Students Using Online Collaborative Tools in Problem-Oriented Project-Based Learning

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BY
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AALBORG UNIVERSITY
DENMARK

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Dissertation submitted

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CV

Nikorn Rongbutsri passed his Bachelor's degree in Information Technology at Mae Fah Luang University, Chiang Rai, Thailand; he continued his Master's degree studies in Advanced Information Technology at the International Insitution of Information Technology, Pune, India. He has taught Software Development at Mae Fah Luang University since 2006. The political situation and problems with Thai education led him to an interest in education. Aalborg University in Denmark, organized a workshop on Problem-Based Learning (PBL) in cooperation with, and at, Mae Fah Luang University; this was the turning point in his life; he followed the speaker at the workshop to study for his PhD at Aalborg University; his dissertation concerns the application of ICT in PBL. He dreams of improving the Thai education system; Mae Fah Luang University has constructed its own model of PBL.

ENGLISH SUMMARY

This research starts by presenting an overview of how students in Problem-Oriented Project-Based Learning (POPBL) adopt online communication tools; the main methodology is the mixed method: qualitative and quantitative. A survey of students was conducted followed by examination of students' blog posts and results analysed. To investigate in depth, two POPBL project groups were observed: experienced and inexperienced; they were observed and subjected to qualitative analysis. Activity Theory was applied to analyse observational data. The research reveals the behaviour of students individually, and socially in their groups, in relation to their attitudes towards adoption of communication tools. Various existing concepts on tool adoption were employed to interpret and discuss findings in respect of students who are Digital Natives.

From the data, the researcher established that a weak division of labour in a project group better enables learning than a strong division; tasks are undertaken collaboratively rather than individually; thus, all members gain from involvement in all aspects of the project. Interaction between members could productively combine collaboration and cooperation; members learn from each other.

This researcher claims that online communication tools for POPBL projects can be classified into three types according to students' communication tool adoption patterns: tools for general POPBL requirements, tools for newly emerged requirements and professional tools.

a. Tools for general POPBL requirements

As students gain experience of POPBL projects, they recognise the requirements of online communication tools to support their activities. They start to establish their practice by setting up tools to support several tasks in the project. When they start a new project they import their previous practices; in this case, discussion to select tools is unnecessary; they can start using them immediately with little or no support from institutions. These are generally are not professional tools; they are intended for public use; however, students find ways to adopt them professionally; their characteristics are simplicity, excellent at performing a single task and shareability.

b. Tools for newly emerged requirements

A group starting a new project encounters new challenges. Whilst undertaking a project, unanticipated requirements for online communication tools may emerge. Members quickly seek and appraise new tools before adopting them. If regularly used, they become "*tools for general POPBL requirements*". Tools for general POPBL requirements are usually adopted during group formation; in contrast, tools for newly emerged requirements may be adopted during any phase. These tools share characteristics of tools for general POPBL requirements.

c. Professional tools

Professional tools perform work-related or professional tasks; professional tools are specialised. Students tend to shun professional tools because they are complex; familiarisation and setting up take time and effort. Even after implementation and using them for some time, they may still be abandoned. Initial and ongoing technical support should be provided in order to encourage students to seek and adopt professional tools effectively.

These educational tools are classified into two kinds: professional and personal. A professional tool is multi-purpose software or groupware; it is complex, expensive and designed for an activity rather than a small task; students can employ a professional tool only if it is provided by their institution. A personal tool has limited scope and is designed for a single purpose; it is easy to use and is accessible from different platforms and devices; it is usually available on free subscription and incorporates entertainment functions; this study reveals that personal tools have displaced professional tools in the context of education. These tools are adopted by students in three stages: Selection, Implementation and Application. The adoption is successful if the tool is utilized throughout all three stages; otherwise, the adoption can fail at any stage.

POPBL projects enable students to learn through solving open-ended problems. The author argues that learning and working socially are not the same; working socially does not necessarily result in learning; for example, when students rush to meet a deadline, they repeat established practice thus missing out on the exploration which results in learning. If a group chooses to be adventurous they may be less productive and could fail to complete their project; in conclusion, cognitive development must be balanced against achievement.

DANSK RESUME

Denne afhandling tager udgangspunkt i et overblik over hvordan studerende indenfor Problem-Orienteret Projekt-Baseret Læring (POPBL) inddrager online kommunikative medier i deres projektarbejde. Den primære metodologi i afhandlingen er "the Explanatory Sequestial Mixed method". Der blev gennemført en spørgeskemaundersøgelse efterfulgt af blog indlæg fra de studerende omkring emnet og resultaterne blev analyseret. For at opnå en mere dybdegående undersøgelse blev to POPBL projekt grupper observeret; erfarne og uerfarne; de blev observeret og underlagt en kvalitativ analyse. Aktivitets teori er anvendt til analyse af de observerede data. Forskningsresultaterne synliggør studerendes individuelle og sociale adfærd i grupper i relation til indførelse og brug af digitale kommunikationsværktøjer. Forskellige eksisterende teoretiske koncepter om inddragelse af digitale værktøjer er brugt for at fortolke og diskutere resultaterne; herunder Diffusion of Innovation og Digitale Indfødte.

På baggrund af de forskellige data konstaterer forskeren at en svag arbejdsdeling i en projektgruppe muliggør læring bedre end en stærk fordeling. Opgaver varetages i fællesskab frem for individuelt; hvorfor alle medlemmer af gruppen vinder ved at involvere sig i alle aspekterne i projektarbejdet. Interaktionen mellem gruppemedlemmerne kan produktivt kombineres ved kollaboration og kooperation; gruppens medlemmer lærer af hinanden.

I kontekst af inddragelse af kommunikationsværktøjer hævder forfatteren at online kommunikationsværktøjer til POPBL projekt arbejde kan klassificeres indenfor tre typer afhængig af studerendes inddragelsesmønster: Kommunikationsvæktøjer til de generelle behov indenfor POPBL, kommunikationsværktøjer til nye behov der dukker op samt professionelle kommunikationsværktøjer.

a. Værktøjer til general brug indenfor POPBL

Når studerende opnår erfaring med POPBL projekter, bliver de bevidste om behovet for brug af online kommunikationsværktøjer til at understøtte deres aktiviteter. De begynder at etablere en praksis ved at samle et sæt af værktøjer der kan understøtte forskellige dele af projektforløbet. Når de starter på et nyt projektforløb bringer de den allerede opnåede praksis videre ind i den nye projektproces. Dialog omkring brugen af de valgte kommunikationsværktøjer er ikke nødvendig, for de begynder deres brug af disse helt naturligt, og institutionel support er ikke nødvendig. Denne form for kommunikationsværktøjer er ikke professionelle, men nærmere udviklet til uformel brug; til trods for dette inddrager studerende disse på en professionel vis, og de karakteriseres som: simple, fremragende til én type af opgaver og applikationer kan deles.

b. Kommunikationsværktøj til nyligt opståede behov

Når en gruppe starter et nyt projekt står de også overfor nye udfordringer. Gennem projektforløbet kan der opstå nye uventede krav til online kommunikationsværktøjer.

Gruppens medlemmer undersøger og vurderer hurtigt nye værktøjer inden de inddrager dem i processen. Hvis de bruges jævnligt, overgår de til at være generelle værktøjer i et POPBL behov. Værktøjer der bliver til generelle POPBL behov bliver oftest inddraget og vedtaget i forbindelse med gruppedannelsesprocessen, i modsætning til værktøjer der søges på baggrund af nye krav kan inddrages i løbet af enhver af faserne. Disse værktøjer karakteriseres på lige fod med de generelle POPBL behov.

c. Professionelle kommunikationsværktøjer

Professionelle kommunikationsværktøjer bruges til at udføre mere arbejdsrelaterede og professionelle faglige opgaver; professionelle værktøjer er specialiserede værktøjer. Studerende har tendens til at afslå at bruge professionelle værktøjer, fordi de er komplekse, det tager tid og energi at sætte op og blive fortrolig med. Selv efter implementering og brugen af dem over et stykke tid kan de opgives. Studerende bør ydes teknisk støtte indledningsvis og efterfølgende for at opfordre dem til at søge og inddrage professionelle værktøjer effektivt.

Denne PhD afhandling er en kombination af en monografi og tre forskningsartikler. De tre artikler kan finde som appendix .

ACKNOWLEDGEMENTS

This dissertation is my most difficult work to date. It has taken me a long time to complete. It would have been impossible to complete without support from Thomas Ryberg, my supervisor; Pär-Ola Zander, my co-supervisor; and Stuart Cassely, my English specialist who motivated and encouraged me. Thanks to you all.

Secondly, I must thank the students who allowed me to observe them and collect data and who are anonymous in the research.

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And lastly, thanks to my Metta and Kvan, my daughter and son, who were my motivation.
With their support, I trust that I have made a contribution to education which will prove useful to anyone who is interested not only in how students adopt and employ communication tools for group projects but also in the more general educational issued raised.

April 2017

Nikorn Rongbutsri

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CHAPTER 1
INTRODUCTION

Applying the right tools to mediate an activity can critically affect the outcome, especially when the activity is designed for learning purposes; all failures and successes are important elements of learning. Teachers in their role as facilitators, IT departments providing technical support and administrators formulating policy all seek the means to support students effectively; tools with potential to enhance learning are crucial. Pedagogy is 'the art or science of teaching'. In this chapter, the author first considers Problem-Oriented Project-Based Learning (POPBL) as a pedagogy in general terms; POPBL combines the pedagogies of project-based and problem-based learning and specifically the impact of communication tools on learning and how they can be employed to enhance learning. The chapter concludes with by discussing the research questions.

** Note: In this dissertation the terms (Problem-Oriented Project-Based Learning) POPBL and (Problem-Based Learning) PBL are used interchangeably as discussed in Chapter 2.

1.1 RESEARCH MOTIVATION

1.1.1 INTRODUCING THE RESEARCHER: ENGAGING WITH PROBLEM-BASED LEARNING

The author went to Denmark to seek ways to improve his teaching and his own learning. He gained inspiration through attending a PBL (Problem-Based Learning) workshop conducted by Thomas Ryberg who was to become his PhD supervisor. The author's background is in conventional teaching and learning but he believes there are better ways of educating. Later, he was inspired by the work of Carl Rogers, a famous American psychotherapist, who wrote *"Freedom to Learn"* in 1969 when Behavioural Sciences were popular. Rogers' book runs counter to the then fashionable idea that learners are objects to be programmed or controlled. Learners can make their own decisions and commit themselves to goals in response to their own values. This view of education attracted this researcher.

> "The only man who is educated is the man who has learned how to learn; the man who has learned how to adapt and change; the man who has realized that no knowledge is secure, that only the process of seeking knowledge gives the basis for security." (C. R. Rogers, 1969)

Education should focus on learning approaches (how to learn) rather than learning content (knowledge), because content is context-dependent; when times or situations change, learnt knowledge may no longer be of value; however, a good learning approach should lead students to seek relevant, current knowledge (information) for their particular problems. As mentioned, the author's purpose in coming to Denmark was to find better ways of teaching, guided by the concept of PBL and Rogers's book. The author's view of education changed. The author decided to devise new ways of teaching based on how students learn rather than simply trying to improve current teaching methods; he made decision to investigate learning in a non-traditional environment – the Aalborg University PBL model which is also referred to as Problem-Oriented Project Based Learning (POPBL) – to enable him to understand how to improve students' learning.

New challenges at Aalborg University

For his PhD, the author who has a background in Computer Science, exchanged technical for educational field. Quality has replaced quantity in his psyche. To switch from rote to self-directed learning was initially difficult. He had little knowledge of the subject but he did have a goal: to learn about POPBL and apply it effectively in his university in Thailand. He and his Chinese wife, who, to complicate matters, was also pregnant, had to adapt to a society very different from the ones that they were used to; being a student in Denmark was radically different from his previous education in Thailand and India; Danish students are self-reliant and organise their own studies. David Kolb makes the point that:

> "Learning requires the resolution of conflicts between dialectically opposed modes of adaptation to the world. Conflict, differences, and disagreement are what drive the learning process. In the process of learning one is called upon to move back and forth between opposing modes of reflection and action and feeling and thinking."(Kolb & Kolb, 2012)

This is how the author felt throughout his PhD studies. It was difficult for him to adapt to the concepts of PBL; the tradition in the Thai educational system of the teacher control and transferring knowledge in one direction was firmly inculcated in him. His research questions had to be revised several times.

Settling Down in Denmark: the author's life as an example of Problem-Oriented Learning

Even a single person moving to a strange country will take time to adapt. The author was not alone; he came to Denmark with his wife; their daughter was born one month after their arrival. Although Denmark is an advanced country, settling down was still a challenge. It started with the language for such matters as accessing municipal services including health, childcare and his daughter's education; friends and University staff were most helpful. The author quickly developed his own strategies

to solve his problems; he learned that, to solve a problem, the first requirement is to understand what the problem is and the second is to obtain relevant information. The strategies of solving problems in his own life are an example of PBL.

One of the author's objectives is to improve educational practices at his university in Thailand. Thailand is a developing country both economically and socially; tradition is important; there is strong resistance to change. All public university students wear uniform and relations between students and teachers are distant to engender respect. Teachers are considered to be high and holy; Thai parents tell their children: "Listen carefully to your teachers and you will be enlightened.' It is disrespectful for children to ask their teachers questions; likewise, teaching methods cannot be questioned. A "good student" listens silently. A report from the World Economic Forum, 'The Global Competitiveness Report 2013-2014', stated:

> "Thailand ranks 37th as a result of a very small improvement in its performance … Poor public health (74th) and education, two other critical building blocks of competitiveness, require urgent attention. For instance, Thailand displays one of the highest HIV prevalence rates outside Africa, while enrolment in and the quality of higher education remain abnormally low." (Schwab, 2013)

The Organisation for Economic Co-operation and Development (OECD), has just released the results of PISA 2015, a test of fifteen-year-old students from over 72 countries; the survey tests students' abilities in science, reading and mathematics. PISA has started in 2000 and is repeated every three years. The international survey results show that Thailand students' performance in three subjects is lower than average and that Thailand's rank is falling – it is now 55th out of 72 countries – especially in respect of reading ability which is deteriorating (OECD, 2016).

	Mathematics		Reading		Science		
Year	Average score	OECD Average	Average score	OECD Average	Average score	OECD Average	Rank
2015	419	490	419	493	421	493	55
2012	427	494	441	496	444	501	50
2009	419	496	421	493	425	501	50

Table 1.1 Thai students PISA results 2009-2015 complied from (OECD, 2010, 2014, 2016)

There are historical reasons for low levels of literacy in Thailand. Literacy was traditionally reserved for royalty and government officials. People who wanted to learn to read could do so in Buddhist temples. Parents taught their children skills for employment. The tradition of respect in schools remains unchanged and hinders educational advance. The focus in Thai schools and universities is still on rote learning (Ek-aun, 1999). The best students are the ones who can remember the most of their teachers' words. Dialogue, engagement, participation, and problem-solving

are postponed until they start working. Students learn through the discipline imposed by their teachers rather than through their own efforts. Problems arise when they start work; employers require graduates who are adaptable, who will learn quickly and who will take responsibility for themselves. Hallinger and Kantamara (Hallinger & Kantamara, 2000) reported on the state of the Thai education system; they tried to change the norms of Thai education by inviting parents and communities to participate in learning and teaching; unfortunately, their new ideas reached few schools and had no effect on the larger community of Thai education.

1.1.2 THE STARTING POINT: PROBLEM-ORIENTED PROJECT-BASED LEARNING

Problem-Based Learning (PBL) – an active learning concept – was first developed in the late 60s in the Faculty of Medicine at McMaster University in Canada. The main characteristics of PBL are that problems initiate learning, learning is in groups, and problems are drawn from real-life. In the early 70s, Roskilde and Aalborg Universities formulated a new educational concept: Problem-Oriented Project Pedagogy which has similarities to PBL and has been adopted by many universities worldwide.
The author became interested in PBL including the Aalborg model because of his disillusion with traditional education; this was the reason that he started to investigate and study the literature. He found that projects allow students to interact purposefully with problems enabling deep learning; as his background is in information technology he chose to investigate communications tools in project work.

1.1.3 COMMUNICATION TOOLS TO ENABLE NEW WAYS OF LEARNING.

> "The tool that extends the human hand is also an instrument of vision. It reveals the structure of things and makes it possible to put them together in new, imaginative combinations." (Bronowski & British Broadcasting Corporation, 1973)

Jacob Bronowski in his Man of Ascent series on BBC television. This expresses the importance of tools for humans. Tools are essential for humans; how they are adopted into human activity is critical. In the context of education, especially in an active learning environment such as POPBL, learning dominates teaching. Tools are adopted into students' activities; tools enhance learning. Adoption of tools incorporates their selection, implementation and employment. Understanding how POPBL students adopt online communication tools in, adopt them into, and create tools for their projects will enable institutions to improve support for them. Thai students brought up in the tradition of rote learning should benefit from the assimilation of communication tools into their education thus creating an active learning environment.

1.2 PBL IN COURSE DESIGN

PBL is organised around scenarios rather than disciplines. Knowledge acquired through collaboration is the foundation of PBL, not merely knowledge but its application. Scholars who write about PBL want to find improved ways of teaching their students. PBL needs to be incorporated into educational design.

1.2.1 PROJECT WORK AND POPBL

Projects enable knowledge creation; simultaneously, students discover how to learn in ways which suit them as individuals. At Aalborg University, students participate in a group project each semester; project is separated from courses, students draw on and apply what they have been taught in the other courses of the semester. Project work is introduced through classroom activities. Typically, taught courses occupy the first eight weeks, the remainder of the semester being devoted to projects in groups of four to six students. Figure 1-1 illustrates the typical structure of courses during a semester at Aalborg University; usually, one course is not related directly to the project – it could be, for example, an English Language course.

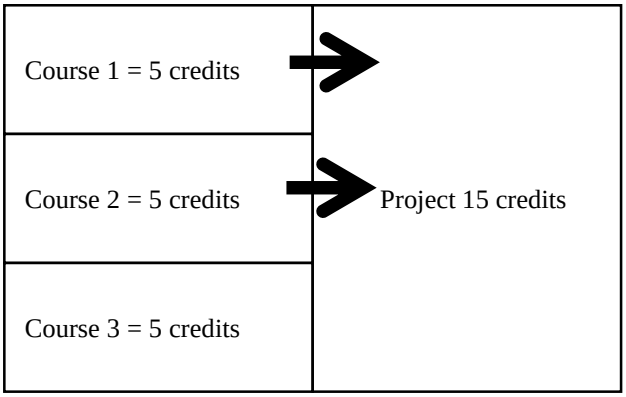

Figure 1-1 The Structure of a typical semester at Aalborg University (adapted from (Anette Kolmos, K.Fink, & Krogh, 2004))

Most courses link directly to projects. Students apply the foundational knowledge from their courses to construct new knowledge in their projects. The relationship between time spent and participation in course activities and project work during a semester at Aalborg University is illustrated in figure 1-2.

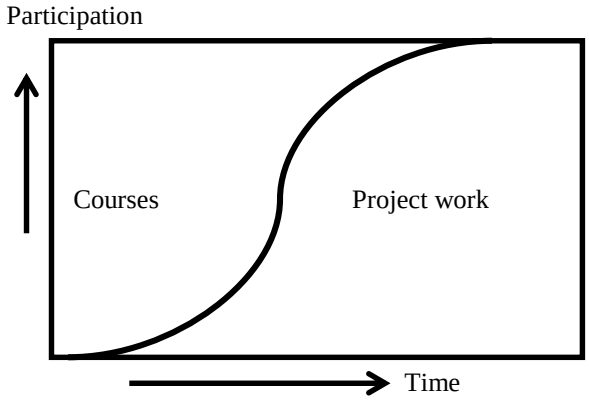

Figure 1-2 Participation of course and project work in a semester

Initially almost all students' time is occupied with courses; time devoted to projects increases gradually, being more than half by the middle of the semester and all by the end. Overall, students usually spend more time on their projects than their courses; the three courses are worth 5 credits each whereas the project alone is worth 15, thus demonstrating their relative importance; integrative, constructive, collaborative, and applicable knowledge are, therefore, considered to be as important as foundational. (The foregoing descriptions of semester structures and the incorporation of projects are generalisations; the structure is adapted to suit the requirements of the syllabus.)

1.3 COMMUNICATION TOOLS IN A POPBL PROJECT

"We become what we behold. We shape our tools and thereafter our tools shape us." (John Culkin, 1967). Tools are designed to meet user requirements, to match their ways of thinking; conversely, users' ways of thinking are shaped by the tools they use. It is, therefore, vital to adopt the right tools; learning may be rendered ineffective by the use of unsuitable or inappropriate tools; this is especially true of digital tools. Students may choose their own learning tools from those provided or seek them externally. POBPL institutions such as Roskilde, Aalborg, and Twente Universities have conducted research on tool-enhanced learning.

1.4 RESEARCH QUESTIONS

One of the ambitions of Aalborg University is to improve education. The PBL (called POPBL in this research) model was developed at Aalborg University and has been applied there since the University's founding; it is implemented in all programmes in appropriate ways. Dirckinck-Holmfeld demonstrates how students working on virtual environments develop during a PBL project. There are tools provided to support students' project work from intuitions; however, students still need other tools to support their project work. In past ten years the literature shows the success of groupware adoption as project work support tools e.g. Lotus quick place, Basic Support for Cooperative Work (BSCW), iGroup ; however, recent literature shows differently, students choose to abandon institution-provided tools e.g. Mahara; instead, choose to adopt their personal tools to support their project work (Guerra, 2015; Heilesen, 2015; Rongbutsri, Khalid Saifuddin, & Ryberg, 2011b). Students concern more on ease-of-use over usefulness (Thomsen, Sørensen, & Ryberg, 2016). This leads to institutions and teachers who provide facilitation in terms of policy, budget, and practice, whether to invest in a groupware to support students or to provide support of those personal tools available in the software market. Based on the survey of literature of Chapter 2, most of recent research was carried out by survey; however, to understand into the details of how they adopt tools are still need more clarity.

This research aims to understand the processes of tool adoption in their POPBL projects. The main research question is 'How do students adopt online communication tools to support their POPBL projects?' The research was conducted at Aalborg University. To answer the main research question, two preliminary questions will be answered:
Research Question 1: What are the processes of tool adoption? What are the barriers and supports?
Research Question 2: How does tool adoption facilitate or frustrate the project?

1.5 THE STRUCTURE OF THE DISSERTATION

This dissertation is composed of eight chapters.

1.5.1 CHAPTER 1 INTRODUCTION

The author starts by providing an overview of the dissertation, discussing his motivation and the importance of the research. At the end of this chapter, the research questions are discussed.

1.5.2 CHAPTER 2 RELATED WORK

Before commencing the research, the author discusses current knowledge of POPBL and ICT integration into PBL projects. Different definitions and models of PBL

including the model that implementing at his university are discussed. He also discusses the terminology of PBL and POPBL.

1.5.3 CHAPTER 3 METHODOLOGY AND RESEARCH DESIGN

One important element of this dissertation is how the research was conducted. Chapter 3 discusses data collection and how the author interacts with the research fields; the selection of methodology, instruments and analytical approaches are also discussed.

1.5.4 CHAPTER 4 PILOT STUDIES RESULTS

The analysis parts of this dissertation starts from this chapter by presenting results from pilot studies which including a survey, students' blog post analysis, and observation of a group of new students called Group A. The results of the pilot studies were presented as a conference paper which is discussed at the end of the chapter; the paper was presented at The 19th International Conference on Computers in Education in Thailand.

1.5.5 CHAPTER 5 PRESENTING ACTIVITY SYSTEMS OF GROUPS A'S AND B'S OVERVIEW PROJECT WORKS

After the pilot studies with observational data from a new student group (Group A), the author gained some experience then conducted another observation with experienced student group called Group B. The main data from this research is the observational data of a group of Master students –Group B. The data allowed the author to gain into the understanding of their practice of using technology. The author introduces Group A and B by providing overview of two projects from the two group using activity systems which is derived from Activity Theory.

1.5.6 CHAPTER 6 ACTIVITY SYSTEMS OF PROJECT PHASES

After presenting the overview of the two projects from the observational data, the author drills down into observational data by divided sequenced of events of Group B's project into phases chronologically. Each phase is presented using activity systems of Group B's project interacting with other activities. Additionally, observational data of group A is also presented in each phase for comparison along with Group B's project phases. Behavior of using tools and tensions are identified at each phase. At the end of the chapter, the author demonstrates an application of project phases by presenting mapping tools for different activities in each project phase to provide tool adoption facilitation for university students. The mapping was presented as a conference paper at Networked Learning Conference 2012 at Maastricht University.

1.5.7 CHAPTER 7 CROSSED PHASE ANALYSIS

In this chapter, the author discusses the analysis of components of activity system of project by through all project phases. Three components are in the focus: tools, rules, and division of labour. The analysis demonstrates two practice of the two groups of the three focus components.

1.5.8 CHAPTER 8 DISCUSSION

Findings from pilot studies and the observational data which are presented in Chapter 4, 5, and 6 are gathered and discussed in this chapter. Behaviors of using tools to support project are discussed along with several relevant concepts including coordination, cooperation, and collaboration, division of labour, personal and professional tools, consensus development, and co-activities. At the end of the chapter the author discusses the effect of using tool to POPBL whether tools are strengthen or weaken the power of the pedagogy. The author also provides a viewpoint if tools and the pedagogy could be introduced to a conventional context such Thai education.

1.5.9 CHAPTER 9 CONCLUSION

In the chapter, the author summarises the findings 4 to answer the research questions. The author also discusses the contribution of the research and makes suggestions for future research.

1.5.10 CHAPTER 10 PUBLICATIONS OF THIS RESEARCH

In the last chapter, the author summaries three published papers which are parts of the product of this research. The three papers are proceeding papers at different conferences; they were co-writing with colleagues to demonstrate the author's participation in the academic community.

CHAPTER 2
RELATED WORK

"That is part of the beauty of all literature. You discover that your longings are universal longings, that you're not lonely and isolated from anyone. You belong." ("Quote by F. Scott Fitzgerald: 'That is part of the beauty of all literature. Y...,'" n.d.)

Pedagogy promises to enhance students' critical thinking skills. Students could be more critical in different dimensions including tool adoption in their profession. The results of self-adaption of students in the context, therefore, students' behaviour in the context could be different from the adopter in other context.
To understand the pedagogy influencing adopters (called students in this context), this chapter first demonstrates characteristics and different models of Problem-Based Learning (PBL) which POPBL is one of its categories. Then the existing knowledge about collaborative tool adoption in the context will be discussed.

POPBL is a kind of problem-based learning (Kolmos & Graaff, 2014). In the context of this study, tools are adopted to achieve an activity; in a learning context, pedagogies frame learning activities; therefore, study of POPBL as a pedagogy within the specific learning context of this study is important. The origins of POPBL in Problem-Based Learning (PBL) are considered first to understand its concepts and philosophy, followed by a review of current practices. This research studies the role of communication tools in the conduct of a POPBL project; current knowledge of the phases of projects is vital to this research because it seeks to establish how communication changes during a project, both actual and potential. Finally, current knowledge of communication tools will be examined.

2.1 WHAT IS PROBLEM-BASED LEARNING?

PBL is an educational approach that emerged in the 1960s and early 1970s. In this section, 'Problem-based learning (PBL)' will be defined and models compared; no single definition satisfies all models but some studies have identified the core characteristics of Problem-Based Learning. Examples of actual practice of PBL from the literature will be examined.

2.1.1 PROBLEM-BASED LEARNING AND ITS CHARACTERISTICS

'Problem-Based Learning [is] Knowledge that Can Be Constructed by Learners Themselves'(Hickman, 2009). PBL is an example of constructivist pedagogy.
"Constructivism' proposes that people construct their own understanding and knowledge of the world through experiencing things and reflecting on those experiences," (Hickman, 2009)

PBL is classified as an active learning environment. Learners bring their own experience to new subjects to solve problems which may be raised by either themselves or by their teachers. No single definition of 'Problem-Based Learning' will satisfy all modes of practice. Wood at the Medical School of McMaster University in Canada states "PBL is any learning environment in which the problem drives the learning" (Woods, n.d.); this definition is all encompassing; it does not specify any activities, roles, tools or approaches; however, it does show that any pedagogy can be called PBL if learning takes the form of problem solving. PBL can be inter- or multidisciplinary it can be controlled by the teacher or student or shared; teachers can teach or be facilitators or alternate between these roles; these factors are supplementary to the major point that problem solving enables deep learning.
Another definition of PBL is given by Barrows and Tamblyn: they suggest that PBL is an educational approach employing real-life projects conducted in small groups whose members direct their own learning to construct knowledge through activities enabled by curricula. Barrows[1] and Tamblyn define the McMaster PBL characteristics as:

- Complex, real world situations that have no one 'right' answer are the organizing focus for learning.
- Students work in teams to confront the problem, to identify learning gaps, and to develop viable solutions.
- Students gain new information though self-directed learning.
- Staff act as facilitators.
- Problems lead to the development of clinical problem-solving capabilities. (H. S. Barrows & Tamblyn, 1980)

'Problem-Based Learning' or PBL was first coined by Wood. Other institutions adopted similar approaches. Examining PBL models other than McMaster's will help understand Wood's original idea. Barrows and Tamblyn expand, but do not change, Wood's main idea that problems are at the centre of learning. A good problem is complex and rooted in the real world; it can drive deep learning and develop competency in the subject, e.g. in clinical skills. Teachers' and students' roles have changed from knowledge providers and consumers to facilitators and knowledge constructers. Students take responsibility for their own learning; additionally, the social dimension assumes greater importance. Another way of looking at it is that learning takes place at an individual, cognitive level which emerges from group activities. Group discussion leads to a common understanding of content; discussion and negotiation lead to deeper learning. Another definition of PBL is proposed by Charlin, Mann and Hansen:

> "We propose to categorize educational activities as PBL or non-PBL according to three core principles: (1) the problem acts as a stimulus for

[1] HS Barrows of the Office of Educational Affairs, Southern Illinois University School of Medicine was a physician and medical educator who had originally taught at McMaster University.

> learning; (2) it is an educational approach, not an isolated instructional technique, and (3) it is a student-centered approach, and four criteria concerning their effect on student learning: (1) active processing of information; (2) activation of prior knowledge; (3) meaningful context; and (4) opportunities for elaboration/organization of knowledge)." (Charlin, Mann, & Hansen, 1998)

Charlin, Mann and Hansen expand Barrows' and Tamblyn's definition but do not change it; problems are at the centre of learning and are the stimuli for learning. PBL is not a cramming technique. The four criteria explain how students apply prior knowledge to new concepts to construct new knowledge. This definition stresses context; PBL must be meaningful, complex, realistic and relevant to what students are studying; it does not, however, define the roles of teachers or social context.

2.1.2 VARIETIES OF PBL IMPLEMENTATION

PBL can stand for either Problem-Based Learning or Project-Based Learning; project-based learning is not always problem-based; neither is problem-based always project-based. Institutions worldwide have applied PBL in individual ways since McMaster University started to implement its model in its medical school forty-six years ago; it has been widely applied in many forms, in other fields and at different educational levels. Classification models of PBL enables examination of the differences between them including preparation and resources required. The culture of the institution and a country's national educational policy must, likewise, be considered. Classification may be a useful tool for implementation of PBL and associated ICT (Information and Communication Technologies); ICT is the primary focus of this research.

