of Leicester. If you have any complaints or reservations about any ethical aspect of your participation in this research, you may contact the Committee for Research Ethics; website is http://www2.le.ac.uk/institution/committees/research-ethics. Any compliant you make will be treated in confidence and investigated, and you will be informed of the outcome.

**Appendix I**
**Sample of a completed worksheet**



**Appendix J**
**Examples of transcripts**

Example of a group interview with students

| Transcript | | Coding |
|---|---|---|
| Interviewer: | Did you enjoy the group activity working together to complete the task? (Question 4) | |
| Student 1: | Yes…It was fun. | fun |
| Student 2: | It was fun to work together. | fun; work together |
| Student 1: | Yes, being with friends in group work... | friends; group work |
| Student 2: | I enjoy thinking together as a group… | thinking together; group |
| Interviewer: | What about you…? | |
| Student 3: | Yes, I like it too… | |
| Interviewer: | And you…? | |
| Student 4: | Yes, group work is enjoyable. | enjoyable |
| Interviewer: | Please tell me more why you like working in groups? | |
| Student 2: | It is…not being alone… | not alone |
| Student 1: | Talking to friends… | friends |

Example of an individual interview with teacher

| Transcript | | |
|---|---|---|
| Interviewer: | Why do you use IT? | |
| Teacher: to | IT is a very common thing…in schools. I wanted them be exposed to IT and use it as a learning experience. | IT is common; IT as a learning experience |
| Interviewer: | Why did you use that tool(s) to communicate to the student/s? | |
| Teacher: same for | I used the computer because it allows me to share different sets of information with the students at the time without having to go through one (group) by one. My task required them to access video files which…first of all, are big files…and I needed a place to store them them to access…then they can watch them in their computers….It also allows my student to communicate with each other. | simultaneous distribution; distribute different sets; individual distribution; communication |

**Appendix K**
**Audit trail**

| Reference | | Description of folder/file | Soft copy name |
|---|---|---|---|
| 1. | Eng 1 (observation) | Each folder contains the following:<br>a. Video clips for 2 dates<br>b. Audio tapes for 1 date<br>c. transcripts of interactions<br>d. transcripts for group interview<br>e. transcripts for teacher | ENG 1 |
| 2. | Eng 2 (observation) | | ENG 2 |
| 3. | Psy 1 (observation) | | PSY 1 |
| 4. | Coding (.xls file) | Contains all the coding for all groups: both open and axial coding | Codes |
| 5. | Memo (.doc file) | Operational and theoretical memos dated: college, students and teachers profiles, classroom observations, reflections | Memo |
| 6. | Artefacts (.xls file) | List of all artefacts, brief description, photos | Artefact |
| 7. | Interview questions (.doc file) | List of all interview questions together with emergent ones. | Interview |
| 8. | Cognitive networks and diagrams (.doc file) | List of all cognitive networks and diagrams | network |
| 9. | Consent forms | Sets of students, teachers and college | signed hardcopies |