HS Barrows published a paper, *A taxonomy of problem-based learning*, in Medical Education, in 1986. Although he was writing of PBL in relation to medical education specifically, he proposed a taxonomy which is relevant to all applications of PBL. Six PBL methods were classified according to types of learning activity employed: teacher to student (lecture-based cases); case-based lectures; case method; modified case-based; problem-based, and closed-loop problem-based. The six methods are further categorised according to two variables: teacher- or student-centric learning. It should be borne in mind that he was writing about medical education specifically but his ideas are valid in other contexts

Method	Sequence		Details
	1	2	
lecture-based cases	teacher-directed learning	complete case or case vignette	non-PBL; little freedom for students to develop their own learning styles
case-based lectures	complete case or case vignette	teacher-directed learning	little freedom for students to develop their own learning styles; improves motivation
case method	complete case or case vignette	partially student & teacher directed	some self-directed learning; higher motivation
modified case-based	partial problem simulation	student-directed learning	students partially formulate problems before investigation; high motivation
problem-based	full problem simulation (free inquiry)	student-directed learning	students identify problems based on given simulation; high motivation; higher level of self-directed learning leading to higher level of competence
closed-loop problem-based	full problem simulation (free inquiry)	student-directed learning	initially the same as problem-based method
	3 review of learning process and learning product; may repeat 1 & 2		highest motivation; highest level of self-directed learning leading to highest levels of competence

Table2-1 A summary of Barrows' taxonomy of PBL

Camp (Camp, 1996) examined the application of PBL in medical curricula; he settled on two models; one is close to the original McMaster University model (see section 2.1.1) which he called 'pure PBL'; the other, which he called 'impure PBL', integrates some aspects of the McMaster model into traditional learning.

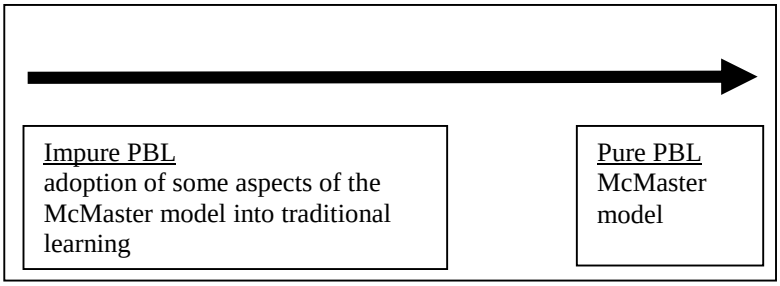

Figure 2-1 Camp's PBL classification

Camp's classification has limitations. It places the McMaster PBL model as the highest level; all other PBL methods are sited between the McMaster model and traditional, non-PBL methods. This classification is unrelated to the effectiveness of the different methods; other models may prove more effective than McMaster's dogmatically applied. Camp's classification was intended to assist institutions changing from conventional teaching to the McMaster method.

In 2000, Savin-Baden classified PBL according to educational objectives; she identified five models and six dimensions. The models are epistemological competence, professional action, interdisciplinary understanding, trans-disciplinary learning and critical contestability (Savin-Baden, 2000). The dimensions for each model are knowledge, learning, problem scenario, student roles, facilitator roles, and assessment method. Objective-directed application of PBL enables efficient planning and effective teaching and learning; it can be applied to the role of ICT.

Model	Dimensions
Model I Problem-based learning for epistemological competence	**Knowledge**: Propositional **Learning**: The use and management of a propositional body of knowledge to solve or manage a problem **Problem scenario**: Limited-solutions already known and are designed to promote cognitive understanding **Students**: Receivers of knowledge who acquire and understand propositional knowledge through problem-solving **Facilitator**: A guide to obtaining the solution and to understanding the correct propositional knowledge **Assessment**: The testing of a body of knowledge to ensure students have developed epistemological competence
Model II Problem-based learning for professional action	**Knowledge**: Practical and performative **Learning**: The outcome-focused acquisition of knowledge and skills for the work place **Problem scenario**: Focused on a real-life situation that requires an effective practical resolution **Students**: Pragmatists inducted into professional cultures who can undertake practical action **Facilitator**: A demonstrator of skills and a guide to 'best practice' **Assessment**: The testing of skills and competencies for the work place supported a body of knowledge
Model III Problem-based learning for interdisciplinary understanding	**Knowledge**: Propositional, performative and practical **Learning** : The synthesis of knowledge with skills across discipline boundaries **Problem scenario**: Acquiring knowledge to be able to do, therefore centred around knowledge with action **Students**: Integrators across boundaries **Facilitator**: A coordinator of knowledge and skill acquisition across boundaries of both **Assessment**: The examination of skills and knowledge in a context that may have been learned out of context
Model IV Problem-based learning for trans-disciplinary learning	**Knowledge**: The examining and testing out of given knowledge and frameworks **Learning**: Critical thought and decentring oneself from disciplines in order to understand them **Problem scenario**: Characterized by resolving and managing dilemmas **Students**: Independent thinkers who take up a critical stance towards learning **Facilitator**: An orchestrator of opportunities for learning (in its widest sense)

	Assessment: The opportunity to demonstrate an integrated understanding of skills and personal and propositional knowledge across disciplines
Model V Problem-based learning for critical contestability	**Knowledge**: Contingent, contextual and constructed **Learning**: A flexible entity that involves interrogation of frameworks **Problem scenario**: Multidimensional, offering students options for alternative ways of knowing and being **Students**: Explorers of underlying structures and belief systems **Facilitator**: A commentator, a challenger and decoder of cultures, disciplines and traditions **Assessment**: Open-ended and flexible

Table2-2 Savin-Baden's Five PBL Models (Savin-Baden 2000)

In 2009, Kolmos et al (Kolmos, De Graaff, & Du, 2009) defined PBL learning principles and models. They identified two types of PBL: problem-based learning and problem- and project-based learning (POPBL). They define problem-based learning in terms of McMaster University's original version; students are set problems in the classroom or laboratory; in problem- and project-based learning, problems are set within the framework of projects with the expectation that they will lead to deeper learning. Problem-based learning, similar to McMaster's, is practised at many universities including Maastricht in the Netherlands and Newcastle in Australia whereas Bremen in Germany and Roskilde and Aalborg in Denmark practise problem- and project-based learning. Kolmos et al also noted two modes of application: course and system.

In the course mode, problem-based learning is restricted to the content of one course and there is a limitation on employment of interdisciplinary knowledge whilst in the system mode, problem-based learning concepts are incorporated into curricula design; therefore, PBL in system mode enables interdisciplinary knowledge acquisition and the integration of courses; POPBL is suitable for the system model since it allows for bigger, longer and more complex problems, teamwork and integration of disciplines thus leading to higher levels of learning; additionally students can learn from each other. POPBL can be classified according to time allocated to problem solving, as follows.

2.2 PBL MODELS CLASSIFIED BY DURATION

Learning by experience takes time; likewise, bonding in groups takes time. According to the theory of experiential learning, the more experience gained, the more learning for students, and learning takes time; group formation, psychologically (Kolb & Kolb, 2009), also takes time; therefore, time is a simple dimension that can be used to classify different PBL models. In terms of tool-support activities, different durations

of project could lead to different strategies and activities including the selection of support tools.

PBL models can be classified by duration as follows:
- One-day project
- Mini project
- Semester project
- Final-year project

2.2.1 ONE-DAY PROJECT

Singapore Polytechnic has implemented a model of PBL called *One Day, One Problem* (O'Grady, Yew, Goh, & Schmidt, 2012). On one day per month, students form groups to work on a given problem within the context of a problem-solving template called 'Problem Theme'. Students spend all day solving their problems helped by assigned supervisors but not their own tutors. They present their own solutions and gain feedback from other groups, other students and experts. Their supervisors assess and grade their work; *One Day, One Problem* days account for half a student's marks during the semester.

2.2.2 MINI PROJECT

There are many ways in which PBL can be incorporated into courses including case-based PBL, task-based projects, subject-based projects or projects which integrate content across course boundaries (Howard S. Barrows, 1986). Several universities integrate projects into their courses (McDonnell, O'Connor, & Seery, 2007); they are known as 'mini projects'. Mini projects have set objectives and students report on them in a simple document. They take from two to four weeks. Mini projects can range from one-shot-problem solving to a continuous programme of solving the same problem at different stages of the course. Examples of such projects can be found in many universities including Aalborg and Mae Fah Luang.

2.2.3 SEMESTER PROJECT

"Semester Projects' are also known as 'the system approach'; a group project is itself a course. This kind of project places students at the centre of their learning; students raise their own research problems. The problems are open, skeletal, and thematic; supervision ensures that deep learning takes place. Students are expected to apply knowledge from current and past courses; unanticipated outcomes are expected. Such projects, assessed at the end of the semester are worth between 30 and 50% of that semester's credits. Bremen University in Germany, Roskilde and Aalborg in Denmark and Twente in The Netherlands have implemented semester projects (L. P. Jensen, Helbo, Knudsen, & Rokkjær, 2003; A. Kolmos, Krogh, & Fink, 2004; Powell, Powell, & Weenk, 2003).

2.2.4 FINAL-YEAR PROJECT

In some universities, students spend the final year of their Bachelor's degree working on a large project which enables them to draw on what they have learned in all previous courses (McDonnell et al., 2007; Mills & Treagust, 2003; Pee & Leong, 2005). Students may work individually or in groups; they are supervised. The underlying rationale is that students are capable of working on real-life projects; they can employ all the knowledge and skills that they have acquired to solve problems that they have formulated; they may also acquire new knowledge and skills. Reports are a component of the assessment.

2.3 PROBLEM-ORIENTED PROJECT-BASED LEARNING (POPBL)

'Problem-Oriented Project-Based Learning' is also called 'Problem-Oriented Project Work', 'Problem-Oriented Project Pedagogy' or 'Project- and Problem-Based Learning'; in this research, it will be referred to exclusively as 'Problem-Oriented Project-Based Learning' (POPBL) except in quotations. It combines projects with problem-based learning. POPBL was first developed at Bremen University followed by Roskilde and Aalborg Universities.

> "It is a particular brand of problem based learning according to which the students are working in groups in a self-directed manner. A group typically consists of 2-5 students, and it is formed on the basis of common interest in a problem or a topic that may be defined rather freely within the framework of an interdisciplinary theme. Project work deals with real life problems, and the nature and development of the project is negotiated in a continuing dialogue and discussion within the group under the supervision of a teacher." (Heilesen & Lerche Nielsen, 2004)

POPBL has its origins in the engineering schools of Bremen, Aalborg and Roskilde but is now applied in different fields and in many universities. Much research has demonstrated its success (Heilesen & Lerche Nielsen, 2004). Depending on the curriculum, POPBL accounts for between 30% and 50% of students' credits throughout their studies; the remaining credits derive from courses which impart basic knowledge or support the projects. Roskilde and Aalborg Universities implemented POPBL more than forty years ago; they have produced generations of graduates.

> "Project work is based on the principle of *exemplarity*: the idea that one can learn a subject by a deep study of one aspect of it. One justification for the focus on exemplarity has been political: a holistic society requires a pedagogy that mirrors "real life" – in particular, that dispenses with a (presumably) artificial disciplinarity [having the quality of being an artificial discipline (definition derived from online dictionaries)], substituting instead the interaction of various disciplines – and project work does just that." (Mallow, 2001)

The concept of 'the exemplary principle' or 'exemplary learning' was the root of Danish POPBL (Andersen & Heilesen, 2015). It was employed to ensure that students would achieve the general learning outcomes of their disciplines through project work. Topics which students choose for their projects must relate to their learning to date. The exemplary principle argues that reducing formal teaching and increasing project work enhances learning by promoting understanding of the broader context without missing important learning outcomes.

Project work is now an integral component of higher education, ranging from projects as exercises in class to final-year projects and project-oriented study. Students gain more than simple acquisition of knowledge when they aggregate individual efforts to achieve shared goals; participation with negotiation and compromise in their groups advances their personal development. Projects with real-life scenarios help students understand society; ethical and environmental concerns raised through projects make students more socially aware.

By working on projects, students advance their skills and knowledge. POPBL curricula combine problem-centered and content-centered learning (Heitmann, 1996). POPBL is integral to the curricula of many universities including Bremen, TU Berlin, Dortmund and Oldenburg in Germany; Roskilde and Aalborg in Denmark; Delft, Wageningen and Twente in The Netherlands; and Worcester Polytechnic, Wisconsin and Stanford in the USA. It has been shown that these education models match the requirements of employers and society. Heitmann (Heitmann, 1996) suggests

> "… that project-oriented study can be connected with divergent aims and objectives. The most significant characteristics, representing also a ranking of their empirical importance, are:
>
> • problem and product orientation;
>
> • student-centred, active and productive learning;
>
> • group cooperation and communication;
>
> • practical or profession orientation;
>
> • self-organized project management;
>
> • multi- or interdisciplinary approach;
>
> • societal relevance of problems;
>
> • democratic processes;
>
> • science criticism and alternative technology."

2.4 THE AALBORG POPBL MODEL

Aalborg University (AAU) was established in 1974; driven by the needs of society, its founders turned to unconventional educational ideas and made educational innovation a specialty of the University. The Aalborg University POPBL model derives from the educational principles of Knud Illeris, Professor of Lifelong Learning at Roskilde University; this author can find his work only in Danish but here is a reference from Kolmos et al (Kolmos, Fink, et al., 2004) regarding his work:

> "The Danish problem-based and project-organised model was developed on the basis of ideas from, among others Illeris, who formulated principles as problem-orientation, project work, interdisciplinarity, participant directed learning, and the exemplary principle and team work"

The PBL approaches developed by McMaster and Maastricht Universities were considered; although neither was directly adopted, features of each are to be found in the Aalborg model. Aalborg University has employed POPBL since its beginning; it is evident in its curricula and in the practices of both teachers and students.
Curricula at Aalborg are divided into ten semesters, six for Bachelor's degrees and four more for Master's. Project work accounts for 50% of credits; study courses provide concepts and knowledge of the subject; project courses supply useful knowledge and skills from which students can select appropriately.

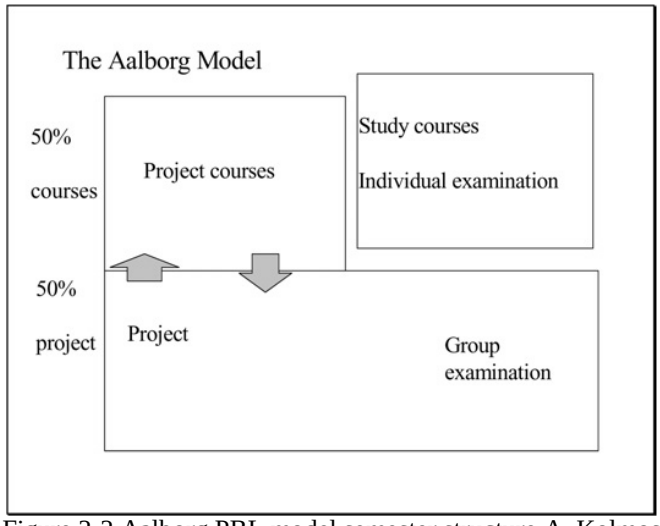

Figure 2-2 Aalborg PBL model semester structure A. Kolmos et al., 2004

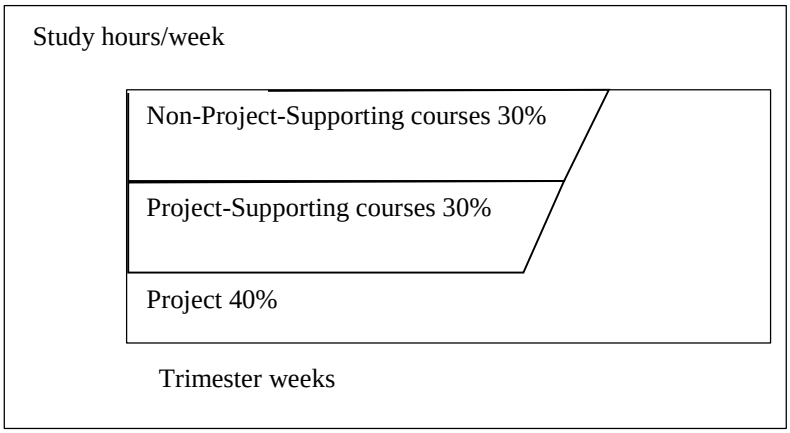

Figure 2-3 Engineering PBL model semester structure at Twente University (adapted from Powell et al., 2003)

Figure 2-3 shows the structure of a trimester of an Engineering student at Twente University in The Netherlands (Powell et al., 2003). The study plan is similar to the Aalborg model; students work on projects for the whole semester; courses are concentrated at the beginning of the semester. Another example of the Aalborg POPBL model is at Mae Fah Luang University, Thailand; it is practised in the School of Information Technology where this author works; however, the structure of courses and projects differs from Aalborg. The typical curriculum structure during a semester in the School of Information Technology at Mae Fah Luang is illustrated in Figure 2-4. Courses 4 and 5 are taught by other schools in the University and provide general education in subjects such as English, Society, Mathematics and Physics; they are not integrated into the project. Courses 1, 2 and 3 are taught by the School of Information Technology and provide the content which feeds into Course 6, the semester project. The figure shows how Course 6 overlaps with Courses 1, 2 and 3 which contribute time, effort and scores for assessment to Course 6. Formerly, students would have conducted projects for each course separately but this led to overloading and not gaining the deep learning required from projects.

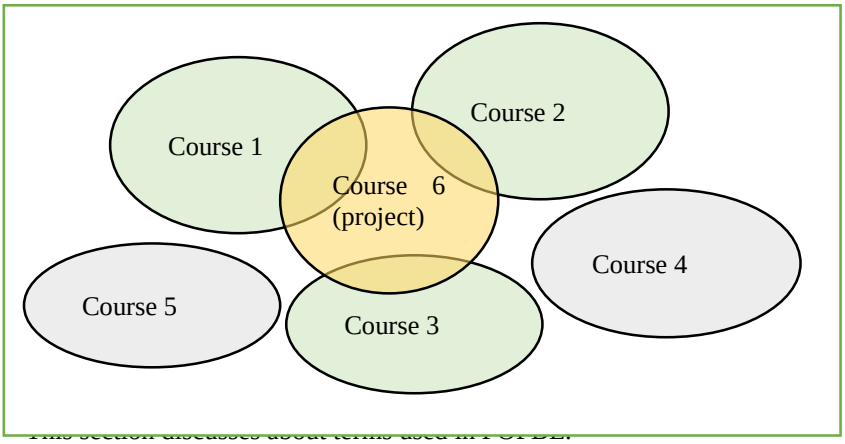

Figure 2-4 POPBL curriculum structure at Mae Fah Luang University

2.4.1.1 Problem Oriented

Social-learning theories stress the benefits of problems in learning:

1. Problems create opportunities to utilise skills and apply knowledge to achieve solutions; problems illuminate the meanings of skills and knowledge.
2. Solving problems demands that students consult outside experts and communities thus extending their learning.
3. Solving problems demands that students acquire, experiment with and apply new skills and knowledge thus further extending their learning.
4. The social aspects of a project enhance problem solving; students socialise, share, collaborate, negotiate; they encourage each other (Hanney and Savin-Baden 2013, p. 10).

Illeris, an Education professor in Denmark, relates problems to study, society and people. A 'good' problem draws on taught skills and knowledge, relates to the outside world and stimulates students' curiosity and develops their interests.

2.4.1.2 Interdisciplinary

Being expert on a field is not enough to survive well in EU context (Anette Kolmos, Fink, & Krogh, 2004, p. 43); European Union commission showed the requirements of employees who quickly learn and adapt knowledge from different fields. Study programs are usually defined by their boundary of knowledge and practice (Andersen & Heilesen, 2015, p. 18). Therefore, there are strong links between disciplines and degrees or program of study in university education. However, the link has both

advantages and disadvantages. Competencies are developed from disciplines in a study program demonstrate ability of the person. Therefore, the person could be expert in the specific field but he may not able to solve a real problem effectively because it complexity which requires a wide range of competencies to solve it. In PBL problems drive learning; even though problems can be scoped in a domain but the solutions are not limited to only the competencies from the disciplines required by the program. Interdisciplinary opens opportunities for students to form their own favour of their expertise rather than being predefined by program or teachers (Andersen & Heilesen, 2015, p. 19).

It is insufficient to be an expert in a single field. Kolmos, Fink, & Krogh (2004, p. 43) relate this to the EU context; the EU Commission requires employees to acquire and integrate knowledge from different fields. Programs of study are limited by boundaries of knowledge and practice (Andersen & Heilesen, 2015, p. 18). There are strong links between a set of disciplines and a degree or a program of study in university education; the links have both advantages and disadvantages. The abilities of a student are illustrated but the competencies developed during a study program; someone could be an expert in a particular field but be unable to solve real problems because of their complexity and the wide range of competencies required. In PBL problems drive learning; even though a problem is set in one domain, solutions are not limited to that domain but may draw on other disciplines. Students, through their own interdisciplinary studies, lean to acquire their own relevant expertise rather than be restricted to the program or what they have been taught (Andersen & Heilesen, 2015, p. 19).

2.4.1.3 Participant-Directed Learning

The term 'participant-directed learning' or self-directed-learning refers to a collective whose members own their learning from the start until the end of the process (De Graaf & Kolmos, 2003). It is a democratic form of study; learners and teachers take responsibility for learning including evaluation. The role of students is to investigate their chosen problems; teachers facilitate learning and ensure that the direction and content of students' projects meet the requirements of the curriculum. Participant-directed learning allows students to build their own expertise and reflect on their own strengths and weaknesses.
Participant-directed learning is difficult for students; Andersen and Kjeldsen (2015) argue that at least three contradictions require consideration:

1. 'Contradictions between the needs and interests of supervisors and students'

The role of a teacher who supervises a project is to be a facilitator supporting groups to initiate and conduct their projects. Students, in their projects, are expected to apply the competencies they have learned in the classroom. The problem domain establishes boundaries but solutions may be problematical; concepts or techniques may be beyond the expertise of the supervisor. If the supervisor does not feel competent to facilitate the group, students may be feel obliged to work within the supervisor's domains.

2. ‘Contradictions between the supervisory function and the obligation of the supervisors to control the result of the students’ project work’

Teachers facilitate projects; students are free to use their teachers’ advice or recommendations or otherwise. Students are examined or assessed by the same teachers. Do students really have free choices when they are examined by the same teacher who supervises them?

3. ‘Contradictions between the students’ needs and interests and the curriculum requirements’

To be awarded a degree a student must meet the requirements laid down in the curriculum; students enrol in a program of study which fulfils all the requirements. Students are aware of the requirements when they choose a program. There may be conflicts between the curriculum and students’ need to acquire new skills and knowledge beyond the curriculum to conduct their projects; students are free to pursue their own interests providing they fulfil the requirements of the curriculum.

2.4.1.4 Facilitators

For learning to be effective, and to comply with the requirements of the curriculum, a facilitator is necessary. In constructivist pedagogy such as POPBL, teachers become tutors and supervisors; their primary role is as facilitators; teachers evolve from transmitters of knowledge to facilitators in the construction of knowledge. Facilitators are more interested in learning processes than content; students can formulate their own problems within a set domain; students will usually apply the methodologies that they have been taught thus limiting their scope of their interests. There are several models or guidelines for facilitators; facilitators should encourage students to enhance:

- communication between members of their group and between the group and other relevant communities such as teachers and experts
- application of knowledge and skills derived from the curriculum
- self reflection; evaluation of their progress in learning
- their participant-directed learning.

To scaffold students to be independent from facilitators is a challenge; Margeton (1994) suggests that facilitators should not provide the best solution to students; rather, they should ask questions to guide students to discover their own solutions; students will then have achieved independence from their facilitator. Desirable skills for facilitators are questioning, probing, encouraging, making suggestions and challenging to allow ideas and solutions to emerge from students. Four roles of facilitators are proposed by De Grave et al (1998): elaborating; directing the learning process; integrating knowledge; and stimulating interaction and individual accountability. How to balance supervision and participant-directed learning presents dilemmas; the more involved teachers are, the less self-direction students have.

2.4.1.5 Knowledge Construction

Knowledge is "Facts, information, and skills acquired through experience or education; the theoretical or practical understanding of a subject" (Oxford dictionary). Knowledge can be acquired cognitively through perception, communication and reason. Communication in knowledge acquisition can be by individuals, for example from books, or collective, such as within groups. Traditional knowledge acquisition in education is by transmission or consumption; by way of contrast, in constructivist education, knowledge is gained by questioning, experiment and evaluation. Constructivist education is most effective within a collective with a common goal.
Authors differ in their definitions of knowledge construction; two examples are:
"Knowledge Construction [is the] process of accessing, understanding, evaluating, connecting and refining information in order to produce personal meaning." (Conceição, Baldor, & Desnoyers, 2010).
"Knowledge Construction: Knowledge construction is a collaborative process which aims to produce new understanding or knowledge which exceeds something that anyone alone could not achieve. It is also essential that knowledge construction is based on each other's ideas and thoughts." (Oksanen, Lainema, & Hämäläinen, 2017).
The definition of Conceição at al is based on how an individual makes meaning – it is personal – whereas for Oksanen, it is collaborative – knowledge construction is social. There are common aspects to the two definitions; prior knowledge may not explain a new situation and a new interpretation be required; new meanings are made by the group or the individual (van Schalkwyk & D'Amato, 2015, pp. 13–15).

2.4.2 POPBL PROJECT WORK

The characteristics of project work in Danish education are discussed by Kolmos (Kolmos, 1996) as follows:

- Problem orientation and interdisciplinarity;
- Open curriculum and experienced-based learning;
- Basic year and gradual specialisation;
- Project work in study groups.

Along with these characteristics, Kolmos and Graaf (De Graaf & Kolmos, 2003) define three learning dimensions of project work: problems, content, and teams. The three dimensions derive from the four characteristics. Project work is a way to organise group discussion and writing concerning both processes and products to achieve solutions for the investigated problems (Kolmos, 1996). Skills and knowledge from all courses taken during a semester are applied to and adopted into their project. Students in teams decide on their own problems for investigation and formulate research questions within given themes which allow a wide scope within the discipline. Projects are the main learning mechanism whilst problems are the goal of the whole process. Group members spend much time together and develop into a team. Each member of the team is an individual who retains his or her own

perspective, mode of working and sense of responsibility; they negotiate to find a common context (space and time). Face-to-face meetings are expensive and inconvenient; the first task for students is to find support tools which enable communication. Some participatory tasks are difficult if performed manually; in addition to communication, digital tools enable new ways of performing tasks whether face-to-face or distantly.

2.4.3 PROJECT ASSESSMENT

Roskilde and Aalborg Universities assess projects at the end of each semester. After students have submitted their final reports, the programme board organises an assessment schedule; they present their project to, and converse with, two "examiners", one being their supervisor (Kolmos, Fink, & Krogh, 2004; Mallow, 2001). Each member of the group is awarded marks individually.

2.4.4 PROJECT PHASES

To understand how tools are used in actions, the processes of the action need to be examined. A project's processes can be divided into different phases chronologically. During each phase different resources and tools are required; furthermore, the process of adopting a tool can occur at the beginning of a project, activity or phase to meet current requirements. Identification of the phases of a POPBL project is necessary to understand tool adoption.

A 'phase' is a period of time when certain activities and processes take place; a project contains different phases; a change of phase marks a change in the type of activity being performed and indicates that the project is progressing. Phases usually run consecutively, but may run concurrently for some of the time: in other words, they may overlap; some project may lack of some phases, some may run in different order; there are examples from this research which will be discussed later. One example is from software development where phases could be Planning, Analysis, Design, Implementation, and Maintenance (Roebuck, 2012). *The life cycle of a research* project usually consists of the following phases: Ideas, Partners, Proposal Development, Research and Publication (White, 2015).

To understand how students choose and adopt tools to support their projects, we need to understand the activity. The Activity plays a central role in this research because they are the reason for tool application. A project is an activity comprising several sub-activities which, assembled chronologically, are called phases. In the identification of project phases, phases are informal divisions identified by and for the convenience of researchers; they are definitely not imposed on students performing projects; therefore, as in this case, actual phases may differ from the model**.** Different researchers have identified and labelled the phases of a project in different ways; they observed students in different universities and in different fields of study. From the literature, there are two earlier researchers of this topic at Aalborg University: Professor Lone Dirckinck-Holmfeld in the field of Computer-Supported Collaborative

Learning; and Professor Annete Kolmos in Engineering Education; other research by Mosby and by this author jointly with Khalid and Buus has also been incorporated. Additionally, project phases of Roskilde Model is also added. The phases from Roskilde model are composed of four phases: Group formation, Design, Work and Reporting (Heilesen, 2015, p. 255). The following table compares the phases identified by each researcher; it clearly demonstrates the equivalence of most phases from the different researchers. In the context of this research, observation of Group B has led to reconsideration of the phases; these phases and their labels are employed exclusively in this research. The phases used in this research are slightly different from other models; see Table 2-3 for a comparison which is further discussed after the table.

Rongbutsri, 2016	**Heilese,2015**	**Khalid, Rongbutsri, & Buus, 2012**	**Moesby, 2002**	**Hansen, Dirckinck-Holmfield, Lewis and Rugelj, 1999**	**Kolmos, 1996**
Human Informatics students	**Roskilde Model**	**Human Informatics students**	**Engineering students**	**Nursing and Medical students**	**Engineering students**
Phase in Model VI Group B	**Phase in Model V**	**Phase in Model IV Group A**	**Phase in Model III**	**Phase in Model II**	**Phase in Model I**
1. Group formation	Group Formation	1. Group forming		1. Group formation	1. Preparation
2. Problem formulation	Design	2. Problem formulation	1. Initiating problem 2. Problem analysis 4. Problem delimitation	2. Problem formulation	2. Problem analysis
3. Planning		3. Task formulation	3. Task formulation	3. Planning	3. Demarcation
4. Data gathering	Work	4. Data gathering	5. Solution	4. Research	4. Problem Solving
5. Analysis		5. Analysis			
6. Solving the problem		6. Design	7. Implementation *		
7. Reporting	Reporting	7. Reporting	6. Discussion and Conclusion * 8. Reporting	5. Documentation	5. Conclusion **6.** Reporting
8. Preparation for examination				6. Examination	

Table2-3 Comparison of project-phase models by different researchers

*Note: Phases number 6 and 7 of Model III are in different order when mapped to Model VI

Table 2-3 compares the phases of previous Models I to V with Model VI which some of the phases identified by other researchers do not easily match the phases of Model VI, the one which is used in this research. Here are the three cases in which the matching of phases from other models to those in Model VI is problematic.

1. One phase has a category which is too broad to be useful in this research.

Phase 5 of Model III incorporates Phases 4, 5, and 6 of Model VI.

2. One phase has a category which is too narrow to be useful in this research.

Phase 1, 2 and 4 of Model III incorporate only Phase 1 of Model VI.

3. One phase has categories in the wrong order and two categories which are labelled differently appear to be the same.

The order of the phases in Model III seems perverse: Phase 4 – problem delimitation is clearly a component of Problem Formulation whereas Phase 3 – Task formulation is clearly part of Planning.

Model VI which is used in this research is composed of 8 phases.

1. **Group Formation**
   Group formation is the initial phase of a POPBL project which they identify group members and choose a topic (Heilesen, 2015, p. 255). Some groups may construct their virtual environment immediately after their group formation. There is no group formation phase in Model III; this might be because Model III concerns students learning but little learning occurs during group formation.

2. **Problem Formulation**
   Problem Formulation is a term used in academic discussion of POPBL (H. S. Barrows & Tamblyn, 1980, p. 28; De Graaf & Kolmos, 2003, pp. 658–661). Students identify a problem; they describe and analyse it. The term "Problem Analysis" used by Kolmos in Model I is partly problem formulation which encompasses initiating the problem, problem analysis, and problem delimitation as defined in Model III.

3. **Planning**
   Planning is the process of imagining and estimating tasks, resources and a timeframe to enable completion of the project by a deadline. In Model I, Planning is combined with the separate Task Formulating of Models III and IV.

4. **Data gathering**
   Phases 4, 5 and 6 in Model I are combined in the earlier Models I, II and III; the combined forms are unsatisfactory for this research because Data Gathering, Analysis and Solving the Problem are performed with different kinds of tasks and, by extension, different modes of communication are required. Model V uses "Solving the problem" instead of "Design" as in Model IV; this is to reflect the core value of POPBL which is about to solve problems (De Graaf & Kolmos, 2003).

5. **Analysis**
   Students can utilize different tools to support their data analysis, to get their new knowledge which is inputs for their problem solving.

6. **Solving the problem**
   During this phase students design, construct, establish, or implement according to the objectives of their project.

7. **Reporting**
   After solving the problem, the report must be written with conclusions in an academic format with proper references to standard academic publications (Kjeldsen & Andersen, 2015, p. 38).

8. **Preparation for examination**
   After submitting their project reports students have some weeks to prepare their presentation and viva (called project examination) (Kolmos, Fink, et al., 2004, p. 28).

Table 2-3 illustrates POPBL project phases from different researchers including the author's, Model VI, the only version used in this research. General information about project phases at Aalborg University derive from the author's informal observation and conversations with staff and students at Aalborg.

Phase 1: Group Formation
One month into the semester, the study board for each program calls a meeting for all its students who are in the same year; described as a "brainstorming session", students discuss common interests and possible projects and form themselves into groups. Topics are open but must match the semester themes which are drawn from the curriculum. Usually the maximum number of students in a group is eight (Andersen & Kjeldsen, 2015a, p. 30); every student must be in a group by the end of the session. Members of a successful group have a 'sense of belonging' and 'ownership'; all members must feel that they are important to the group; the survival and success of the group is the responsibility of all students; students need to be able to coordinate with and trust each other and manage risk jointly. Two case studies follow: POPBL beginners and POPBL experienced. Characteristics of group members are included because they affect group formation. Will the group meld even at the expense of individuality? Will they be able to negotiate compromise and accept democratic decisions? Will they settle and accept each other as individuals including their failings? Will they perform their roles proficiently?

Phase 2: Problem formulation
By the end of the brainstorming session, students will have formed their groups and decided on their topics. They then need to understand and formulate their problem and establish the parameters of their research; they must decide on theoretical

foundations and methodology and communicate with potential stakeholders or third parties. Students search literature and discuss their ideas. Problem projects are interdisciplinary; students need to explore literature from outside their own field; they may consult supervisors and librarians. Problem Formation is the most critical phase of a problem project because the problem must be clearly formulated and understood in order to solve it. Problem solving has two main processes: solution development is contextual – it depends on resources available; problem understanding is transferable – it is independent of resources.

Phase 3: Planning

Planning is also known as 'task formulation'(Moesby, 2002, p. 148). Firstly, the project is divided into stages which are roughly equivalent to phases but established by the group to suit the requirements of their own project; secondly, each stage is divided into activities; thirdly, activities are composed of tasks. Planning can be in the form of a schedule or to-do list with tasks allocated to members; thus, the division of work can be seen. Planning is for guidance rather than strict adherence. Planning should be flexible with students able to make appropriate changes when aspects of their original concept are found to be unsatisfactory or if a better approach can be found; the problem is immutable and dominates the project.

Phase :4Data gathering

Decisions made in the planning phase are implemented starting with experimentation and observation. Tasks performed in this phase culminate in gathering data; also, in this phase, the group will be able to try out theoretical knowledge of their subject and their selected methodologies and will be able to make changes if they are unsatisfactory. The results from this phase are data; there are two types of data:

i) Empirical data is collected through observation and experiment in the real world rather than theoretical knowledge.
ii) Laboratory data is obtained under controlled conditions.

Phase 5: Analysis

Despite different methodologies in different fields of study, Analysis consists of two primary activities: Data Processing and Interpretation. After students have performed their experiment or completed their observations, their output is data. Data can be processed quantitatively or qualitatively according to its characteristics and the objectives of the research. Students can then interpret the processed data to enable them to understand the problem and devise solutions.

Phase 6: Solving the problem

The findings from Phase 5 are applied to produce hypothetical knowledge and in some projects, prototype products or processes. The problem will have been solved if testing confirms the veracity of the hypotheses or practicality of products or processes.

Phase 7: Reporting

Writing the report is the final task of a project. To compile the report, records are selected, edited and written up. The report is written in an academic format; it targets a particular audience. The deadline for submission of the report is an important consideration; it dominates the project's timeframe; therefore, writing up may commence during earlier phases.

Phase 8: Preparation for Examination

After submitting their project report, the group has six weeks to prepare for assessment or, in Denmark, "the examination". Assessment is performed by their supervisor and one or two examiners from the same program; it contains three elements:

i) The project report (completed in Phase 7)
ii) A group presentation
iii) Group viva voce

The purposes of the examination are:

a) To demonstrate the problem, theory, methodologies and solutions
b) To show the contribution of each member
c) To evaluate the project and award grades; usually all members are awarded the same grade but examiners can award individual grades if they find that member's contributions have been unequal. Members are examined as a group; this author heard, anecdotally, that Aalborg University had employed this form of examination from its foundation until 2006 when national educational policy restricted examination in this way; it was reintroduced in autumn 2010. Members of a group work together for several weeks so it is sensible for them to be examined together.

2.5 SUMMARY OF POPBL

Problem-Oriented Project-Based Learning (POPBL) is a kind of Problem-Based Learning. It employs project as the main mechanism for knowledge construction; it has more student-controlled dimensions than original PBL; students can choose their own topics, formulate their own problems before starting their investigation and knowledge construction; this makes POPBL differ from original Problem-Based Learning and original Project-Based Leaning. In POPBL there are two main learning activities: classroom activity and project work. Teachers are encouraged to teach in Problem-Based Learning approach; however, classroom activities are left to teachers to design the activities. Thus, there could be lecture-based teaching in classroom. However, project work which occupies 50% of each student total credits of each semester is employed to ensure all students gain the benefits from the self-directed pedagogy-POPBL. Project work is a research project which is designed and carried out by students in a group setting with facilitation of their supervisor who is an experienced researcher; and will be evaluated and graded at the end of the semester. Depending on nature of students' main discipline and purposes of study, different authors define different sets of project phases. However, the author proposes an 8-

phase model which including preparing for examination. The model will be used for the data analysis in chapter 4.

2.6 ICT ADOPTION INTO POPBL PROJECTS

Virtual learning environments and associated pedagogy are one of the major developments of the POPBL model. A 'virtual learning environment' (VLE) is a set of electronic tools which enhance and support teaching and learning. The effectiveness of VLEs in POPBL has been studied several times; some examples are:

- to support teaching activities (Lillian Buus et al., 2012)
- in classroom learning activities (L. Buus, Georgsen, Ryberg, Glud, & Davidsen, 2010)
- adoption at curriculum level (Tom Nyvang & Bygholm, 2005)
- for distance-learning students (Christiansen & Dirckinck-Holmfeld, 1995)
- to support projects (H. Tolsby, Nyvang, & Dirckinck-Holmfeld, 2002)

This section examines existing knowledge about ICT adoption into POPBL.

2.6.1 LITERATURE SEARCH

Search techniques will be discussed before considering results. This part of the research studies how VLEs support on-campus students' projects; a VLE in the context of distance-learning is considered only when mentioned in literature. This chapter continues by discussing how students' adopt Computer-Mediated Communication (CMC) in their projects; ICT in the classroom and in teaching is excluded. Four global and two Danish university databases were selected to search and collect literature as shown in the following lists:
Global databases

- ERIC: educational resources information center: http://search.proquest.com/eric/
- Science Direct: http://www.sciencedirect.com/
- ACM digital library: http://dl.acm.org/
- Google Scholar: http://scholar.google.dk/

Danish university databases

- Research from Aalborg University in VBN: http://vbn.aau.dk
- Publications at RUC: http://rucforsk.ruc.dk/site/en/publications/

Keywords were chosen to facilitate the literature search as shown in Table 2-4. Complete phrases and abbreviations were searched for separately. Sources in literature employ different terms for the same or similar meanings. Some important terms in literature may describe components of the primary keywords or be associated with them; these are shown as Secondary Terms in the table.

Topic	Keywords for literature search	
	Primary Terms	Secondary Terms
Information and Communication Technology	▪ Information and Communication Technology ▪ ICT	▪ Web 2.0 ▪ Virtual Environment ▪ Virtual Learning Environment ▪ VLE ▪ Technologies ▪ Innovation ▪ Computer-Mediated Communication ▪ CMC
Implementation	▪ Implementation	▪ Integration ▪ Adoption ▪ Appreciation ▪ Employment
Computer-Supported Collaborative Learning	▪ Computer-Supported Collaborative Learning ▪ CSCL	▪ Computer-Supported Cooperative Work ▪ CSCW ▪ Technology-Enhanced Learning ▪ Collaborative Knowledge Construction ▪ CKC
Problem-Oriented Project-Based Learning	▪ Problem-Oriented Project-Based Learning ▪ POPBL	▪ Problem-Oriented Project Pedagogy ▪ POPP ▪ Problem-Based Learning ▪ Project-Based Learning ▪ PBL ▪ Aalborg PBL Model ▪ Project-Organised Studies ▪ Problem- and Project-Based Learning ▪ Project- and Problem-Based Learning
Project Work	▪ Project Work	▪ Group Work

Table2-4 Keywords for searches

This strategy enabled the search for both off- and online publications, especially the most cited. Some research may not have been published worldwide; two Danish university databases – Roskilde and Aalborg – were also searched because these universities were initiators of this kind of research and are still active in this field; studying in Denmark gave this writer convenient access to these databases. Works published before 1999 were excluded due to difficulty of access.
Dirckinck-Holmfeld states that ways of adopting ICT into learning have been studied at Aalborg and Roskilde Universities since 1987. Her first report, Problem-Oriented Project-Based Pedagogy, was published in Danish in 1991. Later research was carried out by Marianne Georgsen for her PhD: 'Den anden dimension. Computer-medieret kommunikation og collaborative learning (1995) [The Second Dimension. Computer-Mediated Communication and Collaborative Learning]'. Three subsequent publications also reported on the same topic before 1999:

- Fjuk, A., & Dirckinck-Holmfeld, L. (1996). Problem Oriented Collaborative Distance Learning: Why so Difficult? In B. Dahlbom, F. Ljungberg, U. Nuldén, K. Simon, & C. Sørensen (Eds.). Proceedings of the 19th Information systems Research seminar In Scandinavia IRIS 19, Vol. 1.
- Fjuk, A., & Dirckinck-Holmfeld, L (1997). Sammenføynings arbejde i kollektive læreprocesser [Articulation Work in Collaborative Learning]. In O. Danielsen (Ed.) Læring og Multimedier [Learning and Multimedia] (pp. 145-176). Ålborg: Aalborg University Press.
- Dirckinck-Holmfeld, L., & Nielsen, J. Collaborative Scientific Work and Learning. Experiences from the MANICORAL Project. Aalborg University and Copenhagen Business School.

Due to limited access, the above-mentioned publications are excluded from this discussion; only works published since 1999 have been taken into consideration. Themes illustrating current knowledge emerged from the authors reading:

- ICT for educational infrastructure
- ICT tools for Collaborative Knowledge Construction
- ICT for Virtual Learning Environments to support project work and other learning activities
- ICT as a place for learning

Literature from each theme is displayed in a table format which identifies authors, titles, theories, tools, and arguments. Theories are identified to seek of common research approach in the field which can be ground for research approach selection. Tools used by students in each papers are identified to observe the movement of tool selection. To see the current understanding of students use tools in their project work, arguments from each paper is identified.
Discussion as to how ICT is integral to POPBL follows the literature search for each theme.

NB: tools in the following tables are described in Appendix F: Tool description.

2.6.1 ICT AS EDUCATIONAL INFRASTRUCTURE

Papers on ICT for Educational Infrastructure are listed in Table 2-5; the authors survey institutional strategies to support students' ICT adoption not only into projects but into all aspects of curricula. Research on this theme aims to investigate how ICT can be used to assist and accelerate students' learning; it focuses on the meso organisational level as suggested by Bygholm & Nyvang (Bygholm & Nyvang, 2009). Meso refers to decisions which are made by teachers and institutions about how to implement ICT; teachers and institutions also advise and assist students at the micro level about their adoption of ICT tools. Research on ICT for Educational Infrastructure is not directly relevant to this paper which is concerned with how students adopt ICT tools in their learning.

Authors and year	Title	Theories	Tools	Arguments
Tom Nyvang & Bygholm, 2005	Human-Centred Informatics – The emergence of an educational infrastructure	Action research; activity theory; theory of learning in community-of-practice and theory of the emergence of infrastructures.	Lotus Quick-Place	The research identifies problems on three levels of infrastructure: communication and media, design and support, and technology.
(Tom Nyvang, 2006)	Implementation of ICT in Higher Education as Interacting Activity Systems	Activity Theory	Lotus Quick-Place	-Three processes in the implementation of an activity: Selection of ICT; adaptation of ICT and change of practice with ICT. -The success of ICT implementation is influenced by personal motives and goals rather than management driven decisions. -Identification of major challenges of ICT implementation in Higher Education based on Activity Theory.
(Bygholm & Nyvang, 2009)	An infrastructural perspective on implementing new educational technology	Activity Theory	Lotus Quick-Place	Critical questions and problems linked to implementation of educational ICT infrastructure can be classified into three practices: pedagogical, support, and technological. The practices can be divided into three organisational levels: macro, meso and micro.
(Tom Nyvang & Bygholm, 2012)	Implementation of an Infrastructure for Networked Learning	Activity Theory	Lotus Quick-Place	Several problems in the adoption of institution-provided tools are identified. Dilemmas in the implementation of networked learning are identified by providing a matrix quantifying/describing certainty or uncertainty of technology and goals.

Table2-5 Related work of ICT as educational infrastructure

2.6.2 ICT TOOLS FOR COLLABORATIVE KNOWLEDGE CONSTRUCTION

Papers on ICT tools for collaborative knowledge construction are listed in Table 2-6. According to constructivist learning theory, which is the basis of PBL and POPBL, activities result in knowledge construction; tools support and enable activities. Writers on this theme identify phases of collaborative knowledge construction (CKC); each phase requires different levels of 'communication richness'; Hansen, Dirckinck-Holmfeld, Lewis, & Rugelj (Hansen, Dirckinck-Holmfeld, Lewis, & Rugelj, 1999) provide the following definition of 'richness':

> "One important dimension of a communication channel is what has been termed its richness (Daft & Lengel, 1984). This can be thought of as the potential information-carrying capacity of data. Factors which contribute to richness are suggested to be:
>
> · interactivity (the speed of reaction)
>
> · multiple cues (verbal, intonation, proxemic, and kinetic)
>
> · language-variety (numbers, natural language, symbols, images)
>
> · socio-emotional cues (social presence, feelings)"

The paper by Hansen, Dirckinck-Holmfeld, Lewis, & Rugelj took the approach from Activity Theory which describes three levels of organisation of an activity:
- intentional level dealing with motives;
- functional level dealing with specific and conscious goals; and
- operational level dealing with practical conditions of actions.

By considering project groups as an organizations and applying these levels they found that students require richer communication for discussion at the 'intentional level'; face-to-face meetings enable the richest communication; at the 'functional level', communication is less rich; and at the operational level, it is least. Communication tools become more suitable as richness of communication declines. Richness is a sliding scale; Hansen, Dirckinck-Holmfeld, Lewis, & Rugelj suggest that it 'will shift back and forth, but not in a random way'.

Authors and year	Title	Theories	Tools	Arguments
Hansen et al, 1999	Using telematics to support collaborative knowledge construction [The term 'telematics' a forerunner if ICT.]	Activity Theory	Classic conferencing tools	The match between tools and the processes that they are intended to support. The paper identifies functionalities of telematics [ICT] tools, then offers two typical contemporary examples of collaborative knowledge construction by groups using these tools.
L. Dirckinck-Holmfeld, 2006	Designing for Collaboration and Mutual Negotiation of Meaning – Boundary Objects in Networked Learning	Boundary Objects [units of electronic learning resources which bind together to create topics]	Virtual-U	Optimising teaching and learning processes through conscious use of boundary objects and how different kinds of knowledge are linked through boundary objects.

Table2-6 Related work of ICT tools for collaborative knowledge construction

2.6.3 ICT AS VIRTUAL LEARNING ENVIRONMENTS

Even though the application of ICT is not formally incorporated into projects, it does provide additional learning environments; papers on this theme are listed with generalised summaries in Table 2-6. The key points from these papers are:
projects can be divided into phases as discussed in section 2.2.5 Project Phases; tasks are performed during each phase; tasks may require different resources including different modes of communication (Lone Dirckinck-Holmfeld, 2002a; Heilesen, 2015). By selecting tools to support their projects, students can set them up themselves; however, for an advanced tool they may need advice (T. Nyvang & Tolsby, 2004; Nyvang, 2006). The evolution of the structure of a students' shared folder from phase to phase of a project reflects the state of their learning (T. Nyvang & Tolsby, 2004). Successful application of ICT in a project requires:

i) a well-established protocol for coordination of activities and knowledge construction
ii) a joint image of their experience (the visualisation of their understanding)
iii) adaptability to meet changing requirements (T. Nyvang & Tolsby, 2004).

The three steps to implement ICT in learning are selection, adoption and establishing new practices (Nyvang, 2006). Tools to support project work can be classified into two categories: basic project operation e.g. communication, planning, file storage; institutions tend to either provide or recommend tools for the purpose (Guerra, 2015; Heilesen, 2015). Requirements emerge during the project; students usually adopt tools used by their peers: friends, classmates and senior students; their teachers and family are less influential (Thomsen et al., 2016). Students tend to value ease of use over functionality and utility; complex tools are not contemplated (Thomsen et al., 2016). Social networking tools often provided by institutions but rarely adopted by students: ELGG and Mahara for example; free subscription tools are widely and individually adopted by students: Facebook and Instagram for example. Students seldom see the necessity or advantages of replacing their favourite tools even though considerable benefits may accrue during the conduct of their projects (Rongbutsri, Khalid Saifuddin, & Ryberg, 2011; Thomsen et al., 2016).

Authors and year	Title	Theories	Tools	Arguments
Nielsen, 2002	The implementation of Information and Communication Technology in Project Organized Studies	POPP, ICT, CMC and development of personal competency	Email, Firstclass, BSCW, internet resources, conference systems	Using Computer-mediated communication (CMC) to facilitate collaboration among students and enable students to learn from each other.
H. Tolsby et al, 2002	A Survey of Technologies Supporting Virtual Project Based Learning	Negotiation of meaning; coordination of group members; and resource management are identified as the key concepts in project-based learning.	Lotus Learning-Space, Virtual-U , Lotus QuickPlace	– Three e-learning systems were selected for the survey. – Virtual-U, Lotus Learning Space and Lotus QuickPlace; each offers a different strategy for e-learning and all benefit users. – Tools to support projects are discussed.
Lone Dirckinck-Holmfeld, 2002a	Designing Virtual Learning Environments based on Problem Oriented Project Pedagogy	POPP, CSCL, didactical principles	Conference systems, internet resources	– The design and practice of virtual learning environments based on POPBL – Project phases and resources are discussed.
L. Dirckinck-Holmfeld & Lorentsen, 2003	Transforming university practice through ICT-integrated perspectives on organizational,	ICT, organizational learning and planning theory	Not specified	ICT as a change-agent to establish new practices, new pedagogical and collaborative methods and new ways to interact between physical and virtual learning environments

	technological, and pedagogical change			
Bjørn, Fitzgerald & Scopula, 2003	The Role of Social Awareness in Technology Acceptance of Groupware in Virtual Learning	Technology Acceptance Model (TAM)	BSCW	– Groupware for Collaborative Learning – Qualitative Application of the TAM model to investigate groupware technology acceptance – The relationship between ease of use and perceived usefulness, as postulated by the TAM model, is not present in the case of groupware technology in virtual-learning group settings. – How social awareness affects acceptance of technology to support collaboration.
Bjørn, 2003	Re-Negotiating Protocols: A Way To Integrate GroupWare in Collaborative Learning Settings	CSCL, Community of Practice: protocols and situated actions	BSCW	– How to apply groupware to POPBL in the context of distance learning – Renegotiating protocols for collaboration is essential for distributed project groups.
T. Nyvang & Tolsby, 2004	Students Designing ICT Support for Collaborative Learning in Practice	Community of Practice	iGroup	– POPBL: student practice and needs – Students are able to construct and reconstruct their own group learning environments without outside intervention.

				– The key activities for application of ICT in group projects are: coordination of activities; coordination of knowledge construction; and creation of joint images of experiences. – Tools must be adaptable to meet changing requirements during progress of the project.
Thomas Ryberg et al, 2006	Conditions for productive learning in networked learning environments – a case study from the VO@NET project	Cross-case analysis	Moodle	– The relationship between course and project work and available resources – The continua which demarcate control of learning processes between teachers and students
Tom Nyvang, 2006	Implementation of ICT in Higher Education as Interacting Activity Systems	Activity Theory	Lotus QuickPlace	A theoretical model to demonstrate the implementation of ICT in higher education based on Activity Theory: there are three steps of implementation – selection of ICT; adaptation of ICT; student practices conform to ICT characteristics; implementation of ICT requires technical and educational assistance from outside the group.

L. Dirckinck-Holmfeld, 2009	Innovation of Problem Based Learning through ICT: Linking Local and Global Experiences	Social appropriation of technology, ICT for Development	Not specified	– Time: computer networks affect time patterns of teaching and learning. Teaching and learning environments can be organised more flexibly due to the asynchronous nature of communication technologies. – Place: mobile and ubiquitous computing devices provide access to information for education anywhere and at any time. – Persistency of learning activities: synchronous and asynchronous activities are easily archived in transcripts, logs, webcasts and audio interviews or podcasts; these records permit more reflective teaching and learning. – Public and private boundaries: there is now public access to much of what would formerly have been private materials; these materials can be taken into consideration during assessment. – Literacy: new forms of literacy have developed from networked learning; they are not adaptations of informal spoken or formal written language but are new forms in

				themselves; an important feature of this new communication is the adoption of audio, images and video with written text. – Content: the boundary between content and process is becoming indistinct and tending to merge; blogs and Wikis provide both learning process and content.
T. Ryberg, Buus, & Georgsen, 2011	Differences in Understandings of Networked Learning Theory – Connectivity or Collaboration?	Connectivism, interactional interdependencies,	Personal Learning Environment (PLE)	The authors propose that Networked Learning' means 'communities', 'negotiation of meaning', 'dialogues' 'groups', 'social practice' and 'collaboration'.
Heilesen, 2015	Supporting Project Work with Information Technology	Collaboratory design	Provided tools: BSCW, Mahara, Sharepoint, Moodle. Extra tools: Mendeley, Dropbox, Google Drive, Facebook group, Instagram	Tools are adopted to support archiving and sharing information, communication and documenting. Basic activities are support by provided tools; others by free-subscribed tools.
Guerra, 2015	Use of ICT tools to manage project work in PBL environment	Qualitative	Facebook, Skype, live-chat, joint calendar, Moodle forum, AAU e-mail, Trello, KanBan, WeekPlan, Grantt Project, Excel, Google calendar, Dropbox,	Free-subscribed tools introduced by the institution are used by the students; they also open for new tools when there is demand; the purposes of adoption including for group communication and collaboration management, for

			Google drive, SVN, Google docs, LaTex, Word, Popplet, PiratePad, Zotero, RefWorks, Aalborg University Bibliotheca (AUB) database	knowledge management, for documentation and report management, and for reference and resource management.
Thomsen, Sørensen, & Ryberg, 2016	Where have all the students gone? They are all on Facebook Now	A mix of quantitative and qualitative	Facebook, Google Docs, Dropbox, Skype, Google Drive, Word Reference management, Refworks, Zotero	Facebook is common use for communication and discussion in group. Google Docs is common used for planning and structuring. Students mostly get influence of selecting tools by their friends, then it's their teachers or supervisor then their family is the less. Their prior knowledge dominates their tool selection. Complex, institution-introduced tools are not adopted. The most motivation of using technology is easy processing and easy communication respectively.

Table2-7 Works which discuss ICT as virtual learning environments

2.6.4 ICT AS A PLACE FOR LEARNING

Papers dealing with ICT as a place for learning are listed in Table 2-8. All authors on this theme suggest that ICT enables students' learning by providing them with locations independent of physical space. From these papers, the author has identified writings on communication tools to support projects and summarised them in the table. Students need to be able to balance their personal space and social networks with commitment and transparency; communication tools must facilitate shared experiences and be flexible and extendable to meet changing requirements. ICT allows students to be less dependent on time and place; furthermore, such learning is retained; experiences are stored and retrieved.

Authors and year	Title	Theories	Tools	Arguments
S. S. Jensen & Heilesen, 2005	Time, Place, and Identity in Project Work on the Net	List of theories	BSCW	– Collaboration and social interaction continuously oscillate between abstract and the meaningful frames of reference of time and place. Such oscillations condition the creation of a double identity of writer and author modes in social interaction. – Collaborative work creates such an ever-increasing complexity of interwoven texts that we have to develop strategies for their organisation, for example the negotiation of roles amongst the participants.
T. Ryberg, 2008	Privacy, power, place and identity – the construction of mixed spaces in an educational context	Participant observation, Web 2.0, identity, place, privacy, power and mixed spaces	ELGG	Social networking tools for projects
Håkon Tolsby, 2009	Virtual Environment for Project Based Collaborative Learning	Place making	iGroup	– The requirement for tools to support collaboration – Two kinds of coordination are required: coordination of CKC and of project activities – Keys to success in group learning enabled by ICT: Balancing interdependency and commitment Transparent coordination Flexible and Extendable infrastructures Creating shared experiences

Table2-8 Works which discuss ICT as a learning place in POPBL

2.6.5 TOOLS IN PROJECT WORK

In this section, the author tries to distinguish terminologies of tools applied in project work. Tools in project work can be classified by different categories, e.g. by their application, design, functions and platforms; however, this study focuses on both the adoption processes and applications.

1. Personal tools

In this study, personal tool refers to information technology that is adopted at the individual level to manage personal information which meets an individual's requirements to perform a specialised task. This also includes maintaining contact with their individual's community, e.g. family, friends. They usually have to have some entertainment value to remain popular. They are mostly free-subscribed tools. Samples of tools in this category are Facebook, Skype, Instagram, Email and Google Calendar.

2. Educational tools

Educational tools or Educational technology have been defined by different authors; however, the current and most cited one is defined by the committee of the Association for Educational Communications and Technology:

"Educational technology is the study and ethical practice of facilitating learning and improving performance by creating, using, and managing appropriate technological processes and resources." (Robinson, Molenda, & Rezabek, 2008, p. 15).

As we can see, the definition relies on the practice of the adoption of a tool to facilitate or improving learning; therefore, any tool used by students in their learning, specifically project work for this paper, is called an educational tool; they may be either institution-provided and free-subscribed; examples are Moodle, Mahara, Google Drive, Zotero, Mendeley and Microsoft Word which incorporates reference management.

3. Professional tools

Professional tools are designed for a particular task or set of tasks which relate to a profession. This study focuses on projects; projects are an approach to learning through research (Andersen & Kjeldsen, 2015b, p. 14); therefore, a tool which is designed especially to support project work or research including group forming, planning, research, experimenting, documenting, reporting and examination is classed as a professional tool in this dissertation. This kind of tool is usually a task-oriented and does not incorporate entertainment functions. They mostly require multiple processes to achieve a goal; therefore, they are complex. Users require more time to install and learn them but they can reap benefits in the longer term and they are sustainable; examples of these tools are: Mendeley, Zotero and Refworks for reference management.

From the three definitions, tools in project work tend to be identified as either personal or professional; however, if they are adopted into their project work, they are classified as educational tools.

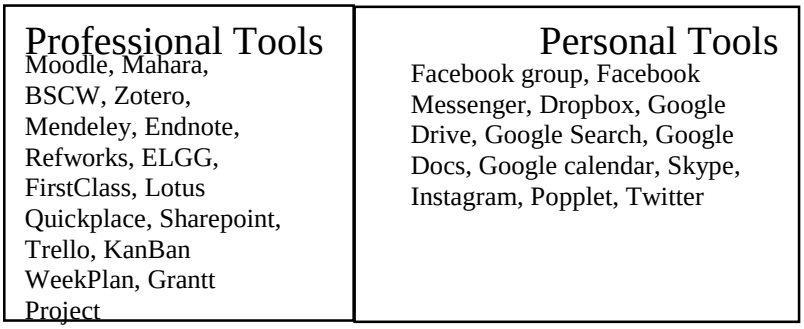

Figure 2-5 Tools appear on literature divided into personal and professional tools

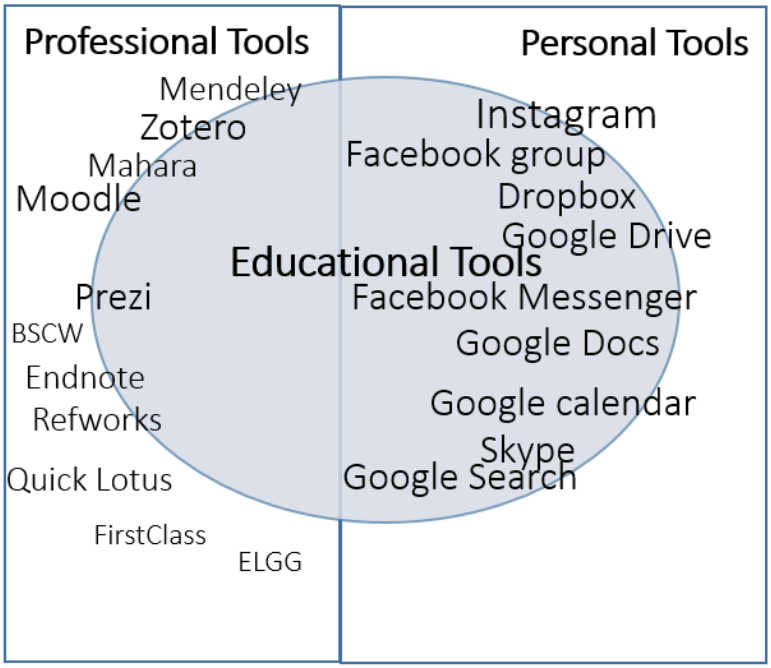

Figure 2-6 Personal and professional tools mapped into educational tools based on students' adoption from data derived from literature

Derived from his literature search, the author proposes a graphical display representing levels of adoption of each tool discussed. Figure 2-6 illustrates the current knowledge of the levels at which tools are adopted for project work. The circle

of educational tools covers both professional and personal tools. The positions of named tools indicate the extent their adoption in project work; those inside the circle are highly likely to be adopted and those outside hardly likely; possible adoption of those which overlap the circle is somewhere in between.

The display shows clearly the higher levels of adoption of personal tools over professional. Institutions have stopped supporting some tools, for example BSCW, Quick Lotus, ELGG and FirstClass; some which are supported are not much adopted by students, for example, Mahara and Moodle. If students do subscribe to professional tools, they are most likely to be self-subscribed rather than provided by their institutions; examples are Mendeley, Zotero and Prezi.

2.7 SUMMARY FROM LITERATURE ON HOW COMMUNICATION TOOLS ARE ADOPTED IN POPBL

In POPBL, most learning takes place in projects rather than in the classroom; it has been demonstrated that it achieves higher levels of learning due to its greater complexity and authenticity. Information and Communication Technology (ICT) involves the application of electronic tools; choosing the right tool for the task and the ability to use it correctly are important and this is what this dissertation seeks to study: ICT in the context of projects. From the literature, the major points concerning the application of ICT to POPBL are:

- Project tools have critical characteristics: they are transparent between group members, invoke social awareness, are selected jointly by members and provide an overview of the progress of their project.
- Members negotiate and renegotiate their roles and ICT protocols.
- Members must coordinate time and location for communication.
- Although ICT can be applied independently at each level – macro (policy), meso (management) and micro (individual) – each affects the others.

Students adopt tools into their project work for different purposes and at different stage of project life cycle or phases. Students can be influenced by the advice of their institution or teachers; however, they prefer to rely on their friends and prior knowledge; ease-of-use is their overriding concern. This is a serious limitation to their adoption of some professional tools; they are complex but are designed and for specific purposes.

This research focuses on the application and practice of ICT at the micro level by examining how POPBL students support their learning with ICT. The objective is to identify the factors in the application of ICT which are advantageous or detrimental to the success of a project. How data was collected and analysed will be discussed in the next chapter.

CHAPTER 3
METHODOLOGY AND RESEARCH DESIGN

How to answer the research questions is discussed in this chapter; the research attempts to understand the behaviour of students when internet tools for communication are adopted into POPBL. This chapter describes how data was collected and analysed.

3.1 RESEARCH DESIGN

Punch (2009, p.112) suggests that research design produces guidelines which will enable researchers to seek answers to research questions; he elaborates by describing research design as a basic plan for a piece of research which includes a) strategy; b) a conceptual framework; c) who and what will be studied; d) the tools and procedures to be used for collecting and analysing data (Punch, 2009, p. 113). Research design establishes empirically the direction and scope of the research enabling data to be interpreted to answer the research questions. Many variables influence research design including the parameters and context of the research questions, context and the researchers' propensities (Creswell, 2012). This research is mixed method; it combines qualitative and quantitative data; it is empirical (Punch, 2009, p. 357). Mixing qualitative and quantitative methods in different ways produces different models.

3.1.1 THE MIXED-METHODS MODEL

The Mixed-Methods model (Tashakkori & Teddlie, 2003) combines qualitative and quantitative approaches for both data collection and data analysis, in a way that complements strengths and/or eliminates weaknesses of both approaches (Punch, 2009) (R. B. Johnson & Onwuegbuzie, 2004).

The aim of the research is to understand students' behaviour in adopting tools to support their project work. To get deep understanding of human behaviour, a survey may not be the best method; instead, observation on focus groups can enable researchers to understand how students adopt tools. The main approach of this study is observation inspired by ethnography in terms of natural settings, holism (i.e. behaviour in context), and descriptive rather than prescriptive approaches (Blomberg, Giacomi, Mosher, & Swenton-Wall, 1993, p. 125). This study draws on the characteristics of ethnography to observe students' behavior in respect ICT adoption in project settings; therefore, this research is primarily qualitative. To test his

methodology, the author conducted pilot studies consisting of a survey, narratives from students' personal and project-related blog posts on technology; and an exercise in observation on one group, called Group A in this study.

A survey was conducted at the beginning of this research to obtain a general understanding of how students adopt online communication tools; the survey was launched by sending emails to three thousand randomly chosen students from all faculties at Aalborg University inviting them to participate in an online survey on their adoption tools and physical working locations; subsequently, students in one class were asked to write blog posts on how they used online communication technology to support their learning. The results of the two approaches were analysed. Observation of two project groups, A and B, was conducted to obtain a deep understanding based on quantitative results. Group A was composed solely of Danes who were new to the POPBL; Group B was composed of Danes in their seventh semester who were experienced in POPBL and one Bulgarian who was not. The two groups were observed and the author was allowed access to their virtual environments which will be analysed in a later chapter.

3.1.2 THE OBSERVATION PROCESS

The major concern in studying human behaviour is the accuracy of the reports; if inaccurate, is it intentional or unintentional (Mariampolski, 1999); participants may describe themselves inaccurately, intentionally or otherwise (Fellman, 1999). Observation is a research instrument originating from Ethnography. First-hand observation in a natural setting is a valuable source of data (Blomberg et al., 1993). Non-participant observation is a strategy of ethnographic research methodology used to find the reality of relationships; much more of out-of-sight and unnoticed behaviour will usually be revealed by it than by other methods such as interviews or surveys. Non-participant observation prevents the researcher from influencing the participants; thus, it can be observed how participants really behave (Blomberg et al., 1993). There are other was to investigate how students use technology to support their collaborative learning but it can be a challenge to employ them; technology permits communication and learning independently of time and location. Sampling methods can include surveys, interviews, observation, and blog and video posts; there are advantages and disadvantages to each of these methods; one method or a combination can be employed to meet the requirements of the research. This study will investigate how students select and adopt internet tools to perform collaborative tasks as part of their projects and to identify the factors that influence their learning. For this study, interaction between students, both face-to-face, and through internet technology, was investigated; students were both observed and gave feedback on their face-to-face and online communication; dialogue, language, artefacts and emotions were all examined to understand how students adopt communication tools to conduct their projects.

3.1.2.1 Observation of face-to-face group interaction to understand technology-enhanced learning

Face-to-face dialogue is the natural form of communication; it is known as 'richer communication' because it is the most productive; social interaction through gesture, facial expression, body language and voice enable deep understanding and appreciation of others' points of view to achieve consensus. Face-to-face communication does not exclude communication technology; it often complements it, for example by the use of computers for keeping records, giving presentations or allowing immediate access to information. Students' face-to-face communication as part of a project can be observed to help understand their use of technology. What technology do they use? How do they use it? How does it support learning? How do they adopt it into their project? How does their communication differ when no technology is adopted?

3.1.2.2 Tracing online interaction to understand technology-enhanced learning

Online tools are used both for virtual communication and to enhance face-to-face communication. One difference between the two modes of communication is persistence; virtual interaction is usually stored and can be traced, e.g. through online forums, web boards, and conference systems and evidence of learning can be identified; conversely, much face-to-face communication, such as body language and facial expression, is seldom recorded. Even though face-to-face interaction gives richer communication, which is critical for group learning, students may choose to adopt internet tools for some activities; some tasks can be performed physically but online tools allow students to optimize their time, share records and improve quality. Several collaborative online tools are available on free subscription; group members can concurrently access online services for work or discussion; free online services include social networking, file synchronisation, co-documentation, and collaborative drafting and design. Group members use online tools to undertake their projects; accessing these services can demonstrate how members collaborated.

3.1.2.3 How group-forum interaction reflects group learning

Even though on-campus students can easily interact face to face, online collaborative tools may be more efficient for learning. An online forum is one source for studying interaction within a group; some groups use a forum as their main channel of communication. Threads can be followed to understand how online technology influences learning, how ideas are discussed and adopted or abandoned, how social interaction between members takes place, how they participate and how difficulties are handled. To understand their learning behaviour, Tolsby, Nyvang, & Dirckinck-Holmfeld analysed how students in one group interacted using their conference system (Hansen et al., 1999).

3.2 CHOOSING THE RESEARCH SETTING

To answer the research questions, quantitative and qualitative methods were selected and combined to understand how students adopt technology to enhance and support their POPBL. This author established relationships with two groups of students; one group was used for a pilot study and the other was the prime subject of the study; he observed them socially and virtually but did not participate.

This author had no experience of POPBL beyond a single seminar and, therefore, had to begin by understanding what POPBL is. Aalborg University employs POPBL in all its science and most of its humanities curricula; preparation for projects, for both teachers and students, is incorporated into curricula. Two groups of students were approached and agreed to be observed. One group – let it be Group A – consisted of five second-semester students, two male and three female, of Humanistic Informatics in the Faculty of Humanities; they were inexperienced in POPBL. The other – let it be Group B – consisted of five seventh-semester students just starting their Master's degrees, all male, in Information Science, also in the Faculty of Humanities; they were well experienced in POPBL. Group A was observed to gain experience and test methodology and make changes as required. Group B was the main focus of the research. The major difficulty with Group A was that they spoke Danish exclusively, a problem for a research student from Thailand; for this reason, one criterion in selecting Group B was the inclusion of a foreign student, thus forcing all members to speak English; he was Bulgarian.

3.3 DATA COLLECTION

In accordance with the research design, two types of data were collected.

3.3.1 QUANTITATIVE 1: SURVEY ON COLLABORATION AND TOOLS

A survey was designed with cooperation with another PhD student who worked for 'E-læringssamarbejdet ved Aalborg University (ELSA) – an IT support institution of Aalborg University. The aim of the survey is to understand communication tool adoption by students in the university across different campuses different faculties.
The questions comprised five sections:

i. Information about the participant and his or her studies (6 multiple-choice questions)
ii. Use of mobile-communication technology both personally and for the project (4 multiple-choice questions)
iii. Experience of collaboration in problem-oriented projects (5 multiple-choice questions)
iv. Online communication tools, both self-subscribed and institution-provided, that the participant has considered using, tried out, has used, or is using

(checklist of 40 currently available online communication tools and 3 questions requiring written answers)

Section 5 is based on Rogers' five stages of Diffusion of Innovation Theory (E. M. Rogers, 1995). In their earlier research, this author and his two colleagues (see Publication I & II at the end of this dissertation) (Rongbutsri, Khalid Saifuddin, & Ryberg, 2011a; Rongbutsri, Khalid Saifuddin, et al., 2011b) devised nine responses for each of forty currently available online communication tools including self-subscribed and institution-provided:

(1) I don't know about it.
(2) I know about it BUT I'm not interested
(3) I know about it AND I plan to try it someday
(4) I have tried it BUT I don't need it
(5) I have tried it AND I might use it later
(6) I am using it BUT I shall stop soon
(7) I am using it AND I shall continue using it
(8) I have stopped using it
(9) I stopped using it but I may use it later

The nine responses are based on Rogers' five stages of diffusion of innovation (E. M. Rogers, 1995):
-Innovators
-Early adopters
-Early Majority
-Late Majority
-Laggards
NB: Diffusion of Innovation Theory(E. M. Rogers, 1995) *is employed within only this survey which was in cooperation with another PhD student.*

The responses give an insight into the extent to which students engage with technology in their problem-oriented projects. Names of tools were collected from different sources such as informal interviews with students and the researchers' observation. After testing and making some adjustments, the survey was launched by sending invitation emails containing a link to the online survey to about 3,000 randomly chosen students from all faculties at Aalborg University; the Director of Study Administration gave his permission and support. The survey questions are in Appendix II.

Data source	Artefacts for analysis	Purposes
Survey on collaboration and tools	– Statistical data – Qualitative answers	– To identify tools used for online collaboration – To identify physical locations for collaboration – Adoption of online tools into project

Table3-1 Data collected from the survey questionnaire of the pilot study

3.3.2 QUALITATIVE 1: STUDENTS' BLOG POST ON TOOLS IN LEARNING AND PROJECTS

At the end of their first semester in 2010/2011 students of Humanistic Informatics in the Faculty of Humanities were asked to reflect on how they use online communication technology to support their learning. The question, translated from Danish, was
"What technologies have you encountered and which ones do you actually use in relation to courses, project work and socially? What is the role and importance of technology in relation to your studies, student life, learning and socialisation?" Analysing blog posts can provide an overview of the benefits of the various technologies that have been made available and the ones actually used, such as Moodle, Mahara, Dropbox, Facebook, Google Services and Wikipedia.

Students were required to write individual blog posts on Mahara, an e-portfolio system provided by the University. Students had been introduced to several online tools with potential to support their projects; the tools were on a list compiled in 2010 by Brian Møller of Aalborg University. Students were asked for permission for their blog posts to be read and analysed for this research; all identification was first removed so that they could be treated anonymously. All posts were in Danish; they were translated into English by Google Translator and the English edited by Danish speakers. The posts revealed internet tools, attitudes towards using the tools and the extent of their integration.

Data source	Artefacts for analysis	Data obtained
Blog post assignment	Single short stories from 133 second-semester students on the online communication technology that they used socially and in their studies and projects.	– To identify tools used for online collaboration and their functions – How online tools were adopted into their projects – Attitudes towards using self-subscribed and institution-provided tools

Table3-2 Data collected from the blog posts

3.3.3 QUALITATIVE 2: OBSERVATION OF GROUP A

During the second semester of 2010 (February – May 2011), this author and his supervisor followed a group of students during their second semester in the Humanistic Informatics program. They were beginners in POPBL. The group comprised three female and two male students, all Danish. The students gave their permission to be observed and interviewed and they allowed access to their discussions on Facebook and shared documents on Dropbox, their main channels of online communication. Initially, the researchers followed the group as they began their project activities; this proved to be impractical for this researcher because the group always conversed in Danish, never in English. A change of strategy was required; students were interviewed in English before and after meetings, enabling understanding of how the project was progressing; general questions emerged regarding communities, roles and tools. The online communication data was in Danish, translated into English by a Danish native speaker.

Data sources	Artefacts for analysis	Purposes
Observation and interviews	– Observation notes – Interview notes – Voice records – Photographs and videos of some interaction	– To identify online communication tools and understand how the students utilised them – To understand how online communication tools contribute to the project – To identify and understand interaction and its roles and rules using online communication tools and how it compares with face-to-face interaction
Facebook discussion	– Online dialogue – Shared files (photographs and documents)	– To understand interaction between members – To understand how members rely on online communication tools
Dropbox group folder	– Shared files – Folders	– To understand the progression of the project – To understand how the project report is structured

Table3-3 Collected data of the observation of Group A

3.3.4 QUALITATIVE 3: OBSERVATION OF GROUP B

To understand the adoption of online collaborative tools in problem-oriented projects, a group of first-semester Master's degree students in the Informatics Science program was observed and interviewed from October to December 2012. In the group of five males, the four Danes were experienced in POPBL but the Bulgarian was not. The group's attitude towards ICT was most amenable and they adopted a variety of online communication tools effectively for different purposes making them ideal subjects for this research. To conduct the observation of groups A and B, the author had obtained their permission and all signed contracts which can be seen in Appendix I.

Data sources	Artefacts for analysis	Purposes
1. Observation	– Observation notes – Voice recordings of group meetings – Photographs and video recordings of some group interaction	– To identify online communication tools and understand how the students utilised them – To understand how online communication tools contributed to the project – To identify and understand interaction and its roles and rules using online communication tools and how it compares with face-to-face interaction

2. Facebook discussions	– Online dialogues – Shared files	– To understand interaction between members using an online asynchronous discussion tool	– To understand how members depend on online communication tools
3. Skype conferences during the writing process	– Discussions – Shared files	– To understand interaction between members using an online synchronous discussion tool	
4. Zotero group folder (reference-and-citation-management tool)	– Folders – References and citations	– To understand how references and citations are managed collaboratively – To understand how content on different tools is synchronised	
5. Dropbox group folder	– Shared files – Folders	– To understand the progression of the project – To understand how the project report is structured	
6. Group Google calendar	– Group notification – Appointments	– To understand how they notified their individual schedules to the group	
7. Interviews	– Interview notes – Voice recordings	– To confirm findings from other sources	

Table3-4 Data collected from Group B

3.4 ACTIVITY THEORY

Activity Theory is widely applied to investigate the behaviour of online learners; the concept, as discussed here, has potential for this research. Vygotsky developed Activity Theory in 1920; Marx was his inspiration in trying to understand how mediated tools affect behaviour.

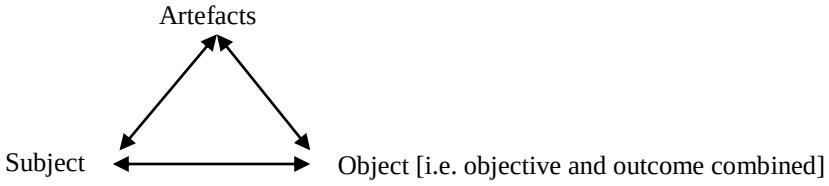

Figure 3-1 S-A-O, tool-mediated activity theory

Vygotsky uses *object* to incorporate the meanings of both *objective* and *outcome* which are differentiated in this research. (See figure 3-3)

Engeström's **'Expansive Learning'** (Engeström, 1987) is a development of Activity Theory. To Vygotsky's Tool-Mediated Activity Theory he added Community and, separately, two of its components, Rules and Division of Labour. He differentiates *object* and *outcome* (to be defined in the section 3.4.1), the latter being derived from the former.

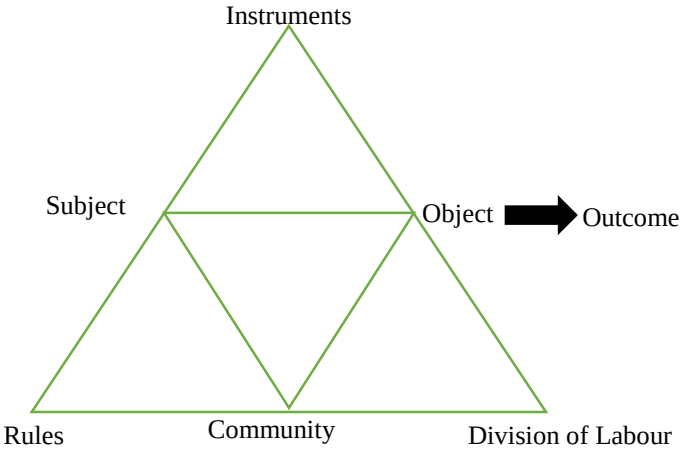

Figure 3-2 Extended activity system by Engeström Engeström, 1987

Names	Description	Dimension
Lev Semyonovich Vygotsky 1920 (Engeström, 1987)	A simple structure to explain the relationship between Subjects using tools (Artefacts) to achieve an Objective	Tool-mediated
Alexei Nikolaevich Leont'ev 1930 (Wertsch, 1981)	Building directly on Vygotsky to develop a cultural historical psychology through consideration of the implications of mediation, he proposed motives, goals and operations combined in a unit of activity. Leont'ev distinguished between activity, action and operation to establish the overall structure to place any human practice within activity, the everyday behaviour directed towards concrete goals (actions) and the underlying operations that are the conditions for performing actions and engaging in an activity.	Psychology
Yrjö Engeström 1987 (Engeström, 1987)	Engeström differs from Vygotsky and Leont'ev in being less interested in psychology and more in 'Developmental Work' by which he means "aiming to improve 'actual working practices'" of the subject or actor.	'Developmental Work'
Kari Kuuti 1996 (Kuutti, 1996)	Kuuti advanced Activity Theory relating to Human/Computer Interaction which he defines "a philosophical and cross-disciplinary framework for studying different forms of human practice as development processes, with both individual and social levels interlinked".	Human/Computer Interaction

Table3-5 A Chronology of Activity Theory

Leontiev (1978) who extended the work of Vygotsky, mentions that an activity is understood as a purposeful interaction of the subject with the world, a process in which mutual transformations between the poles of 'subject–object' are accomplished. Properties of 'subject' and 'object' exist only in the activity. Activity is a key for development of both 'subject' and 'object'. The participation of individuals as subject in the activity may cause changes in themselves and the object. An activity can be understood only if the analysis considers subject and object as one unit. An activity involves interaction of subject, object, motivation, action, goals, socio-historical

context and the consequences of the activity; it is a unit of life that reflects human thinking to attain objects; it is not a reaction but systemic structural processing, internal transformation, conversation and development; however, not all activities can attain their objects; some may collapse (Yamagata-Lynch, 2010, p. 21).

The same tool can be employed by the same user in different ways because of cultural influences, his communities, situations and rules; therefore, to understand how humans use a tool we cannot only consider the users and the tools but the communities in which the user and tool exist. Activity Theory (AT) provides a deep and wide range of factors which researchers should be aware of to be able to understand complex tool-adoption behaviour. AT leads researchers to understand the unity of awareness and activity. AT is concerned with awareness of the result of an individual interacting with others (community) by using tools (artefacts) in their real context and usual practice.

Four aspects of AT are relevant to tool adoption processes: *human intentionality*, *asymmetry of people and things*, *human development*, and *the idea of culture and society as shaping human activity* (Kaptelinin & Nardi, 2006, p. 10).

AT provides separate units of analysis for users (subjects) and tools (artefacts), which are the asymmetry of people and things. By separating the two units, the design and application of tools can differ. It is important to theorise intention, imagination and reflection because they are core elements of human cognitive processes. A tool is designed and used in a context according to the intentions and desire of the user who is counted as the subject in the world (everything which is not the subject). The world and the subject interact via the mediation of the tool.

Any development in AT is perceived as a sociocultural process – the individual develops by being influenced by society and surrounding culture; however, it does not mean that an individual will inherit behaviour and practices from his or her society or culture. Individuals transfer culture into their activities by using the natural dialogical processes of internalisation and externalisation. AT balances both the individual and sociocultural aspects of the individual. Individuals are important because their perceptions and how they learn to adopt tools can restructure their culture and society as they develop and share their practice.

The reasons we need AT to understand tool adoption processes are (Kaptelinin & Nardi, 2006, p. 10):

1. AT is a tool to enable researchers to understand the relationships between individuals, tools and communities in order to acheive the objective.
2. AT focuses on three dimensions: intentionality, asymmetry and development. Asymmetry helps researchers differentiate tools from users. The intention of the design is a characteristic of the tool. The intention of application describes how the ways in which the user uses the tool differs from the intention of design; AT enables researchers to explain how development and improvements of a tool take place and create new

understanding of the activity. By identifying tension or contradictions in an activity, researchers can understand how all elements of an activity develop holistically including tool applications.

3. AT is concerned with long-term outcomes which enable researchers to examine the evolution of an activity, specifically, in this research, of tools and their applications.

Activities can be classified into levels. In Activity Theory, an activity is the interaction between subject and object as mentioned:

"According to this meaning, activity refers to a specific level of subject–object interaction, the level at which the object has the status of a motive. A motive is an object that meets a certain need of the subject." (Kaptelinin & Nardi, 2006, p. 59)

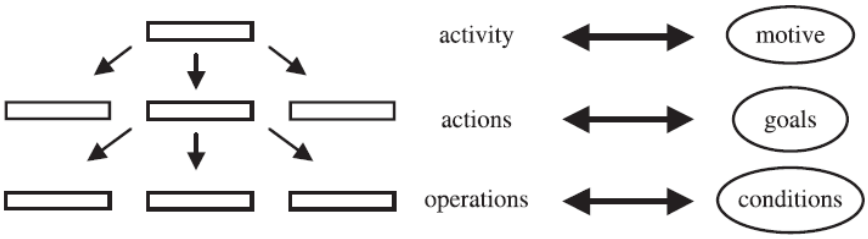

Figure 3-3 Hierarchical structure of an activity (Leontiev, 1978)

To link motivation and action, AT provides a conceptual framework on three levels: activities, actions, and operations; based on the hierarchical structure of activity (Leontiev, 1978), an activity is the top level which is composed of different actions while an action is the middle level and is composed of different operations. Each activity is composed of steps which may not associate directly with the motive; these steps are actions described by AT terminologies. Goals are the ultimate direction of the object; the subject is always aware of goals but may not immediately be aware of motives; to develop awareness of motives requires effort as smentioned by Leontiev. (NB Leotiev's terms 'conscious' and 'conciousness' are replaced in this paper by 'aware' and 'awareness' because although 'conscious' can mean 'aware', it also has other meanings; 'aware' is synonymous with 'conscious' in the meaning required here and will not be confused with other meanings.)

"… motives are revealed to consciousness only objectively by means of analysis of activity and its dynamics. Subjectively, they appear only in their oblique expression, in the form of experiencing wishes, desires, or striving toward a goal" (Leontiev, 1978).

Therefore, to achieve the goal, motives have to be set. Motives can be constructed from individuals' experience or through their analysis. When combined with results from different goals, motives can achieve the object of the activity. An operation is

it is smaller than an action, a routine or autonomous process which is driven by conditions. Operations are routine processes that help complete the action according to conditions. Some operations require attention; others may be performed automatically, unthinkingly and repetitively and become habitual. Habitual operations save time; however, if they fail, attention is required to redesign them.

According to Activity Theory, there is a need or needs behind every activity, either direct or indirect. A need is an objective requirement of an organism to change something in its environment. Needs create excitement and drive individuals to search for objects to satisfy them.

When a subject feels discomfort, a need is created; the subject searches for an object to fulfil it; this is called an 'unobjectified need'. When a subject discovers an object in response to the need, the need and the object link up; this is called an 'objectified need'. When an unobjectified need transforms into objectified need, an activity emerges; the object drives and motivates the activity (Leontiev, 1978). Social aspects and culture play important roles in transforming unobjectified needs into objectified needs because they can be transformed into knowledge and transferred to society through interaction.

Activity Theory has been used widely to explain how communities influence activity especially in education. Sharples, Taylor, & Vavoula (Sharples, Taylor, & Vavoula, 2005) discuss how Activity Theory describes virtual communities; they stress 'the essential role of mobility and communication in the process of learning' and the need to rethink learning in the 'mobile age', i.e. 'using computers and smartphones'. They talk about 'mobile learning' by which they mean 'learning using technology which is accessible anywhere and at any time.' They state:

> "In the tradition of Activity Theory we analyse learning as a cultural-historical activity system, mediated by tools that both constrain and support the learners in their goals of transforming their knowledge and skills. We separate two perspectives, or layers, of tool-mediated activity. The semiotic layer describes learning as a semiotic system in which the learner's object-oriented actions are mediated by cultural tools and signs. The technological layer represents learning as an engagement with technology, in which tools such as computers and mobile phones function as interactive agents in the process of coming to know."

Sharples', Taylor's & Vavoula's variation of Activity Theory provides a framework to examine the relationships between students, communities and mobile tools; it is, therefore, suited to understanding how POPBL students adopt ICT to support their learning in the context of group projects.

Activity Theory enables understanding of human activity as a system; according to the theory, activity systems contain six connected elements: subject, object, tools, rules, communities, and division of labour (Engeström, 1987); apart from the six

elements, outcomes are important because they are what subjects have learnt by performing the activities and which alter or have the potential to alter their behaviour when performing future activities. In the context of education, the curriculum and teaching, as measured by formal assessment, are the object; they are what a course (an activity system) seeks to achieve and measure. Students learn beyond what is formally assessed; this is an intended consequence of POPBL projects; they learn to apply what they have learnt; they acquire skills and knowledge and learn how to learn – these are the outcomes; outcomes may not always be positive – perceptions and personality, for example, may impede positive outcomes.

3.5 ANALYTICAL APPROACHES

Survey results are summarised in tables; they illustrate how students adopt tools in POPBL. Blog posts were, in effect, narratives; mentions of tools by each student were counted. Observations of both groups provided the main data for analysis to answer the research questions; activity systems which are derived from Activity Theory will be applied as the framework for analysis. The forum was the main channel for online communication; it provided information on how tools were adopted in both groups' projects.

3.6 CONCLUSION

This chapter describes the methodology employed to investigate human behaviour in adopting tools to support collaborative activities. To understand the practice and motivation in human behaviours, a survey in isolation is unsatisfactory; therefore, the author proposes the use of observation inspired by Ethnography in conjunction with tracing online interaction from sources such as shared-file storage, online fora and blogs. He proposes Activity Theory as the framework for data analysis; the framework focuses on human activity but does not ignore the social dimension and artefacts which relate to the activity. It provides a holistic approach rather than considering its parts independently; this analytical approach helps researchers to understand the behaviour in its own context.

CHAPTER 4
PILOT STUDIES RESULTS

4.1 INTRODUCTION

As mentioned in Chapter 3 Methodology and Research Design, the research conducted a survey, collecting students' blog posts and observation of Group A as pilot studies. This chapter demonstrates the results from the three studies and presents their findings by summarizing a published paper which the author wrote together with another PhD student by using the results from these pilot studies.

4.2 RESULTS FROM THE SURVEY

In 2011, the author and his colleagues conducted a survey entitled "*Technology Supporting Virtual Project Based Learning*" (see more in Chapter 3 Methodology). The survey was sent via email to around 3,000 students in all faculties and all campuses of Aalborg University but only 250 completed replies were received; however, survey results could be used to initiate the understanding of how students adopt tools for their projects.

4.2.1 ACADEMIC BACKGROUND

Respondents were mainly from the Faculties of Humanities and Engineering and Science in semesters 7 and 8, the first year for Master's degree students at the University. Most of the respondents had had a few semesters of experience in POPBL environments (see Table 4-1 Percentage of respondents by faculty, Table 4-2 Percentage of respondents by semester, Table 4-3 Percentage of respondents by semesters of POPBL experience).

Faculty	Percent
Faculty of Social Sciences	6.2%
Faculty of Humanities	56.2%
Faculty of Engineering and Science	37.5%
Faculty of Medicine	0.0%
Total	100.0%

Table4-1 Percentage of respondents by faculty

Semester	Percent
1-2	6.1%
3-4	6.1%
5-6	12.1%
7-8	66.7%
9-10	9.1%
Total	100.0%

Table4-2 Percentage of respondents by their current semesters

Semester	Percent
1	22.6%
2	58.1%
3	3.2%
4	3.2%
5	6.5%
6	0.0%
7	0.0%
8	6.5%
9	0.0%
10	0.0%
11	0.0%
12	0.0%
Total	100.0%

Table4-3 Percentage of respondents by semesters of expereince of POPBL

4.2.2 STUDENTS' PERCEPTIONS OF POPBL

Questions were formulated to ask students how they perceived POPBL. As one of its core values, (Savery, 2006) suggests that POPBL improves collaboration skills; most students who participated in the survey agreed (see Table 4-4). This shows that, within a year of starting POPBL projects, students already appreciate its value; however, when asked about the contribution of POPBL to the knowledge and skills of their major subjects, students were not convinced. They did not think that they had

achieved higher levels of learning when compared with other educational models (Table 4-5: POPBL contributes to mastering their technical skills). Most students could see the potential of POPBL and thought it better than other learning approaches (Table 4-6 POPBL is better than other learning approaches).

Level	Percent
High	46.7%
Medium	53.3%
Low	0.0%
None	0.0%
Total	100.0%

Table4-4 POPBL contributes to collaboration skills

Level	Percent
High	20.7%
Medium	58.6%
Low	20.7%
None	0.0%
Total	100.0%

Table4-5 POPBL contributes to mastering their technical skills

Level	Percent
Mostly agree	30.0%
Agree	46.7%
Neutral	16.7%
Disagree	6.7%
Strongly disagree	0.0%
Total	100.0%

Table4-6 POPBL is better than other learning approaches.

4.2.3 LOCATIONS FOR COLLABORATION

One factor that drives students to use communication tools is their work location (Golovchinsky, Pickens, & Back, 2009); therefore, the survey asked for locations where collaborative face-to-face working took place and locations where individual tasks (online collaboration) were performed. Individual actions need to be aggregated

for collaborative tasks; communication tools can support this process; likewise, individual tasks also need to be communicated. Results from the survey show that 74% of students often held meetings in a project room and only 10% did not meet in project rooms; sometimes they met in the library; 38% of students met at home for project work whereas 32% never met at home (Tables 4-7, 4-8 and 4-9). Projects of different study programs require different resources; engineering students, for example, may require more sophisticated equipment for their projects than humanities students; meeting in project rooms is more important for engineering students; if only reading resources are required, they can be taken home or accessed via the internet. Locations for face-to-face meetings have internet access and power outlets provided; students can easily access virtual environments.

Frequency	Percent
Almost Always	39.3%
Often	35.7%
Sometimes	10.7%
Seldom	3.6%
Never	10.7%
Total	100.0%

Table4-7 Meeting at project room to do project

Frequency	Percent
Almost Always	7.1%
Often	3.6%
Sometimes	32.1%
Seldom	14.3%
Never	42.9%
Total	100.0%

Table4-8 Meeting at library to do project

Frequency	Percent
Almost Always	10.7%
Often	28.6%
Sometimes	14.3%
Seldom	14.3%
Never	32.1%
Total	100.0%

Table4-9 Meeting at home to do project

4.2.4 LOCATIONS FOR WORKING ALONE

Collaboration is the ethos of POPBL but collaboration is an aggregation of individual tasks. Locations for working alone are essential for POPBL projects; when asked about their locations for working alone on their projects, 27% of students said that they worked alone the project room often or almost always and 34% never; 45% of the respondents work alone at library, whilst 21% said never; 89% said often work alone at home, whilst 4% said never (see Tables 4-10, 4-11 and 4-12).

Frequency	Percent
Almost Always	10.3%
Often	17.2%
Sometimes	17.2%
Seldom	20.7%
Never	34.5%
Total	100.0%

Table4-10 Working on project alone at project room

Frequency	Percent
Almost Always	10.3%
Often	34.5%
Sometimes	20.7%
Seldom	13.8%
Never	20.7%
Total	100.0%

Table4-11 Working on project alone at library

Frequency	Percent
Almost Always	60.7%
Often	28.6%
Sometimes	7.1%
Seldom	0.0%
Never	3.6%
Total	100.0%

Table4-12 Working on project alone at home

4.2.5 USING EMAIL IN POPBL

For this research, the most important part of this research concerns the online tools adopted by students during their projects. Questions concerned common applications of online communication tools: email, file sharing, calendar and document editing and social networking.

Regarding emails, 87% used emails to communicate with members of their group; 87% used emails to communicate with their supervisors. There were no students who did not use emails thus confirming that all student were capable of using basic communication tools; it should be borne in mind that the survey was conducted across all disciplines, not solely IT or science subjects. (Table 4-13) "For Self" in this survey means using emails for private use.

How	Percent
With Group Members	87.1%
For Self	58.1%
With Supervisor	87.1%
In Mobile	22.6%
Never	0.0%

Table4-13 How students use email

4.2.6 USING FILE-HOSTING AND SHARING TOOLS IN POPBL

Documents, photographs and videos accumulate whilst performing a group project; they need to be stored and shared between and accessed easily by all members. A file-hosting and sharing tool is a necessity rather than a luxury. Most students, 73%, used such a tool at least partly (Table 4-14). That 27% of students never use a file-hosting

or sharing tool is a surprise. How do they communicate and cooperate during their projects? Are there differences between IT and other students?

How	Percent
With Group Members	70.0%
For Self (i.e. file hosting)	26.7%
With Supervisor	10.0%
In Mobile	6.7%
Never	26.7%

Table4-14 How students use file-hosting and sharing tools for their projects

4.2.7 USING A SHARED CALENDAR IN POPBL

A shared calendar is, likewise, a necessity; it enables planning, monitoring and coordination between members. Only 17% of respondents used a shared calendar (Table 4-15). How do the other 83% manage and coordinate their projects?

How	Percent
With Group Members	17.2%
For Self	17.2%
With Supervisor	3.4%
In Mobile	0.0%
Never	65.5%

Table4-15 How students use shared calendar application for their projects

4.2.8 USING CO-WRITING TOOLS IN POPBL

Writing is common to all projects; all projects conclude with a report. Writing can be performed individually or jointly; individual contributions can be collated by co-writing; co-writing tools may be used. The survey shows that only 34.5% of students used a co-writing tool for group writing. More than 50% of students had never used a co-writing tool. Writing can be undertaken both individually and jointly. Depending on purposes, students may perform joint writing or co-writing (Calvo, O'Rourke, Jones, Yacef, & Reimann, 2011). Therefore, using a shared writing tool is a good indicator to understand the level of using tool for project collaborative activities. However, the survey reports that only 34.5% of students used online document editor,

while 52% never use it (Table 4-16). This shows students did not use tool in a high level in their profession.

How	Percent
With Group Members	34.5%
For Self	20.7%
With Supervisor	0.0%
In Mobile	6.9%
Never	51.7%

Table4-16 How students use online online co-writing tools for their projects

4.2.9 USING SOCIAL NETWORKS FOR POPBL

Communication is a basic requirement of any learning and especially projects. Instead of using asynchronous and formal tools such e-mail, many adopt their everyday tools such social networks (e.g. Facebook) to keep their members updated (De Villiers, 2010). The survey reports that 87% used social networks for group projects, while 7% said they never used them (see Table 4-17). Their adoption processes and motivation need more investigation.

How	Percent
With Group Members	86.7%
For Self (non-academic)	50.0%
With Supervisor	0.0%
In Mobile	16.7%
Never	6.7%

Table4-17 How students use social network for their projects

In conclusion, the survey shows that professional tools such as file-sharing, shared calendar and co-writing tools are not popular with students conducting projects; they usually adopted social networks and word processing tools to support their projects. The tool adoption processes require further investigation.

4.3 RESULTS FROM THE BLOG POSTS

To confirm the findings from the questionnaire survey, students in their second semester of the Humanistic Informatics program were asked, with the support of the author's supervisor, to reflect on their tool-supported learning; they kept a blog post for this purpose; some of the students had contributed to the survey. All 133 blog posts were collected and collaborative tools identified; the number of students using each tool was recorded (see Table 4-18).

Collaborative tools used in projects	**Percent of numbers of students who adopted the tool**
Dropbox	100.00%
Facebook	100.00%
Shared Calendar	58.64%
Skype	40.60%
Zotero	7.52%

Table4-18 Percentages of students who had adopetd tools identified in their blog posts.

All students had been introduced, in their first semester, to professional communication tools with potential usefulness for their projects; however, adopted tools were decided within their groups without interfering from others including institutions and supervisors. Table 4-18 reveals that few adopted the professional tools to which they had been introduced, such as Zotero, preferring instead familiar tools such as Facebook and Dropbox. It had been expected that students would adopt professional tools such as Mahara and e-Portfolio for their projects. Mahara, for example, had been provided by the University and students had been asked to use it. Many students, in their blogs, did report on their reasons for rejecting Mahara. The following comments on blog posts about Mahara were in Danish and translated into English by Google Translator; all posts were in Danish; they were translated into English by Google Translator and the English edited by Danish speakers; generally the meanings are obvious but occasionally confusing.

> "When it came time for P1 [First semester project in semester one, year one], we quickly agreed to Mahara was dead and that we would rather use something user friendly and convergent [meaning unclear]. We therefore took the Dropbox in use." (No.7 Male)

Students stuck with their familiar tools on the grounds of user friendliness; Mahara was perceived as not being user friendly.

> "Mahara is a bit complicated to figure out, so it's not something we have been using in my group. I often have uploaded my duties in the wrong forum. They [There] are many different places, which confuses me. I know there are a lot of [a lot of students with] the same problem as me, so a little improvement to Mahara would perhaps be that the page's structure is slightly easier to navigate in. In return, we have instead used Dropbox partly recalls [similar features to] Mahara. In addition to being student-

related websites, trying both sides to make it more personal for the user." (No.10 Female)

This is another example of a professional tool being rejected because of the complexity of its navigation; even though the University tried to improve it, students used an alternative tool which is more personal than professional.

> "I personally believe that the reason there was someone who like the idea of Mahara was a little strange was because it was so clearly a "copy" of Facebook idea, and Facebook had more users and was easier to navigate, personally I do not think that Mahara was hard to use, but it is limited in how much they bother to create a community inside of a site when you could just go Facebook, but as a way to deliver tasks were Mahara unique and positive for me anyway." (No.19 Male)

In this case, it is not so much about user friendliness for this student personally as the time needed to learn the new tool when they already have a tool, Facebook, which will do the job; spending time on Mahara is unnecessary.

In conclusion, professional tools such as Zotero and Mahara were rejected or deferred whilst Dropbox (a file-sharing tool) and Facebook were quickly re-adopted. The tool-adoption process, its reasoning and outcomes need further investigation; observational data will be analyzed in the following section.

4.4 THE SUMMARY OF PRELIMINARY RESEARCH

From the pilot study the author had learnt that the main barrier to understand Group A observation is the language. Therefore, for choosing the next group requiring English speaking group. From the survey, narratives of blog posts and observation of Group A, we can see the patterns of tools adoption of students in POPBL that they are using more personal tools in their projects rather that professional and instruction-provided once. Moodle was adopted as student-teacher communication, students get in only when it is required. They do not choose it for their project work; thus, functions for students on Moodle are limited than teachers, however, Moodle students are still has values for group work. Likewise, Mahara was installed and introduced to students but students perceived it as an alternative of Facebook a common social media among students. They blamed about its complicated interface and only used it when they were asked to. Unlike Facebook, Dropbox, Skype, What's app, they are adopted extensively. Thus, some of these tools come from their personal use before introducing to project.

The findings from pilot studies were used to associate with the main study. Language was the main barrier for the author to understand Group A; therefore, the latter group was a group with English as mediating language. Tools and the practice of tools found in the pilot studies let the author be more focus during observation.

CHAPTER 5
PRESENTING THE ACTIVITY SYSTEMS OF GROUPS A AND B: AN OVERVIEW OF THEIR PROJECTS

In this chapter, observational data is interpreted through the concept of activity systems derived from Activity Theory as discussed in Chapter 3; it presents an overview of the projects of Groups A and B. The data will be used for analysis in chapter 7.

5.1 INTRODUCTION

Human activity may be explained by Activity Theory. Activity systems are described in Chapter 3, Section3.5; an activity system is composed of interacting components: subject, object, instruments or tools, communities, rules and division of labour (Engeström, 1987); the components as a whole create the outcome. This chapter presents an overview of two POPBL projects with specific reference to the employment of communication tools in all components, not only subject and tools. Figure 5-1 represents Engeström's activity system as a triangle which is employed to analyse data obtained from each group. The projects of Groups A and B are independent activity systems; each system was mapped from the observational data into the triangles. The following section explains each component of Group A's and Group B's projects

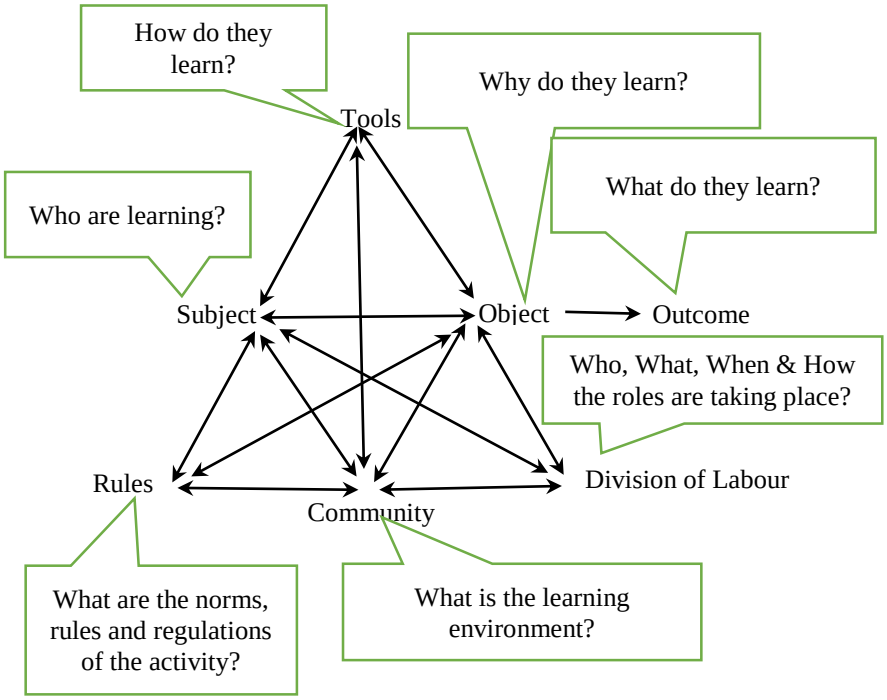

Figure 5-1 Activity System by Engeström with questions proposed by (Hong, Chen, & Hwang, 2013)

5.2 AN OVERVIEW OF THE ACTIVITY SYSTEM OF GROUP A'S PROJECT

Group A was in their second semester in Human Centred Informatics program. Here is description of each component of their Activity System.

5.2.1 SUBJECTS

All subjects were Danish including three females who commuted by train from their home city, a 45-minute journey to their campus in Aalborg. The other two were male and lived in Aalborg. All chose to live at home with their parents; they all went straight from school to Aalborg University. They were all in their second semester on the Human Centred Informatics Program at Aalborg when they were observed; they were working on their third project, known as P2; projects at Aalborg are described in Chapter 2. All of them were born around 1990; the internet had started to penetrate Scandinavia in the middle 80s (Nordhagen, 2003); students in Group A grew up in the digital age.

Group A usually worked together on campus and sometimes at home; they divided themselves into two divisions because the female members lived in another city; it

was easier for them to meet at each other's homes; the male members also met in their homes; the two divisions sometimes held conferences jointly on Skype.

Figure 5-2 Members of Group A

Characteristics	**Group A**				
	Karen	Grace	Pam	Peter	Viking
Gender	Female			Male	
Nationality	Danish				
Academic origin	Starting BA Human Informatics				
Age	Young and of similar age; were born around 1990				
Residence and distance from campus	Resident in another city: 45 minutes by train			Near campus but different locations	
Married/Single	Single				
Work experience related to field of study	None				
Part-time job during studies	None				

Table5-1 The diversity of members of Group A

5.2.2 OBJECT

The group's aim was to produce a good report under the set theme of "Interpersonal Communication"; they interviewed the manager of a business to gather empirical data. They planned and accomplished tasks together. They employed interview techniques introduced by their teachers; they transcribed speech from video recordings and

subsequently coded the text. Writing their report was the main task of their project; they started the writing during the Problem Formulation phase; they wrote independently and collaborated for the final version. The report's cover was designed by one member with input from the others. They submitted their report on time and achieved good evaluation.

5.2.3 TOOLS

Group A had no fixed venue for meetings; they were able to reserve a room when required on a schedule – sheet outside the room; otherwise, they could meet in public spaces in the University where they risked being disturbed. The only tools provided in public spaces were black- and white boards and chalk, but not marker pens. Booked rooms had to be vacated after meetings and they were unable to leave anything behind for future use. They regularly used pen, pencil and paper to express their ideas visually. They communicated with each other and wrote their report in Danish. Each member owned a laptop and some had smartphones; meetings were photographed and shared on Dropbox. They employed interview techniques which they had been taught in a class of "25 questions". Their report was written using Microsoft Word; they chose to use free-subscription tools including Facebook Group, Dropbox, Skype and Google docs.

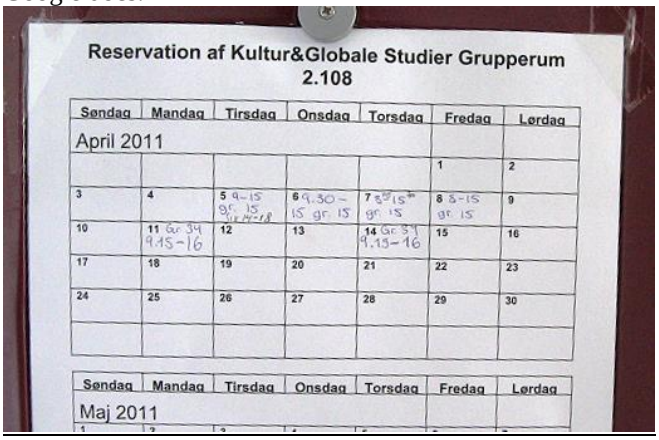

Figure 5-3 Schedule paper for room booking

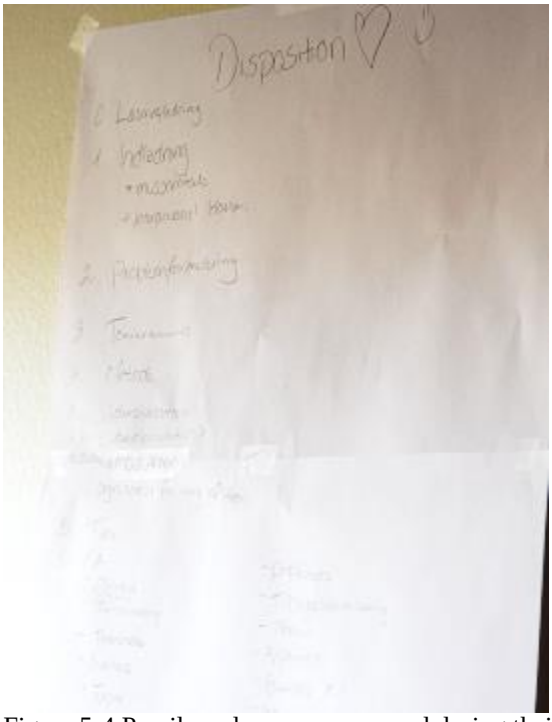

Figure 5-4 Percils and papers were used during their planning

Zotero was considered whilst selecting tools and the group agreed not to employ it for their current project and postpone its use until their next one. They found the tool was complicated and requiring more time to learn and set up. They complained of lack of time to learn how to use the new tool. They wanted to devote their time directly to their project.

5.2.4 COMMUNITY

They were supported by the University through their supervisor; they made appointments with him by email; they did not share their working locations and facilities with him. They employed library facilities and services, especially during Problem Formulation; likewise, library staff assisted them. They maintained contact with the lecturer who had taught them interview techniques; in particular, they sought his advice before interviewing and analysing data. Parents were also able to help with, for example, transport or contacting the subject of their interviews. Normally, group members would have sole access to their online environments such as Facebook closed group, Skype conference or shared calendar; exceptionally, in this case, this researcher also had access for this research, but not their supervisor or teachers.

5.2.5 RULES

The group established its own rules to ensure that each member would contribute fully; text files were to be shared on Dropbox in a file called "Generelle retningslinjer for P2.docx" which means "Guidelines for P2". Some examples of the rules are

"Regler:
- Man møder op når vi har en aftale
- Man overholder deadlines
- Prøv at lav en litteraturliste fra start af
- Lav fodnoter nede i bunden af siden
- Sige vores mening → konstruktiv feedback "

translated by this author as:

"Rules:
- If we agree to meet, all members will attend.
- Deadlines must be maintained.
- The bibliography should be continuously updated.
- Notes will be inserted at the bottom of the page.
- Constructive feedback should be provided. "

They followed the rules strictly. Apart from the formal rules, behavioural norms developed informally.

5.2.6 DIVISION OF LABOUR

The group agreed that each member would perform an administrative role which was recorded in the project folder: note taker, meeting scheduler, IT specialist, secretary and final-decision maker. Reading and writing were divided into topics which they allocated amongst themselves. Peter was formally appointed by the group as their IT specialist; he sought, investigated and evaluated new tools, introduced them to the group and made final decisions regarding their adoption and application. Although passive in tool adoption, the other members were active in employing the technology; for example, even though some members dominated the Facebook group, all participated. As note taker, Pam was in charge; she entered minutes into the Dropbox shared folder and announced on Facebook group that they were available. Members retained the same roles throughout the project; there was no rotation.

5.2.7 OUTCOME

They completed all tasks and submitted their report online and achieved good evaluation; their report demonstrated their achievement in terms of concepts and skills promoted by the curriculum.

5.2.8 SUMMARY

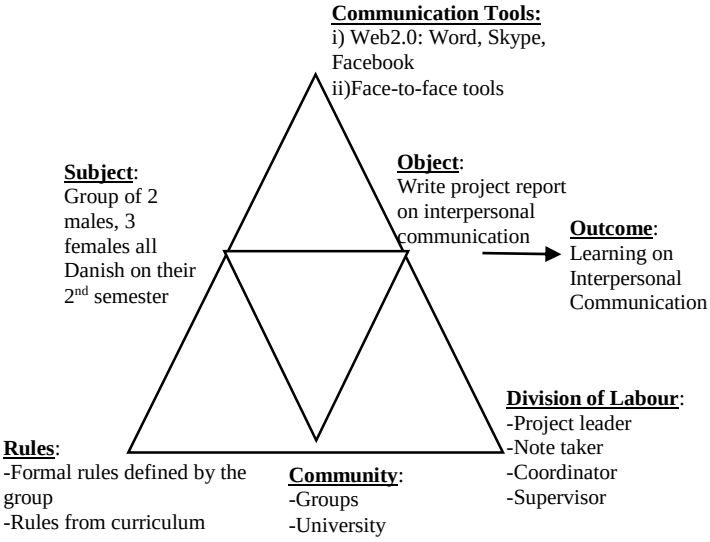

Figure 5-5 Overview of the activity system of Group A's project

An overview of the activity system of Group A's project is illustrated in Figure 5-5. It should be noted that Group A were all Danish and Danish was their working language for the project; language, therefore, was a barrier for this researcher when observing the group; data for interpretation was obtained primarily from interviews after their meetings; this limited the scope for understanding motives, visions and values of group members.

5.3 AN OVERVIEW OF THE ACTIVITY SYSTEM OF GROUP B'S PROJECT

During the autumn semester of 2012, the author observed a Master's degree project group. Four of the five members were in their seventh semester continuing seamlessly from their Bachelor's degree in the same program. Because there was one foreign student in the group, English was their main language. The Danish members were experienced in learning through POPBL which influenced their actions.


Figure 5-6 Group B in their project room

5.3.1 SUBJECTS

Group B consisted of five male students in their seventh semester of the Human Centred Informatics program. One was from Bulgaria with a background in Computer Science; the others were Danish. Names of group members are not published in this research; individuals are identified by nicknames to maintain their privacy. All members were born around 1990 and were familiar with digital and internet technology.
Goodie, Spider, Postie and Scholar were continuing their studies on the same program at Aalborg University. Goodie and Spider had worked together on their project during the previous semester; likewise, Postie and Scholar had also worked together on a project during the previous semester. Mac was new to POPBL; it was his first semester at Aalborg University. Mac was welcomed by the group. All members lived near the campus which was in the city and they usually met there. They worked well together and there were no cliques. All members had part-time jobs; Scholar and Spider worked in fields directly related to their studies, the latter in technological education and the former was employed by the university to manage the online content of a local laboratory (e-learning lab). The employment of the other members was unrelated to their studies; Postie was a part-time postman, Mac a burger seller and Goodie worked in a second-hand charity shop. All members were single, this helped them to be able to put all effort on their study.

Characteristics	Group B				
	Spider	Goodie	Scholar	Postie	Mac
Gender	Male				
Nationality	Danish				Bulgarian
Academic origin	BA Humanistic Informatics				BSc Computer Science
Age	Young and of similar age, were born around 1990				
Residence and distance from campus	Near campus but different locations				
Married/Single	Single				
Work experience related to field of study	None	Has worked previously	None		
Part-time job during studies	Webmaster	Charity-shop volunteer	IT consultant in a local school	Postman	Burger King seller

Table5-2 The diversity of members of Group B

5.3.2 OBJECT

The students' primary objective was to develop a good project report for their assessment; this is, however, only the end product. The objective of the project was to design a mobile application to support teaching and learning activities in Mathematics for primary-school children. The project was suggested by one of their lecturers who introduced them to an e-learning development company which was interested in developing this type of application. The e-learning development company provided support and a contact, effectively a co-supervisor, and gave them a real-life situation. The group needed their own original ideas to design the whole system, not just for the children who were the end users and teachers, but involving others such as parents. They chose a local school for a case study to understand how Mathematics was taught and learnt interactively to enable them to design the mobile application. They interviewed teachers and conducted workshops with teachers at the school to gain insights and visions as to how their application could be integrated into teaching.

They each transcribed portions of their video recordings of the interviews and workshops; Mac, however, was unable to participate because of being unable to speak Danish. They subsequently translated the transcribed text into English thus enabling Mac to participate fully in the coding; they all sat together with a projector to classify insights and visions; discussion was integral to coding and they identified themes.

They discussed the text jointly and settled between them on parts of the report to write individually. They submitted the report on time and got the maximum possible score for their evaluation.

5.3.3 TOOLS

Group B adopted several tools for collaboration. Physical-technical tools included furniture, black- and whiteboards, rooms, projectors, laptop computers and mobile phones. Psychological tools (coined by Vygotsky) (Kozulin, 2003) included the English language; they applied Activity Theory to data analysis, Technological Pedagogical Content Knowledge and User-Driven Innovation concepts to application design. Soft-technical tools included Microsoft Word for writing, Microsoft Excel for simple calculations and Adobe InDesign to design the report cover. The group chose not to use the online collaborative tools provided by the University: Mahara for the electronic portfolio system, Moodle for Content Management and IBM Lotus QuickPlace for groupware; instead, they chose to use free-subscribed tools including Facebook, Dropbox, Google, Google Calendar, Google Docs, Zotero and Skype. A Facebook closed-group was created by Scholar following the formation of the group which had preceded the formal group-forming session. The closed-group was used mainly to keep members informed of the others' progress whilst they were working independently and to raise matters requiring discussion. They met regularly in their project room; it was their primary mode of communication; the closed-group was secondary.

Together with the Facebook closed-group, a Dropbox shared folder was created to share files among the members; shared Google Calendar was created during planning; this researcher was given access to these environments but did not otherwise participate. The stakeholder, from the e-learning company participated in the closed-group on request; they tagged posts for him to comment on. Contact with the stakeholder was initially via email but subsequently through the closed-group; additionally; deep discussion with him was conducted on Skype conference. The group selected Zotero as their reference management tool; Goodie rejected it outright; he wanted to continue to use a tool with which he was familiar, Microsoft Word Reference, even though the task had, therefore, to be carried out manually. Despite agreeing to use Zotero, the group allowed Goodie to choose for himself. All members collected project reference items including Goodie; they could have benefitted considerably from automated reference management but instead they all, except Spider, abandoned Zotero individually as the project progressed without consulting their colleagues.

To understand what collaborative tools Group B used in their project, the author provides the list bellowed with their application of group B.

5.3.3.1 Facebook

Facebook enables the creation of three kinds of group: public, closed and secret. The title, member's names and content of a public group are available to everyone on Facebook or via a search engine; the title and members' names of a closed group are available on Facebook or via a search engine but not content; no information about a secret group is available via search engines, only on Facebook to group members. Group B set up a closed Facebook group consisting of their members, their supervisor, the stakeholder and this researcher. Group B members communicated with each other not only to develop the project but also socially; their supervisor and the stakeholder were notified on Facebook when they were mentioned and they could respond; this researcher had access to all their Facebook group posts but only observed them. In this research, the closed Facebook group will be referred to as 'the Online Forum'. Documents in progress, text messages, photographs, videos and links were posted. Data was extracted from the Forum to show how members of Group B cooperated and collaborated.

5.3.3.2 Skype

Skype is an online communication tool which provides a service for live voice, live video, messaging and sending files. Communication is between two or more people. It is often used for conferences. Group B held conferences on Skype; the stakeholder sometimes participated. At weekends particularly, if they needed to keep in touch, they used Skype. It was also especially useful for communicating with the stakeholder because he was unable to attend any meetings in person. Skype enabled difficulties and disputes to be resolved promptly. Dedicated conference software would have provided some advantages but it is expensive.

5.3.3.3 Dropbox

Dropbox is a file-hosting tool through which files can be shared and synchronised. It provides applications for client computers and mobile devices. Users can upload files and download them from the servers; files stored on Dropbox servers can be updated by manually uploading them; however a client application can be used to upload and download updated files automatically; the client application synchronises the server and all client files so that they are identical. Every member of Group B installed the Dropbox client application on their devices; they called their shared folder 'P7'; shared documents included files for writing, workshops, planning and resources such as reference articles.

5.3.3.4 Google Calendar

Google Calendar is a free online application for time management; it can be used individually or communally and is, therefore, suitable for collaborating on a project. Group B created a shared calendar on Google Calendar named *'Project 7. Semester'*. The calendar was marked with milestone; it was used to give notice of project events such as deadlines or meetings; social events, such as birthday parties, could also be viewed; it was helpful for all members to know when one member would not be available due to private business such as a dental appointment.

5.3.3.5 Prezi

Prezi is an online shareware application for presentations. It is similar to Microsoft PowerPoint but has the advantage that all group members can contribute simultaneously. The group also used Prezi's slide-transition feature which gives the impression of moving around one giant slide and zooming in on elements of content thus creating the illusion of smooth flow and integration.

5.3.3.6 Zotero

Zotero is an online shareware application; it is a digital library tool for managing references. The user's interface with Zotero is Mozilla Firefox. Zotero stores artefacts along with its tagged metadata: author, title, date, publisher, place of publication, etc. Zotero and Dropbox work well in combination because they serve different functions and support each other; the former is for storage; the latter for reference management in a word processor. They both have a sharing feature; the group was able to create shared space in both tools; therefore, there was no conflict when editing text and references even when group members were working independently. Group B adopted Zotero and Word thus facilitating the insertion of references, quotations, diagrams, graphs, photographs, etc.; they were able to choose their own format for references and how to list them. Group B committed themselves to Zotero during Phase 3 – Planning to manage references and their bibliography. Goodie announced at the start of the project that he would not use Zotero; he already had experience of the same functions in Word which he preferred.

5.3.4 COMMUNITY

Group B interact with the institution from their supervisor, who could be called for meeting when they needed him. They usually showed their plan, achievement and writing to the supervisor. The students were in their seventh semester so they did not require much support from the institution. They understood the expectations and the evaluation criteria; however, they relied more on support from a professional, the stakeholder. The stakeholder was assigned as their contact by the e-learning

development company to provide critical feedback, watch progress and ensure that the completed project will be of value to the company. The group never met the stakeholder in person; he was participating in an international project for the entire semester; contact was via email, Facebook and Skype. The group benefitted from contact with classmates and friends; for example, Goodie was introduced to a book on activity theory, some ideas from which he incorporated into his own writing. They worked on their campus in the city centre during problem formulation; they acknowledged that they could easily find relevant books and that the librarians were helpful; the University's main library is located on the Aalborg East campus, ten minutes by bus from city centre; following problem formulation, they used only their departmental library, adjacent to their project room, on their own campus where they were able to request any books that they required; they did not return to the main library; the departmental library was staffed by a librarian who supported them.

5.3.5 RULES

The seventh semester in the Danish system is the first semester for Master's degree students. It is during the seventh semester, from October to January, that they conduct their project, in groups, culminating in their report; projects must comply with the theme *ICT Design and Development*. The report was assessed (called 'examination' in Denmark) by their supervisor and another lecturer and the group also gives a presentation; grades are awarded on a scale of up to 12. In Group B, communication between members was informal; nothing was concealed or private and individuals' decisions were respected even if they went against what had been agreed upon by the group. They did not establish any formal rule; instead, they accomplished tasks together. The four local members knew each other; they chose to work together; they demonstrated self-discipline. Basic rules were followed without formality including being on time when meeting, being responsible for their individual tasks, acknowledging when personal issues emerged, and dealing with deadlines. All of the group members were responsible for themselves without formal rules.

5.3.6 DIVISION OF LABOUR

Group B worked differently from Group A. They did not allocate roles at the beginning of the project; demarcation emerged informally as and when required; they volunteered willingly and planned jointly. They did not maintain any formal roles but worked together closely; tasks were divided when needed to be more productive, e.g. to manage practical issues during the field trips to the school, and whilst transcribing and translating the resultant video, and for writing.

5.3.7 OUTCOME

The group gained the maximum score for their project. The quality of the report revealed their understanding of their learning including curriculum-requirement concepts and fundamental skills and the additional knowledge and skills acquired in

order to be able to conduct the project. They profited from good collaboration and effective employment of support tools; the employment of a professional tool, Zotero, could have could have relieved them of routine clerical work and the time thereby gained applied to the main purpose of the project.

5.3.8 SUMMARY

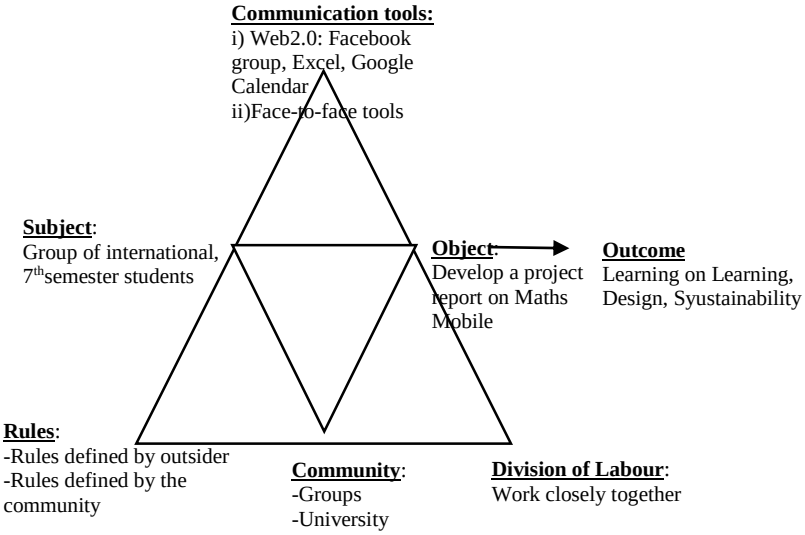

Figure 5-7 The overview of activity system of Group B project work

The summary of the overview of Group B's project work activity system is displayed in Figure 5-7.

5.4 SUMMARY

Activity Systems of Groups A and B are presented in this chapter. Group A were POPBL virgins whilst Group B were experienced. They belong to the generation who were born with digital technology and the internet. Some researchers claim that the emergence and dominance of digital technology leads young people of the digital generation to having a different outlook on life and different learning practices from previous generations (Prensky 2001.)

The activity systems reveal that students utilise a variety tools to serve their purposes and be able to write a good project report; they conduct research and construct knowledge with support from several communities. The two groups followed different strategies to complete their projects. Group A, POPBL beginners, set up and maintained a formal organisational structure governed by rules; in contrast, Group B,

experienced POPBL practitioners, had no formal organisation and no specific roles. In respect of their evaluations Group B's performance was better than Group A's.

In order to understand how students employ technology in their project, we need to need to better understand the 'object' of activity in that project. The following chapter examines the projects of the two groups in detail.

CHAPTER 6
ACTIVITY SYSTEMS OF PROJECT PHASES

6.1 INTRODUCTION

This section examines the behaviour of project groups regarding communication-tool adoption. Projects are divided into phases; the phases are analysed as activity systems. Group A and Group B are the subjects under consideration and the events described derive from the author's observation of the groups, each group's Facebook group discussions and shared Google calendar.

Group A were Bachelor's degree students on the Human-Centred Informatics program at Aalborg University. Observation was conducted during the second semester (February to May) of 2010; their examination followed in June. Only data relating to tool adoption was extracted from the observation; because the group communicated in Danish, the collected data was harvested from interviews following their meetings.

Group B were Master's degree students on the Human-Centred Informatics program at Aalborg University. Observation was conducted during the autumn semester (October to December) of 2012; their examination followed in late January 2013.

Phases, as they are applied in this research, are listed below; how tools supported each activity in each phase is the concern of this research. The phases are Model IV from Section 2.4.3 Project Phases:

1. Group formation
2. Problem formulation
3. Planning
4. Data gathering
5. Analysis
6. Solving the problem
7. Reporting
8. Preparation for examination

Only data from Group B is mapped into Model VI's phases; language problems prevented the same process from being applied to Group A but their phases were similar. The phase classifications of Model VI derive from the author's observations of the two groups. The behaviour of each group with regard to communication tools is analysed for this research. The phases of the two groups are discussed in the following section.

6.2 MOTIVATION OF PARTICIPATION IN PROJECT WORKS OF GROUPS A AND B

The two groups were in the second and seventh semesters of the Human-Centred Informatics (HCI) program; according to their curriculum, they are required to perform a project in a group setting to practice their qualitative approach on the theme of interpersonal communication. Individuals may have different motivations but to meet the requirements of the curriculum is the common to all of them. Apart from the extrinsic motivation, the topics they chose were based on their personal and group interests; they formed their own groups, chose their own topics, theories and methodology; these demonstrate their intrinsic motivation. Group A was interested in managerial communication; they chose to investigate how a manager interacts with his team in a company. Group B chose to design a learning application for iPad. They chose to work with a group of local school teachers to investigate their teaching and how it could be integrated with technology. POPBL project topics are based on society, curriculum and personal interests to ensure curiosity, commitment and motivation among members (Andersen & Heilesen, 2015, p. 24; A. Kolmos et al., 2004, p. 77).

6.3 PHASE 1: GROUP FORMATION

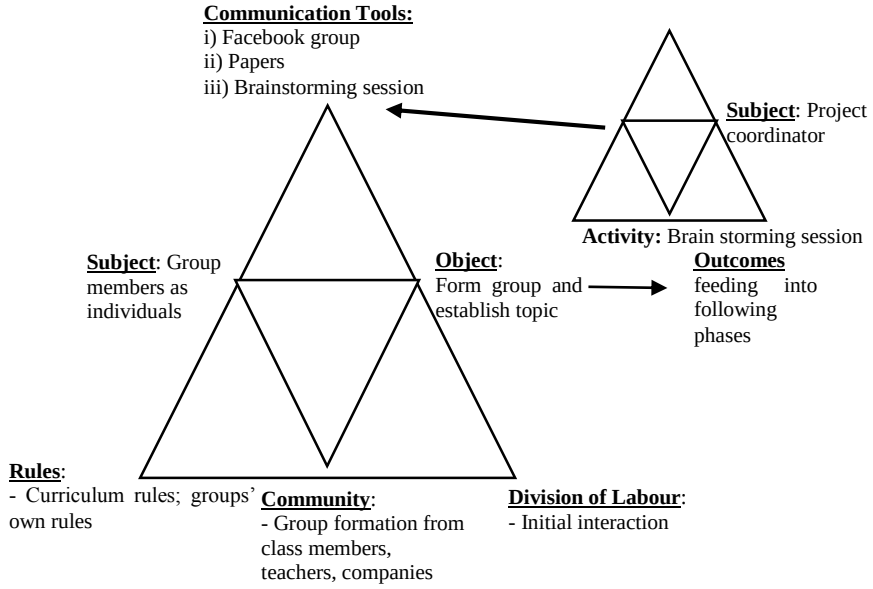

Figure 6-1 The activity system of project phase 1: Group Formation

Group formation and topic selection are the sequential objects of Phase1; they normally take place at a "brainstorming" session organised by a lecturer who acts as

the project coordinator. The brainstorming session is a formal meeting for all students in the same study batch program; interaction takes place between classmates and the project coordinator. The session starts by introducing themes and possible topics to students; then students discuss the themes to form common topics; the project coordinator lists topics on the board to give visualization to all students; at the end, all students must form themselves into groups with a topic for their project; only then, are students allowed to leave the session. Themes are a requirement of the curriculum; they are laid down by the study board; they provide a wide scope for students but always within the range of the specified competencies. The author perceives Phase 1 as being an interaction of two activities as shown in Figure 6; Phase 1 is the students' mediation and brainstorming session with the project coordinator; the brainstorming session may be considered to be a tool for group formation. Students participate in the brainstorming session by discussion to establish common interests and to notify the project coordinator of their groups and chosen topics.

Group A had their brainstorming session in a large auditorium which was one of their classrooms; all students of their batch and program were present along with the project coordinator. Group A's members had known each other, discussed group formation and formed themselves into a group of five including three females before the session. Group A chose the topic 'Managerial Communication' under the theme of 'Interpersonal Communication'. Within a week of the group's formation, Peter had, without discussion with other members, created a Facebook closed group and a Dropbox shared folder; he informed members after the event; all the other members later expressed their appreciation by commenting that it was a good idea. At their first meeting, they agreed to rules to ensure that each member would contribute fully; text files were to be shared in a Dropbox file; additionally, during that first week, it was recorded that each member was to undertake an administrative role: note taker, meeting scheduler, IT specialist, secretary and final-decision maker.

Group B were also from the Human Informatics Master's program; there were fewer students in their batch compared with Group A's. Most students were continuing their study in the same program and had known each other on the campus for three years; they were familiar with brainstorming and how to conduct projects; in their batch, there were some students from Bulgaria, France and Greece who were new to both the University and POPBL. Group B had attended classes during the month before the brainstorming session; the new students were able to familiarise themselves with Aalborg University, and fraternise with local students during this time; Group B was formed about a week before the brainstorming session. Tools, including a Facebook closed group and a Dropbox shared folder were set up by Scholar without discussion immediately after the formation of the group; he informed them via Facebook. The brainstorming was a formality for Group B since they had already agreed on group members and decided on a project. One of their lecturers had introduced them to a stakeholder who was interested in developing a mobile application for primary school children; the topic fitted with the theme: "Sustainable, Learning, and Design." In contrast with Group A, Group B did not establish a formal organisation; discipline, likewise, was informal.

During the brainstorming session, students are supposed to ignore personality and friendships; the function of the brainstorming session is to enable group formation on the basis of common interest; in practice, group performance depends heavily on personality, including for example responsibility, work and social skills. The brainstorming session is a formal meeting but it is insufficient to challenge students with larger problems which offer greater learning opportunities; students discuss topics before the brainstorming session in the absence of support and encouragement.

6.4 PHASE 2: PROBLEM FORMULATION

Problem formulation is critical; groups usually establish concepts, substantive domains and methodology before starting to plan their projects. Groups are supposed to study the literature to delimit the scope of the project topic including its concepts, methodology and tangible activities that relate to their project; students should apply the concepts and methodologies that they have learnt. A project is dominated by the disciplines of the curriculum; interdisciplinarity is a fundamental concept of POPBL; students are expected to cross boundaries into other disciplines. During Phase 2, students search literature and are free to consult librarians, teachers and supervisors (their community).

Group B's first meeting was initiated by Scholar; his outlines with a proposed schedule were posted on Facebook group (tool); his post was viewed by all members but only Goodie commented and praised his initiative. At the first meeting, members introduced themselves and revealed their expectations; they followed up with their experiences, from superb to contemptible, of writing reports at Aalborg University particularly to assist Mac who was new to the University; the meeting ended with brainstorming and constructing an outline plan for their problem formulation. Before their second meeting at the main campus library, Spider sent a post to members encouraging them to use Zotero; he urged them to encourage other members to install it on their devices. All saw the post but none reacted. During their first meeting, they had agreed to use Skype as their conference tool if any of them were to be absent from campus; they posted their Skype IDs on Facebook group. The second meeting was proposed by Goodie to discuss what they knew about the topic and what information they required from the stakeholder (professional community) who had proposed the topic to their supervisor. The third meeting was proposed by Postie to discuss methodology, report structure and deadlines. Scholar later announced their stakeholder; he was working on an e-learning development project (another activity) in an e-learning company; he had had the original idea of developing a mobile application in Mathematics for primary school pupils; the group had been introduced to the stakeholder and topic by one of their lecturers (community). The fourth meeting was proposed by Mac who volunteered to construct a draft plan. A work room in the main campus library was the venue for the fifth meeting; it was proposed by Spider to formulate the problem; they were able to search for relevant books which ignited discussion; discussions were open, nothing barred; ideas were illustrated on boards

(physical tools). Members presented several books and online articles (tools) to the others to stimulate discussion; additionally, promising links were posted on their Facebook closed group; Goodie posting his favourite music in the same way elicited no reaction; they wired a computer to the projector in the room; the boards provided by the University in the room were extensively used for visualisation and to record what they agreed on. Group B did not maintain specific roles for its members; therefore, no member was responsible for taking minutes. Taking minutes is a standard procedure for any organisation for recording decisions and dissent but Group B did not take it seriously; thus, there was a mismatch between a standard requirement and task allocation which is interpreted as a tension within division of labour. As an alternative to taking minutes, during discussion on problem formulation, members wrote extensively on boards. Scholar took photographs of the boards on his smartphone and posted then on Facebook group; subsequently, Goodie and Scholar volunteered to compile their problem formulation document on Microsoft Word.

Problem formulation encompassed the following activities:

- Establishing the theoretical framework
- Building a virtual environment by adopting, adapting or creating online tools
- Contacting and negotiating with their stakeholder
- Exploring, designing and selecting methodologies
- Establishing the substantive characteristics of the project and the practicalities of how to conduct it
- Searching for and contacting a school for class observation and teacher workshop and interview

Completion of phase 2 indicates that the group was ready to commence field work.

Group A put less time and effort into problem formulation than Group B. They followed suggestions from their teachers and supervisor (communities); they consulted recommended books and papers. Report writing commenced during problem formulation.

Comparing to Group B, Group A spent less effort on their problem formulation. They more relied on suggestions from their teachers and supervisor (communities). Books and papers (physical tools) suggested by teacher from a course were utilized during this phase. However, the group paid their attention to plan their interview more than spending time for problem formulation.

Problem formulation is critical to the success of the project; it sets the parameters including concepts, methodology and substantive domain. Group B expended much time and effort on this phase considering motives, goals and conditions before they started planning; they made extensive use of the library in their literature search of both established knowledge from books and recent knowledge available online and in academic papers. Group A's approach to problem formulation was different; they expended less time and effort on problem formulation than Group B and they combined it with planning; they concentrated on practice (goals and conditions) at the expense of motives. Group A's problem was less complex than B's and they were

able to anticipate how the project would develop; therefore, they concentrated on planning and conducting their investigation (actions and operations). Their problem formulation was conducted with established knowledge and guidance from their teachers. Their approach was academic as opposed to professional. As with Group B, Group A's report writing commenced during problem formulation.

Both groups constructed environments for their projects during problem formulation. Both groups were unadventurous in selecting communication tools; they fell back on the same tools which they had employed in previous projects; they were aware of their communication requirements would be. Both groups set up communication tools during this phase to meet their requirements. Communication tools served different purposes including asynchronous communication (forum), synchronous communication (conference), file sharing, shared calendar, reference management, and writing.

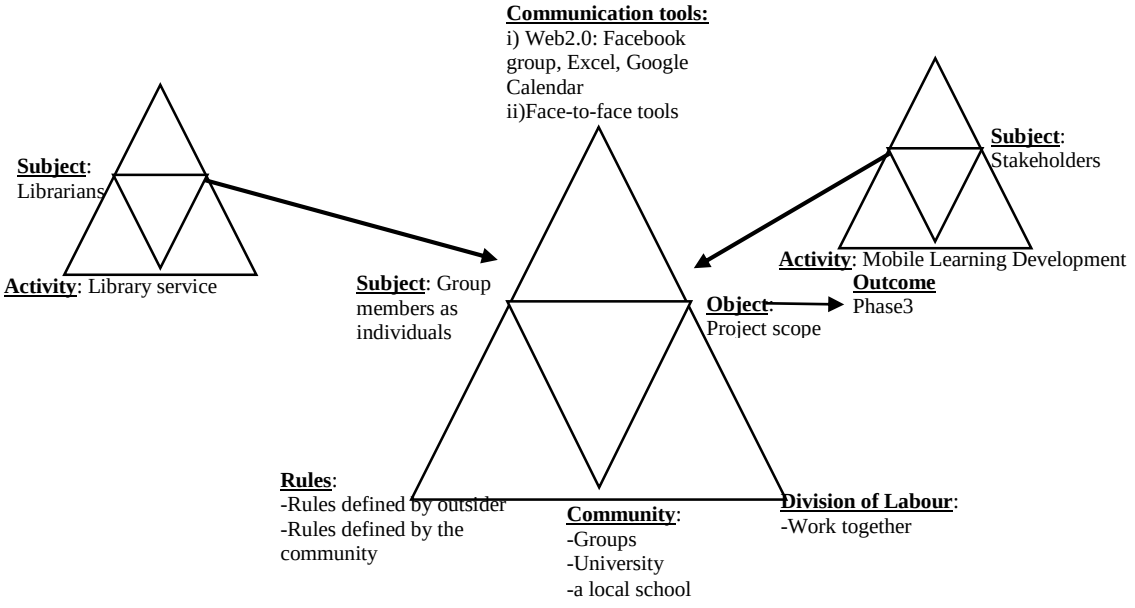

Figure 6-2 The activity system of project phase 2: Problem Formulation

6.5 PHASE 3: PLANNING

During this phase, Group B formulated a plan for conducting their project. They started searching for a school at which to conduct a workshop. They were assigned a supervisor (community). They initially contacted their stakeholder by email; he introduced himself via the group's Facebook group; he told them about his current project in another country and other projects in his schedule; he showed that he was happy to participate and appreciated being part of their group. The group agreed with him that they would use Skype when they needed to hold intensive discussions with him. They sought a local school to participate in the project; they firstly tried the school where Scholar worked as a part-time IT consultant; unfortunately, the school would not cooperate. They even asked their stakeholder if he could help them in their search. Their search was interrupted by a mini-project, a component of their course, in which they all participated and which lasted for two weeks (interference from another activity); after several meetings, they found a willing school twenty kilometres from their campus. They planned interviews with teachers and pupils and a design workshop with teachers through the medium of a card game. Also during this phase, they drew up a tentative schedule in a Microsoft Excel file which was shared on Facebook group; they also printed it and displayed it on the wall of their project room. Spider later transferred the schedule to Smartdraw, a shareware diagram tool; it was shared with the stakeholder who liked it and asked about the software. During this phase, Group B produced an outline for their report; Goodie suggested to Spider that a section of the report from their previous project on which they had worked together might be of value to the current project. Due to their Skype meetings with the stakeholder, Mac introduced Skype recorder for record keeping: he posted:

"Nice skype recording software that integrates with Dropbox and is free for limited time. Tested it and works like a charm"

Group B shared the development of their project on a Dropbox file with their stakeholder but he did not reply via this medium; Skype meetings were held the following day when Spider asked him to comment; thus the stakeholder was able tom provide feedback; the stakeholder edited documents on Facebook group.

Posting of relevant books by members was a continuous process. A link to the stakeholder was set up to provide information about the project; only Goodie liked the link.

Mac provided the group with simple descriptions (the chosen project development approach) on Facebook of how the project was developing; only the stakeholder responded; he shared a mobile design from one of his own projects.

Scholar provided basic information about integration of technology in their chosen primary school; members liked his post.

They asked their fellow students (a use of a local community) to participate in a trial of their workshop before conducting it at the school; their supervisor was invited to comment.

In contrast to Group B, Group A's planning followed suggestions made by their teacher (relying of scaffolding). Group A's interviewee worked in another city; he was the father of one of their classmates (community); they put much effort into the interview for which, as a guideline, they used a technique known as "25 questions" which had been developed by a famous local professor. Writing up problem formulation and the literature review commenced during this phase, initially primarily by the female members (division of labour); complementarily, references were collected in a Microsoft Word file and stored in Dropbox. Phase 2: Problem Formulation and Phase 3: Planning were concurrent. During Phase 3: Planning the schedule was agreed and members were appointed to specific roles; this data was stored in their shared folder in Dropbox. Planning is preparation for the practicalities of exploration, investigation, field work or experiment. Group A, as a group, followed the protocols for demarcation, milestones and deadlines (object of this phase); their organisational strategy was formal and conventional as opposed to Group B's whose organisation was primarily extemporaneous (division of labour). Group A worked systematically whereas Group B's organisational manner was often impromptu.

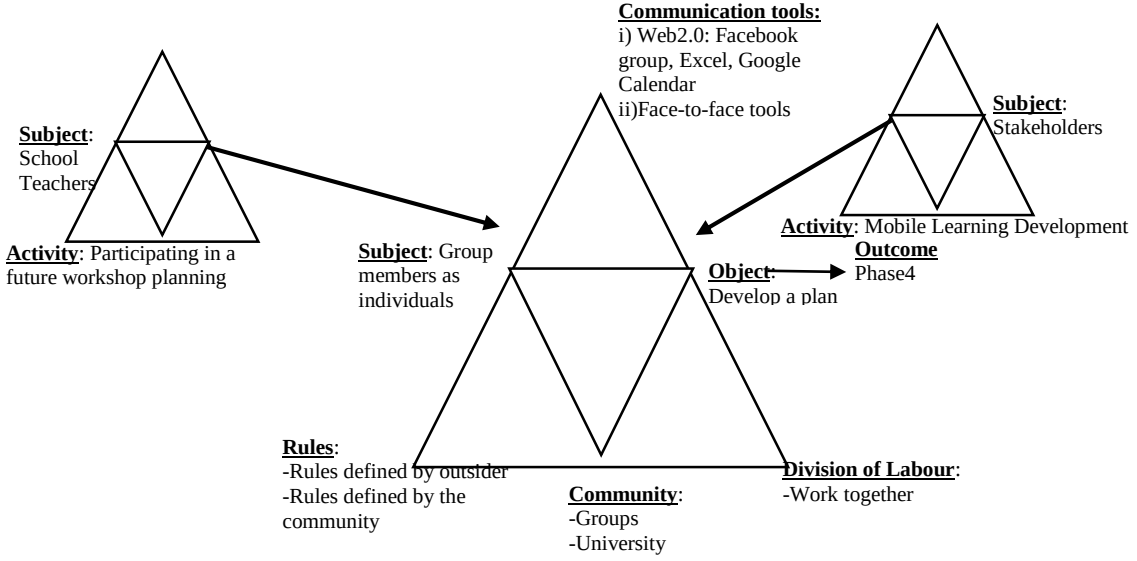

Figure 6-3 The activity system of project phase3: Planning

6.6 PHASE 4: DATA GATHERING

During this phase, group B were preparing for a presentation for another course; Postie introduced Prezi[2] for that presentation but it was not adopted at that time for their current project. They continued to compile links to literature but otherwise made limited use of communication tools. They conducted interviews and held a design workshop with the school teachers, and interviewed their pupils which was the object of this phase. They took some notes manually but records were usually video clips and photographs which Scholar filed in Dropbox shared folder; the stakeholder was invited to view them and was able to see when they had utilised his suggestions. All fieldwork was conducted in Danish; Mac, who knew no Danish, took on a support role.

Spider restructured the Dropbox shared folder in preparation for the commencement of writing; he made a video on Youtube to demonstrate the new structure (tools); only Mac discussed it with him; subsequently, Spider made a video demonstrating how to use their customised Zotero which he published on Youtube; he later made it available on the group's Facebook group, video on Facebook being unusual at that time; only Goodie replied but by posting his favourite song. Spider also introduced a new Microsoft project management tool, suggesting that they needed it; he described its features in a post as:

"Microsoft has just launched a platform called 'Team Foundation Service' that allows development teams to have a shared space where they can manage their source-code in real time together, as well as their Scrum process and various other things. For now it is free, so I have made an account and will try to invite you guys. Maybe it will be a great tool for us - maybe not" posted by Spider.

Mac thought, judging by the description, that it was too good to be true; Spider later explained that he was just introducing it; no other member gave it a try (the new need could not emerge because they had existing solution and it would be high risk if change the project management approach at this point). Spider later posted a funny photograph of the other members with thought bubbles; Spider asked whether spider had nothing else to do casualness was normal for Group B.)

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[2] Prezi is a cloud-based presentation tool; it is free-subscribed but with limitation of number of presentations; it supports co-development – users can access and work on the same presentation. For more detail see www.prezi.com

Figure 6-4 Spider's funny thought bubbles

Members continued to post resources and suggestions for their writing; there were suggestions from their teachers (participating with community). Following completion of their mini-project, they were able pull out all stops to proceed with their semester project.

Mac posted a humorous photograph of Goodie and Postie.

Figure 6-5 Funny posture by Mac

By way of comparison, Group A planned well for their interview which was the object of this phase. Each member performed his or her role as they had agreed. In asking questions, they followed the set guidelines. They recorded the interview; Peter, in his role of being in charge of technical support, shot the video; he subsequently filed on Dropbox.

Phase 4: Data Gathering is the phase in which students investigate, experiment or perform fieldwork depending on their methodology; for Group A, the purpose of the phase was to gather data for analysis. Group A interviewed a manager whereas Group B conducted a workshop with primary school teachers. Both groups garnered qualitative data which they had to transcribed, coded and analysed. Group A consulted their supervisor regarding how to conduct their interview; Group B involved a professional – they sought advice of their stakeholder but he commented only on their trial workshop. This illustrates the contrast in strategies to achieve the object between consulting an insider from their academic community and outsider from a commercial environment. Group B's investigation was more complex because they interacted with another activity system – school teachers who volunteered to participate; they had previously held a trial run of the workshop.

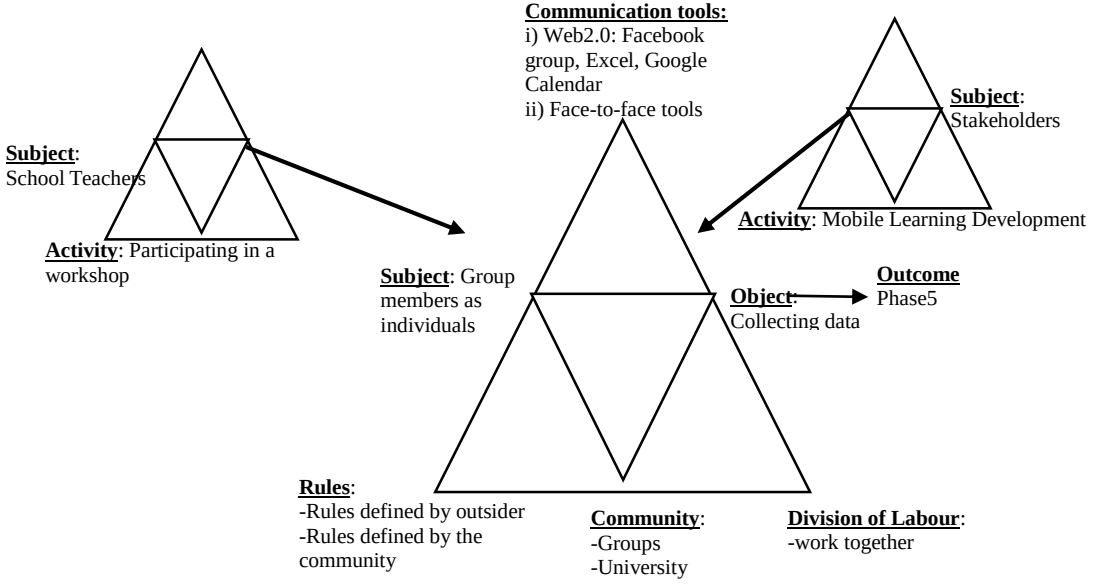

Figure 6-6 The activity system of project phase 4: Data gathering

6.7 PHASE5: ANALYSIS

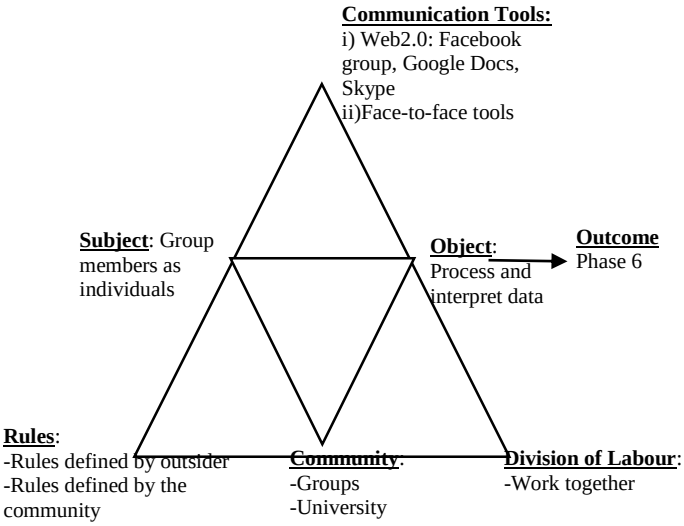

Figure 6-7 The activity system of project phase 5: Analysis

The four Danish members of Group B divided the video of the workshop into sections to be transcribed individually (division of labour); the following day, the Danes jointly coded the text (object).

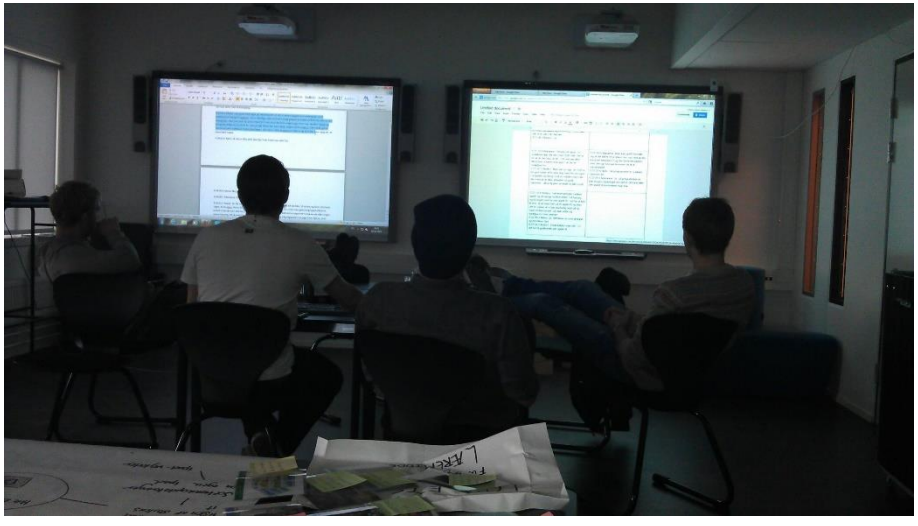

Figure 6-8 Co-analysis with two projectors

It was the first time that they had ever coded by projection. Initially they used a single screen, switching between text and the code table both of which were on Google Docs[3]; subsequently, they discovered that they could use two screens, making them happy and excited; the new application suited their need better. Members apart from Mac transcribed the speech of participants in the design workshop (division of labour); the transcribed speech was laid out in two columns according the whether the speaker was expressing insights or visions at any moment; defining 'insight' and vision' is irrelevant to this research; speech was colour-coded by topic. The Danes, but not Mac, were familiar with coding (psychological tool); coding had been planned in Phase 3: Planning (tension between tool and subject). Mac was learning for the first time to work with qualitative data. Findings were assembled from patterns and topics; observation notes and interviews provided supplementary data. Group B seldom interacted with their stakeholder (community) during this phase.

Compared with Group B, Group A had a similar strategy for data analysis. Pam divided the interview video into parts for each of the five members to transcribe (division of labour). Peter proposed a new transcribing tool; the other members agreed to use for their individual contributions. Grace said that coding needed to be performed collaboratively; since she had to absent on private business, she requested that they meet online rather than face to face. Grace produced an outline report; all members collaborated to conduct the analysis which they presented to their supervisor.

During analysis, students process their collected data which can be either quantitative or qualitative depending on their methodology; the purpose (object) is to identify findings or achieve new understandings which will be input into the problem solving later. For their analyses, both groups employed similar strategies; they divided the video into parts for individuals to transcribe before conducting the analysis together, for both groups, this required full cooperation of all members; both groups worked jointly, face to face, to perform this task; close collaboration between and the strong commitment of group members are essential. Tools so support collaboration are critical to perform the task effectively; in response to any new analytical approach, requirements for tools may change.

6.8 PHASE6: SOLVING PROBLEMS

Group B used findings, theories and ideas from analysis of their workshop transcriptions, literature searches and input from their stakeholder to design their mobile application which is the object of the project including functionalities, and the roles of students, teachers and parents. The group produced a variety of designs of their application; they sought feedback from the stakeholder; in return, the stakeholder showed some of his own designs and invited criticism from the group (interaction

[3] Google Docs is a free-subscribed cloud word processor. It requires only internet browser with Google account to perform the task. It also support collaborative writing. Users can access and manipulate text in the same file at the same time.

between two activities). A second workshop was held with the same school teachers to test their tentative final design; adjustments followed).

While they were working, Mac posted a photograph of Goodie in a funny posture; Goodie replied in Danish (norms, socialisation). They met their supervisor to explain their analysis and demonstrate their design; she provided feedback on the file which had been sent to the stakeholder; it contained his comments; she added hers.

In contrast, Group A's project was an explorative study to observe human behaviour in the context of interpersonal communication; therefore, their solution lay in answering their research questions and writing their report which is the object of the project.

Phase 6: Solving Problems is when students apply their findings to answer their research questions which may include design or development and a product which is a component of the solution. During this phase Groups A and B behaved quite differently. Group A's project sought solely to answer research questions whereas Group B's was to design a product. Group A interpreted their findings during this phase while Group B's were the basis of their design for a Mathematics application for primary school students. Group B showed their design to their stakeholder and his feedback was incorporated into the final design.

The involvement of professionals, whether supervisors or stakeholders was apparent during this stage. Members of Group B were all male; they liked to joke with each other; thus maintaining a friendly atmosphere conducive to maintaining productivity. Tools employed during this stage varied according to subject matter and methodology; tool selection during the phase can be delayed until a need is identified.

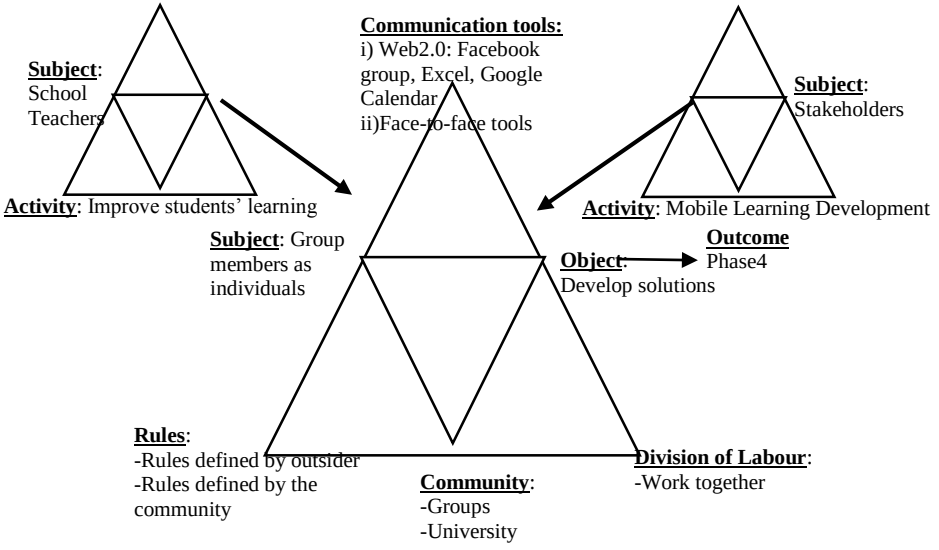

Figure 6-9 The activity system of project phase 6: Solving Problems

6.9 PHASE7: REPORTING

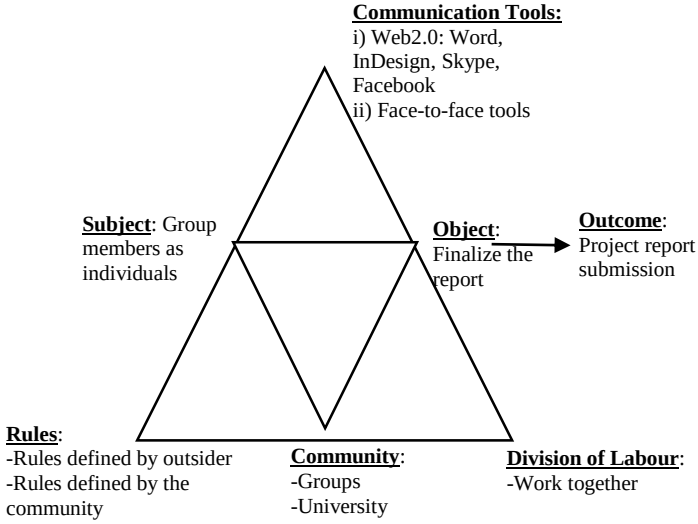

Figure 6-10 The activity system of project phase 7: Reporting

Writing for the report was divided into sections for each member (achieving the object through division of labour) by Group B. They usually met face to face but when it was inconvenient, for example at weekends, they held meetings on Skype conference; Skype conference was used for the first time during his phase. Spider again reminded the group to use Zotero (emphasizing their needs by using another tool); he posted:

"Watch out when you add a book or any kind of literature using the ISBN-function in Zotero. It works fine, except for the fact that it usually has spelling errors and incorrect information. I found out that it is because Zotero gets the info from a shitty Google free-for-all database. So keep in mind that you need to check that every info is correct when you use this function!"

The post was counter-productive; it had drawn attention to the major objection to using it. Mac replied jokingly:

"You should take that back, Google is always right"

Knowledge gained from solving the problem which was to design a mobile application was compiled in the report. Members came to a consensus on how to compile the report: chapters, topics, sentence style, etc. They agreed between themselves how they would divide the report up for writing (division of labour). Individual contributions were assembled for editing and formatting in a single Microsoft Word file. Through several posts, members encouraged each other to get on with their

writing; the posts included "HELL-WEEK" from Spider and several of Goodies favourite songs (norms, socialization). Posts from other members included:
"Hellweek Day 3 - Chaos Reigns!"

"Day 4 - Only evil lives here!!"

"Day 5 - The Gates Are Open!!"

"Day 666 - pick up your weapons and FIGHT!!"

"Day 7 - Dance with the devil !!"

"For the group. REAL MEN DANCE!!"

All group members had to participate to ensure that the deadline would be met (rules); contributions had to be satisfactory and coherent within the whole report. During the night or at weekends, they wrote at home but, on working days, they met in the project room to update each other on the others' progress before continuing their writing individually (norms).

Each member resorted to the location which suited him best for writing. Mac would write in the shared kitchen next to the meeting room; the sound of refrigerator running reminded him of home and kept him active. For his writing, Goodie sat next to a busy path with his headphones on; he mentioned that the noise and fuss kept him alert and active. The others worked at their tables in the project room.

As the file for each section was completed, it was placed in the Dropbox shared folders (tool). Near the end of the phase, they held an aggregation meeting; they ordered all the files by chapter as they had previously agreed. All members sat together as a group (division of labour) and discussed content in terms of typos, format, tense and other language mistakes and style; the also addressed how to make individual contributions coherent in their report. Scholar controlled aggregation from his computer which was connected to the projector; all the other members participated by watching the screen and continuously commenting.

Only after having started aggregating the portions of text, members of Group B discovered that only Spider had persevered to the end with Zotero for reference management. Other members had, as already described, abandoned Zotero during the previous phase and by reason of the disadvantage mentioned by Spider (for Spider, a new need, partially fulfilled but other members were unable to escape from their established practice). Four members had used the Microsoft Word Reference Management Tool to manage citations and the bibliography; Spider had to transfer all his references from Zotero to this tool.

The Microsoft Word file was imported into Adobe InDesign and the table of contents and acknowledgments added. Scholar had had experience of using Adobe InDesign;

however, this time, he coached Postie (division of labour and norms) to use the tool to layout the project report; they used the projector for visualisation for all the group who made comments while Postie controlled the computer with coaching from Scholar to design the layout of the report. Printing was carried out professionally and the report submitted to their coordinator on the day of the deadline. Following submission of the report, Mac departed from Denmark and posted thus:

"Great job guys! Please let me know if there is anything else I can do.
P.S. I have just arrived home successfully and in one piece, very tired though. Thank you again for being such a good friends and for all your support! It has really meant a lot to me! Wish you have wonderful holidays and see you soon in January."

Scholar had organised the printing and subsequently posted the costs along with a photograph of the report; he also claimed to have found a mistake in it.

Group A employed the same strategy as Group B in writing their report (object). Their first meeting was to construct meanings from their findings in order to answer their research questions and to structure the report. They allocated sections of the report to each member to write and subsequently aggregated them (division of labour). Their writing had commenced during Phase 2: Problem Formulation. They had shared their initial writing in Dropbox but they had changed the structure of the Dropbox folder when they recommenced writing (tools were customized according to new needs). During this phase the structure of the Dropbox folder was realigned to match the chapters of the report. Members' original folders were stored in a new folder called "old stuff" in case they might be needed for future reference. Files from members and from Dropbox were aggregated into their report in accordance to the structure that they had previously agreed on. Peter designed the cover and they submitted the report on time (norms).

The intent of the Reporting phase is not only to write the report but to finish it; some groups will have started writing during an earlier; all files will need to be collected and compiled to complete the project report. Groups A and B had commenced their writing during Problem formulation and continued until Reporting; likewise, both groups employed the same strategy for writing; they constructing new knowledge from their findings before writing was intensive and collaborative; writing was divided among all members (division of labour). After all members' contributions to the writing had been filed the met to coherently compile their reports.

Writing and publishing tools were mostly employed during this phase; publishing tools were selected as and when they were required. Microsoft Word was ideal for their professional writing and, in tandem with Dropbox, provided a collaborative learning environment. Language, format, tense, and writing styles were discussed before individual writing started; this simplified the task of compilation later.

6.10 PHASE8: PREPARATING FOR EXAMINATION

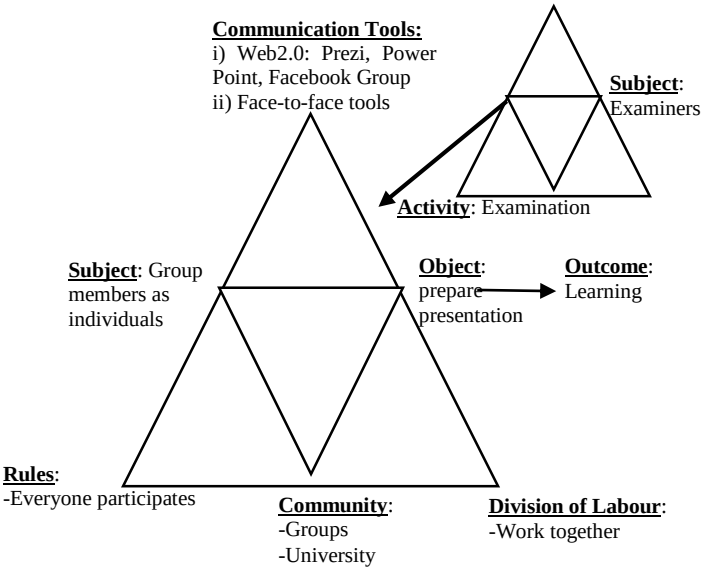

Figure 6-11 The activity system of project phase 8: Preparing for Examination

The Examination closes the project; it has two parts: a presentation and a vive voce or oral examination. Following submission of their report, Group B had six weeks to prepare. The group presentation (object) had to be designed, planned and constructed and was therefore, a continuation of the group's collaborative process; they needed to demonstrate the achievements of the project and the contributions of each member.

Spider posted the exam schedule; Group B was the first group to take the examination. Each group had 110 minutes; they were supposed to present for forty-five minutes and discuss their project with the examiners (interacting with another activity) for the rest of their time.

Mac, after his return to Denmark, asked to meet to prepare for the examination; the other members agreed and divided content according to the sections of the report that each member had written to prepare their presentation in Prezi; the sequence of presenting was also agreed. Each member had his own Prezi template. Several photographs from their discussion board were posted on the Facebook group by Mac.

Since it was to be his first project examination, Mac requested that the other members explain the process to him:

"One more thing guys - are you completely, absolutely 101% sure that we are going to have group exam and that we are stayin together the whole time during the exam? Two of my flatmates studying at AAU already had their project exams and they were

both NOT group exams. They had a group presentation and then they were interrogated individually."

The night before the examination, Goodie asked to be excused from using Prezi for his part because he was unable to integrate it into other members' parts (tension between norms and object; informal organisation can create problems). Goodie's post read:

"Hey people. Would any of you mind if I ran my presentation in another window on Prezi! Im having trouble importing it to the common presentation?"

They all tried to solve the problem, led by Scholar who searched various sources and found that it was a common problem when Prezi produces new versions as had happened that night; ultimately, he did find a solution (division of labour, community). Group B had successfully prepared their forty-five-minute presentation on Prezi; the viva voce took one hour. They were rewarded with maximum marks.

Group A had four weeks break before their project examination. The group did not spend time much on preparation. They used Microsoft PowerPoint to make their presentation; each member had prepared his or her own parts for the presentation (division of labour). PowerPoint does not support collaboration but can be used collaboratively via the sharing feature of Dropbox; in this case, members could not work on the same file, otherwise Dropbox would create new versions to protect against losing data during manipulation by different users.

6.11 APPLICATION OF PROJECT PHASES

By chronologically grouping project actions into phases, tools for those actions can be identified. An example of applications of the project phases is demonstrated by a conference paper which the author wrote with another PhD student; the paper presents ideas of introducing students tools to support their project by classifying tools into different requirements of phases; however, tools are composed of mainly two groups: tools for specific phase actions and tools for common phase actions; for more details please see Appendix C.

In this section the author has demonstrated the processes of a POPBL project as an activity system and phases; components of an activity system and phases of a POPBL project have thus been identified; additionally, students are traced individually, though anonymously, throughout the project in respect of their use of tools.

CHAPTER 7
CROSSED-PHASE ANALYSIS

In this chapter, the author demonstrates the analysis of tool adoption crossed-phase. Practice of each tool of Group B practice will be mapped into project phases Model VI.

7.1 THE PRACTICE OF TOOLS

7.1.1 THE ANALYSIS OF PROCESSES OF TOOL ADOPTION CROSSING PHASES

Groups A and B were observed to discover the criteria and processes of tool adoption. From phases of project (see Chapter 6), we can look into students' behaviour towards tool adoption chronologically. The Phase Model helps author to see different motivation and activities at different periods of a project; thus, this leads to different needs of tools or artifacts to mediate the activity. Then it could lead to patterns of tools adoption from the observational data.
Of the tools introduced by the University, both groups quickly adopted Dropbox but rejected Zotero; Zotero is a free-subscription digital library and reference management tool. Both Dropbox and Zotero had been introduced to students along with other tools when they first started at the University; because many of their teachers and supervisors used Zotero, they had been conversant with it since that time.
During Phase II Problem Formulation, **Group A** members discussed whether to adopt it for their project; they quickly rejected it because it is too complicated and they needed time to familiarise themselves with it; they expressed an interest in adopting it in the following semester when they would have a longer period to conduct their project. **Group B** were more interested in using Zotero and gave it deeper consideration during Phase II Problem Formulation before rejecting it in Phase VII Reporting for general use but did adopt it for one specialised application but ultimately abandoned it because another Web 2.0 program which they were using incorporated all of the features that they required.

Facebook and Dropbox were selected from all their Web2.0 tools to study **Group A**'s tool adoption processes. The combination of Facebook and Dropbox was adopted with little discussion; they were familiar with them from their previous project; they did not have to learn the tools and could use their time productively.
Zotero, Skype, Dropbox and Facebook were selected from all their Web2.0 tools to study **Group B**'s tool adoption processes. For four of the students, this was their seventh project, and first for one, Mac; the four project-experienced students were well versed in using Skype, Dropbox and Facebook in combination and there was little discussion regarding their selection; discussion was confined to establishing the

environment, for example setting up the Facebook group and creating the Dropbox folder structure; this happed during Phase II Problem Formulation. Time was spent on implementation, not selection. Zotero was proposed by Spider who asked the group to commit to using it during Phase II; he posted his own video explaining how to use Zotero during Phase IV Analysis; he contributed most of the effort for adoption with little contribution from the other members. They did, however, commit to using Zotero. In practice, they used Zotero only for collecting references from Phase II Problem Formulation to Phase VI Solving Problems; only Spider used it for writing. The group gained no benefit from Zotero because individual members, apart from Spider, abandoned it unilaterally during Phase 7 Reporting. Zotero failed for Group B to apply the tool to the most beneficial stage or in the application stage.
Table 7-1 and 7-2 summaries tools adoption at different project phases based on project phase Model VI.

	Facebook	**Skype**	**Dropbox**
Phase 1: Group forming	A closed-group was created.	-	A shared folder was created and members joined.
Phase 2: Problem formulation	Continued using	Skype used for discussions with stakeholder	All members put files in the folder; Scholar informed members of a space campaign by Dropbox.
Phase 3: Planning	Continued using	Skype used for regular discussions with stakeholder, occasionally by group only.	Spider restructured Dropbox and announced it on Facebook group; all members put files in the folder.
Phase 4: Data gathering	Continued using	Skype used for regular discussions with stakeholder, occasionally by group only.	All members put files in the folder.
Phase 5: Analysis	Continued using	Skype used for regular discussions with stakeholder, occasionally by group only.	All members put files in the folder.
Phase 6: Solving the problem	Continued using	Skype used for regular discussions with stakeholder, occasionally by group only.	All members put files in the folder.
Phase 7: Reporting	Continued using; Goodie changed cover photo to factory workers to represent hard work	Skype used for regular discussions with stakeholder.	All members put files in the folder.
Phase 8: Preparing for examination	Continued using	Not required	All members put files in the folder.

Table7-1 Tools adoption at different phases of Group B (Facebook, Skype and Dropbox)

	Zotero	Prezi	Other tools
Phase 1: Group forming	Discussed; all except Goodie committed to using it.	-	-
Phase 2: Problem formulation	Spider created a shared folder for each member; all joined; all entered a few references.	-	Mac introduced a Skype recording tool; adopted.
Phase 3: Planning	Spider restructured Zotero and made and shared two video clips to demonstrate changes; all entered a few references.	Postie introduced Prezi to the group.	Spider introduced a project management tool but the group did not adopt it.
Phase 4: Data gathering	All entered a few references.	Not required	-
Phase 5: Analysis	All entered a few references; Goodie stopped using it.	Not required	Google docs was used for data co-coding.
Phase 6: Solving the problem	Spider reminded members to use it; Scholar, Postie and Mac stopped entering references; Spider continued entering references.	Not required	-
Phase 7: Reporting	Only Spider entered references and used the tool to manage references for his writing; other members including Goodie managed references manually during writing.	Not required	Adobe InDesign was adopted to format the report.
Phase 8: Preparing for examination	Not required	Prezi template used for individuals' contributions to combine in Prezi presentation.	-

Table7-2 Tools adoption at different phases of Group B (Zotero, Prezi and other tools)

From tables 7-1 and 7-2, this research reveals patterns in the way students adopt tools for their projects by analyzing their individual consideration and group agreements or consensus: the author can classify stages of tool adoption into three stages: Selection, Implementation, and Application. Here the author defines factors of individual consideration and group consensus:

Individual Consideration: 'Consideration' here refers to the knowledge, experience, research and trials of tools brought to the project by individual members. Members of Group B had, with the exception of Mac, previously participated in six projects, but Group A in only one. Group B were aware of how to conduct a project and understood, more than Group A, the importance of selecting the right tools. Members of both groups had, apart from Mac, been introduced to web tools to support projects since their first semester. Some tools, such as Facebook and Dropbox, were tried out immediately; other tools such as Zotero were more complicated and the students had little time available; investigation of these tools was postponed until later. Students in both groups were, therefore, individually aware of the potential of some tools which could support project work; through their experience, they could, again individually, evaluate the tools and consider how they might be effectively applied to their projects.

Group Consensus: 'Consensus' here refers to the sharing of knowledge, experience, research and trials to reach an agreement on which tools the group will adopt and how they will use them. Ideally consensus requires commitment; obviously, it would be impossible to conduct a group project satisfactorily if individuals pursue their own agenda. Consensus does not mean 'fixed in stone'; groups can reach new consensuses in response to experience or changing requirements.

An example of a breakdown of consensus was provided by Group B in relation to their adoption of Zotero. Zotero offers two distinct but linked functions; reference collection – references can be stored, shared and retrieved including those which are not ultimately cited; and reference management – insertion and collation of references in the final report. The group, led by Spider, agreed to use Zotero in both functions. They discussed Zotero in face-to-face meetings. They stored some publications and references on Zotero and reminded each other to use it in their online forum. Spider made a video on how they could use Zotero to support their work. The reference collection function of Zotero would have operated primarily during Phase 2 – Problem Formulation but further references could be entered in subsequent phases. If Zotero had been fully applied throughout the project by all members, reference management could have been much simplified in Phase 7 – Reporting.

Zotero was terminated despite being used by most of their teachers and other researchers. Group B inserted references into their final report manually, including Spider's. Zotero could have made this writing more efficient by supporting and partly automating reference management; it could have saved much time which they could have spent on other tasks.

Zotero was widely used by Group B's lecturers; they introduced it to their students as a tool with potential make their projects more productive. It is free. It is instantly available online. It is easy to learn and use. Why did four out of five members of Group B reject Zotero?

a) When asked, Scholar suggested that the format of some of the collected references was incorrect: capitalisation, incorrect order and incorrect information such as the wrong year, edition or publisher; these are known, common problems with Zotero but users learn to live with them and make corrections. This is confirmed by a post from Spider to convince other members to use Zotero:

> "Watch out when you add a book or any kind of literacy using the ISBN-function in Zotero. It works fine, except for the fact that it usually has spelling errors and incorrect information. I found out that it is because Zotero gets the info from a shitty Google free-for-all database. So keep in mind that you need to check that every info is correct when you use this function!" (posted by Spider on their Facebook closed-group)

   Members of Group B, apart from Spider, did not have enough time to make corrections and found it more efficient to work with familiar manual procedures. Spider, alone, maintained his commitment to use Zotero throughout the project.

b) The group did not use Zotero to its full potential, as a digital library for their reference collection; only one member, Spider used for reference management. Using it with limited application reduced its usefulness.

c) Three members preferred to manage their references manually and independently. Spider's diligence in sticking with Zotero was, to some extent, negated when it came to writing the final report because references, including his, had to be handled manually thus consuming much time and effort; Zotero was incompatible with other members' reference management.

d) One member, Goodie, had refused to commit to Zotero from the start on the grounds that he preferred stick with his own practice of using Microsoft Reference Management; however; he did not use it; he collected and managed his references manually.

Goodie's refusal to commit to Zotero at the start of the project was accepted without challenge by all the other members of the group. Was his lack of commitment to Zotero detrimental to the project or learning? In one way, yes, it was, because the group used much time and effort managing references mechanically whilst writing the final report; the time and effort could have been more gainfully employed.

Spider was totally committed to Zotero; Spider used Zotero for both reference collection and reference management; his references, alone, were easily managed and inserted into the final report automatically saving time and effort; however, due to lack of compatibility with other member's practices, his references still had to be reordered manually along with theirs. At the start of the project, Spider had encouraged other members to use Zotero and had produced a video on how to use it.

Mac, Postie and Scholar committed to using Zotero at the start of the project but used only one function – reference collection – thereby much reducing the usefulness and effectiveness of the tool; furthermore, their reference collection on Zotero was only partial; many references were not entered. Although Goodie had not committed to Zotero, he did participate, but only nominally, since he entered hardly any references. Mac, Postie, Scholar and Goodie all abandoned Zotero at the same time apparently without consulting each other or Spider. Goodie had started the project using Microsoft Reference Management, a similar tool to Zotero but not online and with no sharing facility; he abandoned it in favour of collecting and managing references manually.

What factors led four out of the five members to reject Zotero?:

a) Goodie rejected Zotero because he was familiar with and had experience of Microsoft Reference Management.
b) Goodie thought that it would take time to learn how to use Zotero; he did not want to change his existing practices.
c) Goodie's refusal to commit to Zotero may have reduced Mac's, Postie's and Scholar's commitment; opting out by one must have given the impression that it would be acceptable for any member to do so.
d) The group's focus on tasks in Phases 2 to 6 may have led them to disregard the longer-term benefits which would have been reaped whilst writing the report in Phase 7.

Member	Zotero for reference collection	Zotero for reference management	Details
Spider	----------⟶		advocated Zotero; totally committed; used it throughout except for final reordering
Scholar	----------⟶		not totally committed; abandoned Zotero
Postie	----------⟶		not totally committed; abandoned Zotero before Scholar
Mac	-------⟶		not totally committed; abandoned Zotero before Postie
Goodie	-⟶		not committed but participated in some reference collection

Table7-3 Group B members' Zotero adoption for the project

Was lack of commitment to Zotero detrimental to the project or learning? In one way, yes, it was, because the group wasted much time and effort managing references mechanically whilst writing their final report; this time and effort could have been more efficiently adopted. In another way, no, it was not, because whilst spending time managing references, they should have realised that it would have been simpler and quicker to manage references using Zotero; hopefully, they will have learnt from the experience. Goodie insisted on collecting and managing references in the same way that he had done in the past despite the advantages, not only of using Zotero for both reference collection and reference management, but also of committing himself to the group; he chose to adopt Microsoft Reference Management and collected his references manually, a system which was incompatible with Zotero to which the other members had committed themselves. Mac, Postie and Scholar had agreed with Spider to use Zotero from the start of the project; they used one function, reference collection, sporadically, and ignored the other function, reference management, completely. By not using Zotero's reference management function, they missed out on its greatest advantage: highly automated collation of references in their final report.

On the online forum, there are many posts about tools: introducing them, making changes or problems encountered. All members participated in these discussions. When Spider introduced Zotero at the start of the project, and later when Scholar introduced Dropbox and Postie subsequently introduced Prezi, there were no replies from other members; this may have been because members were already familiar with them and their posts merely confirmed their agreement to adopt them. Spider introduced a folder structure for Zotero and posted a video on how to use it; he had tried hard to persuade members to adopt it. Two new tools were introduced during

the project: Callnote Premium, a tool for recording calls on Skype, and Team Foundation Service, a project management tool. Only Callnote Premium was adopted; it had the advantage that its voice files were automatically shared in Dropbox; it was simple to use, required little processing and met their needs at the right time; there was little risk in adopting it yet it offered tangible benefits. Team Foundation Service was introduced by Spider in the middle of the project; it was complicated, needed time to learn; and would have necessitated substantial changes to the management processes of the project; it was seen as carrying a high and unnecessary risk whilst giving only long-term benefits and was, therefore, not adopted. Some tools can be beneficially introduced during a project to meet specific needs; conversely, some tools can only be introduced satisfactorily at the beginning of the project, notably project management tools such as Team Foundation Service. Spider introduced some tools, such as Team Foundation Service, during the project, not for immediate adoption, but for consideration for future projects; there was a possibility that the same group might work together on future projects.

Adoption of each tool is mapped to the three stages of adoption in tables 7-4 Group A and 7-5 Group B.

Stage:	**Selection**		**Implementation**		**Application**	
	Individual consideration	Group consensus	Individual consideration	Group consensus	Individual consideration	Group consensus
Zotero: a web based shared digital library tool incorporating reference management	They had been introduced to it during the previous semester so they were aware of its potential.	They discussed Zotero; they knew it could support their task well but they needed time to learn how to use it; therefore, they rejected it.	Not adopted	Not adopted		
Facebook: a web-based social network, with a closed-group feature.	All members of the group had previously used Facebook in project groups.	Facebook was selected without discussion and no dissent.	One member took on the role of technology consultant and created the closed group and added all members	The closed group was set up to be their main channel of online communication.	All members communicated effectively on Facebook including circulating information, requesting assistance and ideas but little social interaction.	Many instances of member's participation and achieving consensus are recorded in the closed group.
Dropbox: an internet-based file-hosting tool with a sharing feature.	They all had experience of using Dropbox in groups.	Owing to their familiarity with Dropbox, it was selected with little discussion and no dissent.	The technology consultant set the folder up and shared it with the other members but not their supervisor.	They agreed to set folders up for each member and allow access to each other's files.	They added new files to the shared folders.	Folder structures remained unchanged, new files being added to the original structures.

Table7-4 Group A's three stages in the adoption of Web 2.0 tools

Stage:	**Selection**		**Implementation**		**Application**	
	Individual consideration	Group consensus	Individual consideration	Group consensus	Individual consideration	Group consensus
Zotero: a web-based shared digital-library tool incorporating reference management	4 of the 5 members had been introduced to the tool 3 years earlier; they had not used it but were aware of its potential. Goodie declined to use it; he used the program he was already familiar with – Microsoft Reference Management.	The group, except for Goodie, agreed to use Zotero for literature collection and reference management; they accepted his decision not to use it.	The folder was set up with structures initially for literature and subsequently for writing synchronisation. All members stored their references on Zotero except for Goodie.	The group used Zotero to collect, but not manage, references. The folder was set up with structures initially for literature and subsequently for writing synchronisation. For report writing, they abandoned Zotero and inserted references manually.	Although terminated for this project by group decision, members would consider using it in future.	During phases 2 to 6, Zotero was used to make all literature and references available to all members at all times. Zotero was terminated for phase 7 because it was perceived to be easier to assemble text manually.
Facebook: a web-based social network, with a closed-group feature.	All members of the group had previously used Facebook in project groups.	Facebook was selected without discussion and no dissent.	Spider had set the closed group up before the project's formal starting date; he added all members plus supervisor and stakeholder.	The group changed its profile pictures several times to reflect phases and current challenges.	All members communicated effectively on Facebook including circulating information, requesting assistance and ideas and for social interaction.	Many instances of the group's participation and achieving consensus are recorded in the closed group.
Dropbox: an internet-based file-hosting tool with a sharing feature.	They had all previously used Dropbox in groups.	Owing to their familiarity with Dropbox, it was selected with little discussion and no dissent.	Scholar set the folder up and shared it with the other members but not their supervisor and stakeholder.	They agreed to set folders up in the names of each member; they agreed to allow access to each other's files but not to edit them before combining them to produce drafts.	Members found that their folder structures did not always suit particular phases.	Folder structures were changed according to the phase to suit current needs.
Skype: an internet-based conference system.	They had all previously used Skype in groups.	Owing to their familiarity with Dropbox, it was selected with little discussion and no dissent.	Each member added all the others to his account.	Skype required no customisation.	Skype was adopted throughout the project.	Skype was not a primary tool for members. It was used only for conferences in which all members participated.

*Note: that all tools mentioned tools are available free of charge and can be subscribed to at any time.

Table7-5 Group B’s three stages in the adoption of Web 2.0 tools

7.1.2 INDIVIDUAL DIGITAL TOOLS BUT TO ASSOCIATES CO-ACTIONS

A feature of Web 2.0 tools is that they allow interaction between users. Users can access common work spaces and collaborate. Youtube is a video hosting and sharing service; comments can be added by viewers and replied to thus exchanging ideas. Facebook is another example; it provides space for individuals to communicate using multimedia: text, links, files, images, video, audio, emotion icons, etc. Both Youtube and Facebook permit collaborative activities and group learning. Web 2.0 tools are usually available on free subscription but may require payment for more advanced features; there may be a limit on space available free with additional space having to be paid for.

Do individual tools still have a place in group work? In group work, there is still a need for members to work individually; individual digital tools offer more and more-advanced features than Web 2.0 tools; they have developed over a long period whereas Web 2.0 tools have been available only for a short time; thus there are advantages for group members to use individual tools when working individually; group members will also have had long familiarity with individual digital tools and would be thoroughly conversant with their operation and capabilities; internet speed may also restrict the full enjoyment of Web 2.0 tools' features. Work on individual digital tools is stored in files; these files can easily be shared for collaborative work with other group members through Web 2.0 tools. Group members thus able to draw on and combine the most useful features of both individual digital tools and Web 2.0 tools.

Observation of Group B revealed an advantageous combination of individual digital tools and a Web 2.0 tool. Dropbox was used for file synchronisation; Dropbox was, in effect, a shared space. All project files were stored in Dropbox and thus available to all members at all times; files from individual digital tools thus stored included: writing, including writing in progress on Microsoft Word; diagrams created on SmartDraw; spread sheets on Microsoft Excel; and presentations on Microsoft PowerPoint.

There are Web 2.0 tools which perform the same tasks as individual tools such as Google Docs for Microsoft Word; both are word processors and Group B used both. Word was adopted for individual writing and Google Docs for data analysis. Google Docs allows access to the same file for all members at all times whereas a Word file can be accessed by only one individual. Google docs is designed for group writing so why did the group not adopt it for this purpose? Firstly, Word has more, and more-advanced, features than Google Docs. Secondly, for individual writing, Word files were shared so that members could follow each other's progress and make comments and suggestions; although each member could have manipulated other's files, they agreed not to do so without prior agreement. Google Docs was adopted for data analysis which is a collaborative, not a cooperative, task; data analysis requires the close attention of and simultaneous participation of all members; Google Docs allowed instant access and enabled them all to manipulate text without being

concerned about formatting, layout and embedded components such as pictures, images and diagrams. Google Docs was thus ideal for the shared task of data analysis.

1. Community
   A 'community' is here defined as a group of people who regularly co-operate to achieve common goals. Subjects are influenced by their communities such as project groups or their university.

2. Rules
   Rules are conditions and are set by the community; they may be formal or informal and are likely to be subject to outside influence. Projects are subject to conditions such as time of completion, evaluation and defined themes; additionally, groups establish their own rules to facilitate coordination such as scheduling, communication, choice of tools and writing styles.

3. Division of Labour
   Communities establish roles for their members. Within a project, students may take on different roles such as leadership or recording minutes; individual members may take roles which require deep understanding of particular aspects of the project in order to participate in knowledge construction; division of labour may be the most efficient way to conduct a project.

In conclusion, the processes that students adopt tools as are as follows:

i. Consensus is the agreement of members of a social system, in this case a project group; communication tools need to be adopted fully by all members for them to be effective and enhance the project. In the case of Group B and Zotero, there was lack of consensus; Goodie refused to commit to Zotero from the start; this condemned Zotero to oblivion because, for it be useful, all members would have had to use it for sharing resources and references. This problem might have been overcome if the group had adopted a hierarchical structure; one member could have imposed it on the others; participation and learning would probably have been less.
ii. Inertia is the continuance of old practices; Goodie continued with his old practices form the start of Group B's project; other members, except one, unilaterally reverted to their former and familiar communication tools during the project; only one persisted with the Zotero but to no advantage, even for himself, because Zotero is a collaborative tool.
iii. Lack of critical selection of tools leads to the failure of adoption; lack of full commitment from the group, likewise, leads to the failure of tool adoption. Critical selection and full commitment are key factors for successful tool adoption
iv. Three stages of tool adoption were identified: Selection, Adoption, and Application; decisions in each stage must be the result of both individual consideration and group consensus.

v. Community spirit within the team is another key factor influencing group performance.
vi. Some programs at Aalborg University provide an introduction to online communication tools to support students' projects; Groups A and B were introduced by the University to some of the tools that they used or considered using.
vii. Some easy-to-use tools were readily adopted by both groups and used throughout their projects, e.g. Facebook group and Dropbox.
viii. Both groups postponed using complex tools such as Zotero because of the time required for setting up and customisation despite being aware of the benefits.
ix. A strong commitment to using a tool is required from all members; otherwise, it may be abandoned during the project with the loss of potential benefits.

7.1.3 BARRIERS AND SUPPORTS OF TOOL ADOPTION

i. Individual tools contribute to collaborative tasks; Microsoft Word as an individual tool was used for writing, whilst a groupware document editor like Google Docs was not used for writing the report but only for co-coding and analysis. Features of groupware are not sufficient for demanding co-activities; standard personal computer applications respond faster.
ii. Critical in selecting tool, leads to critical in project undertaking.

7.5 THE NORMS (RULES)

Writing dominates a project; co-writing is a challenge because contributions are written individually and subsequently merged; consensus before writing is essential. This section illustrates how a group achieves a consensus and how it works.

7.5.1 ONLINE DISCUSSION

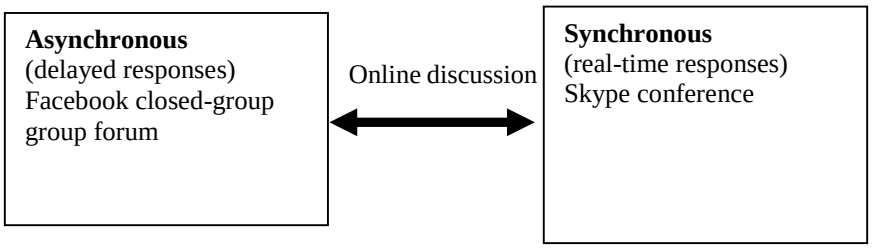

Figure 7-1 Online discussion modes and tools

Asynchronous (delayed responses)	**Online Discussion**	**Synchronous (real-time responses)**
Facebook	Web 2.0 tool	Skype
Forum	Function	Conference system
Closed-group	Application by Groups A and B	Holding conferences
Regular channel of communication		Occasional channel of communication
used throughout the project		Substitute for face-to-face discussion when it was not possible

Table7-6 Group B's communications on Web Tools

Discussion is the action or process of talking about something in order to reach a decision or to exchange ideas, based on the definition in online Oxford dictionary; it is an important element of group learning. Group discussions can be conducted online or face-to-face. In groups which combine both, the primary mode of discussion is usually face-to-face. Online discussion mirrors face-to-face discussion; therefore, monitoring online discussion can help us understand how groups learn. Online discussions are of two kinds: synchronous – real time responses; and asynchronous – delayed time responses. Group A's and B's online discussions were generally asynchronous but were synchronous for particular purposes. Each group adopted Facebook as its online group forum, its medium for asynchronous communication, and Skype for synchronous exchanges; members often contacted each other and the stakeholder through the forum but met through a Skype conference when real-time interaction was most useful. Group B held conferences on Skype; one example is

provided in Phase 2, Problem Formulation, when they communicated via Skype to enable all members to participate in live discussion. Skype conferences engage participants fully; all matters discussed require immediate attention; they cannot be postponed.

7.5.2 LANGUAGE

Language is a mind tool in the activity system of a POPBL project. Groups develop their own exclusive language which is understood within the group; the new language is the norm of the group. Language develops similarly in a group of mixed males and females such as Group A when compared with an all-male group such as Group B. Swearing is looked upon as friendly and not putting on airs; Group B addressed each other as *fuckers* in postings on Facebook in respect of both project activities and socially. Similarly, Group A members also insulted each other and swore in their Facebook group; they called each other 'bandits'; they swore to express emotions. Swearing was common among both male and female members. The following are examples of swearing from Group A with the author's translations in square brackets:

"Jaaaaa! ☺ Pisse fedt!" [*Yeahhhh! ☺Bloody cool!*]

"PISSE GOD" [*Bloody good*]

"Hej Banditter" [*Hi Bandits*]

Images, like language, can release tension and generate fun as shown on Group B's Facebook closed-group (see figure 4-4 and 4-5); they found fun in making comments about each other; similarly, Group A enjoyed their working time drawing a heart-shaped girly symbols on their discussion papers; this may indicate that female members were dominant within the group (see figure 4-6).

Figure 7-2 Secret expression of Group B

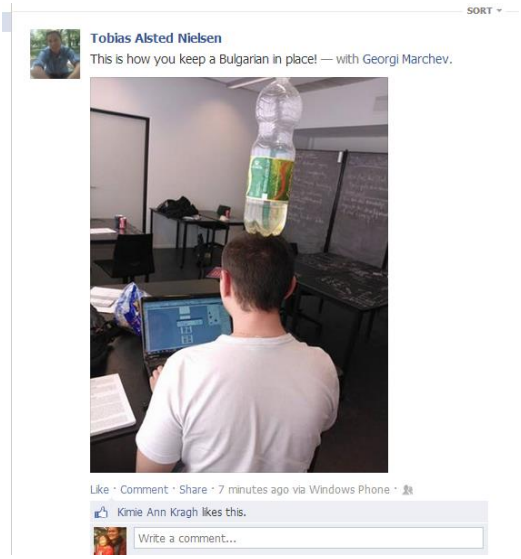

Figure 7-3 Having fun while working of Group B

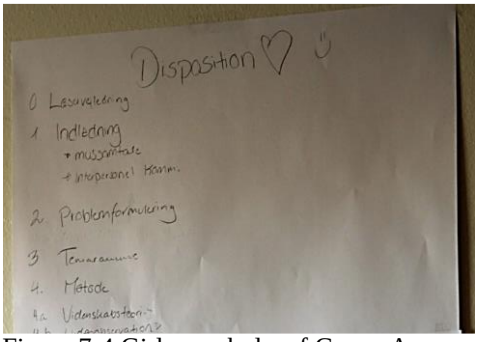

Figure 7-4 Girly symbols of Group A

Group Dynamics, the study of how groups work, was the work of Tuckman (Tuckman, 1965) who described the stages of group development: Formation, Conflict (Storming), Structure (Norming), Productivity (Performing), and Dissolution (Adjourning). Before a group can perform, members establish norms and rules, formally or informally; the rules are reshaped during the life of the group. Language used within a group can indicate how close they are as a team; members tend to use informal language and particular terms to create their own identity; norms are established. In traditional classes, there is little room for students to develop intellectually and socially; the focus is on discipline and conformity to achieve the objective.

7.5.3 SOCIAL ACTIVITIES

Apart from language they also discussed and talked about informal activities both during face-to-face and online discussion such Facebook. This took place during social activities such as example going to the gym, sitting in a bar, and ordering a pizza. The example from the observation is some of the members of the experienced group were interested to go to gym, they sharing information and invite each other to attend the same gym, where they can get to know each other more.

7.6 DIVISION OF LABOUR

7.6.1 COORDINATION ENABLES COOPERATION AND COLLABORATION

To facilitate the adoption of communication tools in POPBL projects it is first necessary to understand group learning; group learning can be collaborative or cooperative; both have been described in different ways in literature. Johnson, Johnson and Smith (D. W. Johnson, Johnson, & Smith, 1991) argue about the distinction between collaboration and cooperation as follows. Cooperative learning is structured and has pre-defined goals which are common to all group members; learning can be influenced by teachers. Collaborative learning is an open learning processes in which a group constructs knowledge by working together closely. Table 4-32 shows the differences between collaborative and cooperative learning both through interaction between members and due to outside influences. Collaborative and cooperative learning require different means of coordination between members; therefore, tools to support collaborative learning are different from tools to support cooperative learning. Groups A and B communicated both face-to-face and online. They met face-to-face but kept in touch with each other online through Facebook. Two of the main activities, writing and the forming and developing of ideas, were conducted face-to-face and online thus requiring good coordination.

Dimensions	Cooperative Learning	Collaborative Learning
Aims	To gain curricular knowledge	To construct new knowledge; requires higher-order thinking
Participant engagement and control	Engaged in pre-defined procedures in a group to finish tasks.	The processes are open; participants must develop their own approach. Participants control, design and develop their own problem, approach, and solution.
Processes	The work can be divided and separated working on individuals, then putting the work together at the end.	The work cannot be separated; they need to work together closely. Possible to interact online when they are not on the same location.
Teacher or supervisor involvement	Teachers play an important role to conduct the activities.	Supervisors or teachers will be called when needed.
Online space	They can engage both online and face-to-face. However, they may not engage each other during individual task.	They can engage both online and face-to-face.
Coordination	Needs good coordination tools since they can work individually on some activities. They may not know the other participant's work or current process, but their only concern is about the outcome of the individual tasks.	They are always aware of each other's progress and current processes. The work of individuals becomes transparent to the others.

Table7-7 The distinction of Cooperative and Collaborative Learning

7.6.2 CO-WRITING

Both groups started their writing during Phase 2: Problem Formulation. They documented their meetings and started writing whilst performing their projects. Writing was most concentrated in Phase 7: Reporting; precursory meetings ensured that all members understood the content; they wrote individually to meet an agreed deadline; subsequently, working face-to-face, they collated and revised their work. Collaborative learning ensures that all members acquire the same knowledge; however, they sometimes work individually, especially when writing; individual members' writing tasks are allocated only after discussions to ensure that they all have the same understanding. Knowledge is constructed during discussions; the knowledge thus gained is presented in writing; writing is creative since individual members must present the knowledge in ways in which it can be understood and retain the interest of readers who may or may not be specialists in the subject. Writing is obviously most productively conducted individually because of having to meet deadlines; conversely, final revision and editing are again conducted collaboratively. Cooperation and collaboration in a project are not exclusive; rather, groups switch between and combine them.

7.6.3 CO-CODING AND CO-ANALYSING

Members of Group B divided video recordings from the workshop into sections; each section was transcribed by one member individually to produce written text; this process was cooperative although Mac, unskilled in Danish, did not participate. By way of contrast, the subsequent coding was collaborative; it was carried out in a project room with two projectors as shown in figure 4-7; all members took part throughout; their participation was critical because consensus was essential – they all had to agree. Text was highlighted with colours representing categories and the frequency with which each colour appeared was recorded. Analysis was, likewise, collaborative but was carried out on display and blackboards as illustrated in figure 4-8.

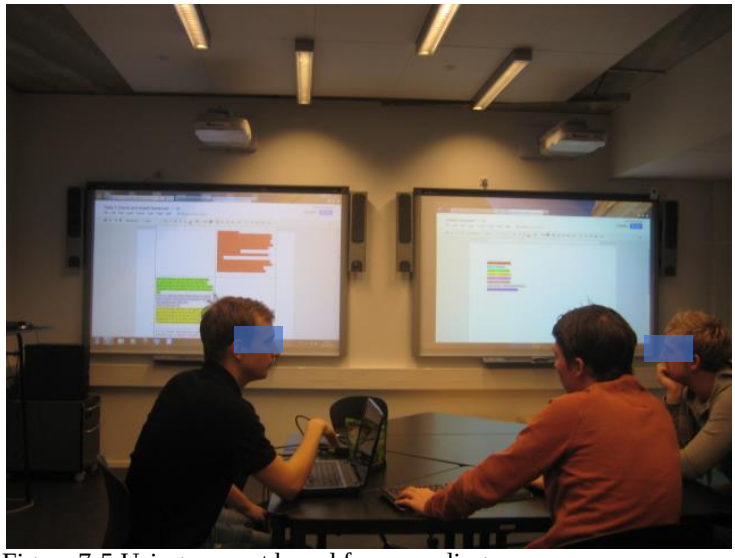

Figure 7-5 Using a smart board for co-coding

Figure 7-6 Using blackboard for co-analysis

Some group activities need to be performed collaboratively because they require consensus: choice of writing tools, structure, style and layout; handling of references; etc. Within the collaborative framework, some tasks may be most productively performed cooperatively, especially if they are time consuming: typing, preparing tables and diagrams, inserting images, etc. Co-writing is a collaborative activity in which, for practicality, some tasks are usually cooperative. An example from Group B's project of a collaborative activity with some cooperative tasks was co-analysis; transcription is fairly mechanical and was unlikely to cause conflict and was,

therefore, performed cooperatively; in contrast, coding and interpretation required extensive discussion to reach a consensus and were performed collaboratively.

Cooperation depends primarily on individuals thus requiring only limited communication; the opposite is true of collaboration. Group B adopted several tools to communicate whilst performing collaborative activities, whether face-to-face or online; pen and paper, display boards, black- and white boards, computers, projectors, etc. facilitated face-to-face meetings. Both face-to-face and online communication were further facilitated by online communication tools; a combination of Microsoft Word, Dropbox and Zotero provided their online writing environment; they could work independently or share resources, keep in touch with each other's progress or collaborate. Another example of an online tool which was adopted both face-to-face and online was a *closed group* in Facebook – the closed group was adopted by the group as their online forum; it was their primary channel of online communication. Their project's progress was recorded in the closed group; it could also be used for long discussions; face-to-face and online communications, especially in the closed group, were complementary – discussions could be switched between the two modes; records stored on their closed book were visible and accessible to all members at any time thus stimulating effective collaboration.

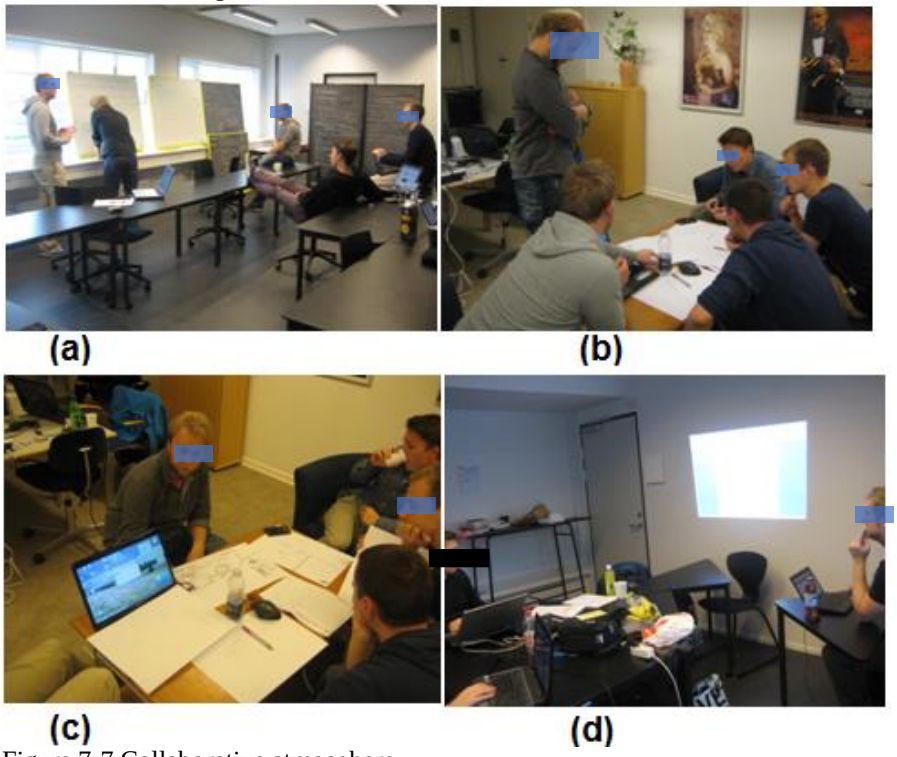

Figure 7-7 Collaborative atmosphere

7.6.4 STRONG DIVISION OF LABOUR

In Chapter 3, Section 3.4, the author discussed Activity Theory; it is now applied to group learning and tool-enhanced learning in groups. Engeström's Division of Labour (Engeström, 2001) explains how members of a group participate in an activity. Division of Labour can be classified into *strong* and *weak* (Cornish, Zittoun, & Gillespie, 2007; Hansen et al., 1999). With a strong division of labour, an activity is divided into tasks which are assigned to members; members' roles are strictly demarcated. With a weak division of labour, tasks are not assigned to particular members; members' roles are overlap; members may share tasks. A task may be accomplished more quickly with a strong division of labour if they are assigned appropriately. Weak division of labour has some advantages in a learning context; members face problems, work closely and make decisions together; the activity may take longer and cost more but should ensure that all members participate and are learning. In practical terms, in a learning situation, some activities are best performed with a strong division of labour and some a weak division.

This author observed two groups, A and B, as already described. In terms of division of labour, the two groups adopted different strategies.

Following discussion, Group A decided that members should take on particular organisational roles which they decided on themselves and recorded in the project folder: note taker, meeting scheduler, IT specialist and final-decision maker. Reading and writing were divided into topics and assigned amongst themselves.

Group B's organisation was, by comparison, informal. There were no set roles for members; they worked closely and made decisions together. There was no official role of note taker; records were kept in other ways such as photographing blackboards at the end of meetings. Topics were divided up and assigned amongst themselves voluntarily; likewise with Group A, reading and writing were carried out individually.

Cooperative reading is an example of strong division of labour; topics are divided up for members of the group to explore individually. Cooperative reading provides the opportunity to investigate problems, theories and methodologies; the sharing of files and discussions which follow lead to understanding and subsequent application to the project. Cooperative writing is, likewise, an example of strong division of labour; discussion will have established a framework for the writing of the report. Content is divided up for individual members to compile.

Group B shared materials and discussed ideas before, during and after reading and writing which were, nevertheless, performed individually. They were aware of each other's progress in acquiring and constructing knowledge. They commenced the writing process by discussing content and how to present it. Individual members' writings were assembled; editing was carried out in face-to-face meetings; they read the report out loud from the first page to the last. They worked collaboratively to

correct and improve their English as well problems with concept and logic; in this way all members achieved the same understanding of the project

Communities, Rules and Division of Labour enable learning and the achievement of common goals in a project; they are essential. In conclusion we can summarise as follows:

i. Online interaction reflects face-to-face interaction.
ii. Minutes of meetings are replaced by photographs taken on their smartphones of their discussion boards; the photographs are immediately available and promote continuous knowledge construction; thus, by combining face-to-face and online communication, knowledge construction is not limited by time or location.

CHAPTER 8
DISCUSSION

In this chapter, the author discusses his research findings from Chapter 4 Pilot Study Results; Chapter 5 Overview of Activity Systems of Projects of Groups A and B; Chapter 6 Activity Systems of Project Phases; and Chapter 7 Cross-Phase Analysis.

This discussion takes the point of departure from Computer-Supported Cooperative Work (CSCW), considering PBL group activities and the integration of tools as an activity system that can be categorized as CSCW process.

Research in CSCW (Computer-Supported Cooperative Work) has shifted to investigate how technologies are employed with regard to tools, time and location. This change in emphasis arose because tasks can now be performed independently of time and location. Because of their variety, how tools are selected and employed is an issue, especially their organisation in the context of joint activities; tool selection has become more complex (Ciolfi & De Carvalho, 2014; Rossitto, Bogdan, & Severinson-Eklundh, 2014). Collaborative ICT tools enable students to work and various locations and locations apart from other members of the group, and even at different time zones. The resulting mobility may be by choice, opportunity or obligation (Ciolfi & De Carvalho, 2014). Members of a group, in this case students, may work, may be able to work or may be forced to work at differing locations depending on circumstances, objectives and resources. "Nomadicity" (Ciolfi & De Carvalho, 2014) is a term which has been coined to describe people who, enabled by new technology, are not tied to particular working times or locations; studies in Nomadicity concentrate on technologies and users' behavior.

Different aspects relates to tool adoption in POPBL are discussed here including the direction of tool selection of students, categories of tools, stages of tool adoption, rules, division of labour, communities and the assessment of the innovation of students in POPBL.

8.1 SHIFTING FROM POWERFUL GROUPWARE TO AN ECOLOGY OF SMALL ONLINE APPLICATIONS

In the current era, individuals own several computational devices with overlapping and often integrated functions. Tools can be accessed and information processed, manipulated, stored, disseminated and communicated on and to different devices; it is often the same data which is processed on these devices. Users can choose which device and tool to use at particular times or locations; it is interesting to investigate how users choose which device and tool to employ to access a service.

How devices and tools are employed individually and collectively is of great interest to CSCW researchers; studies in this field have been variously called 'learning ecology' by (Bødker & Klokmose, 2012; Kidder, n.d. Rawsthorne, n.d.; Rongbutsri, Ryberg, & Zander, 2012; and Siemens, 2003); 'constellation of technologies' (Rossitto et al, 2014); 'personal learning environments' (Attwell, n.d.; Buchem, Attwell & Torres, 2011; Rongbutsri et al, 2012); and 'networked learning environments' (Jones, 2011). In this section, the author discusses the different kinds of tool were previously adopted and current trends based on his findings and analysis. Based on their characteristics, collaborative tools may be grouped into two types: *professional tools* – expensive, provided by institutions, effective in accomplishing tasks but take a long time to learn; and *personal tools* – free, available online, easy to use but require customisation to accomplish professional tasks effectively. The trend is away from institution-provided to self-subscribed tools as shown in Chapter 2.6. Groupware such as BSCW, Lotus Quick Note and Adobe First Class was used ten or twenty years ago but has since been abandoned. New groupware such as Mahara has been introduced but less successfully than formerly; see Chapter 2 for more information and references. The current tendency is for students to find out for themselves how to deal with the same problems which they do by subscribing to free tools which are mostly single purpose but with multiple functions and platforms and can be integrated into other services such as social networking; thus, the learning environment is composed of several small tools rather than one large multi-purpose tool. Some researchers propose calling this learning environment with a number of small tools an 'ecology', for example 'personalised learning ecology' (Kidder, n.d.; Rawsthorne, n.d.; Rongbutsri et al., 2012; Siemens, 2003). 'Ecology' describes better than 'environment' the connections of selected tools for personalised learning.

8.2 CATEGORIES OF COLLABORATIVE TOOLS

Based on the analysis online tool adoption in POPBL, focusing on according to students' adoption patterns, the tools are grouped into three categories. These are:

- Tools for general POPBL requirements
- Tools for newly emerged requirements
- Professional tools

Rossitto et al, (2014) propose two categories of constellations of collaborative technologies in nomadic settings: '*potential constellation*' and '*aligned constellation*'. If students discuss whether to adopt tools with which they are familiar, it is a 'potential constellation'; if students already have an established package of tools, it is called an 'aligned constellation'.

8.2.1 TOOLS FOR GENERAL POPBL REQUIREMENTS

There are general requirements of tools to support POPBL projects, e.g. asynchronous discussion, synchronous discussion, file-hosting and sharing, shared calendar, writing, and giving presentations. The more experienced students are in POPBL, the better

they understand these requirements. Students establish their own individual practices; their established practices transfer from one project to the next; even though group members may not have worked together previously, they bring their established practices with them with little discussion regarding their selection; if members have similar experiences and practices, selection is ignored at the expense of the details of implementation and application; they may, however, optimise the application of these tools by trying new functions or by adopting them in new ways. Observation shows that these are not usually professional tools; they are adopted initially and primarily for personal use, socialising and entertainment and then adapted to meet their professional requirements. The characteristics of these tools are that they are simple, excellent for one type of task and applications can be shared.

When students form their groups, they usually bring their experience of tool ecology from their previous project to their current one; the new group will consider adopting the tools; this set of tools is called 'potential constellation' (Rossitto et al., 2014, pp. 143–144).

8.2.2 TOOLS FOR NEWLY EMERGED REQUIREMENTS

Students starting a project have to contend with new colleagues, locations, topics, concepts and methodologies; their established practices with communication tools may no longer match their requirements. How students meet these challenges was demonstrated by observation of the two groups; when they encountered new communication requirements not met by their established practices, they sought new tools and appraised them before adopting them. Once established, these tools may also become "tools for common POPBL requirements"; conversely, observation also revealed that if a tool is introduced for which there is no current requirement, it will not be considered, let alone adopted.

8.2.3 PROFESSIONAL TOOLS

Professional tools have no entertainment features. There are professional tools to serve both general and new POPBL requirements. They meet specific requirements which general tools may not; however, they are complex and require more time to both implement and learn. Although professional tools can serve specific requirements effectively and productively, they may be rejected or adoption may fail, particularly if students have an established practice; even if they commit to using the tool, they may still revert to their former practices. Adopting professional tools requires more technical support than general tools.

8.3 THE THREE STAGES OF TOOL ADOPTION

This research focuses on the behavior of students in using collaborative tools to support their projects which they perform at different locations e.g. permanent project room, temporary project room, library, home; and to examine their behavior of adopting tools in their groups. As stated by Bødker and Klokmose, there are three states in which people adopt technologies into their ecology: 'unsatisfactory', 'excited' and 'stable'. They define the 'unsatisfactory state' as a situation that the current adopted technologies are not enough to meet their new requirements and they need to explore new technology. When new technology meets their requirements, students will try the tool out and seek potential applications beyond their current needs. This situation is called the 'excited state'. When they have gained enough knowledge, the tool is employed to its full potential; however, the learning process still goes on for more detail and enhancement of the tool; this situation is called a 'stable state' (Bødker & Klokmose, 2012).

By considering the behaviour of Groups A and B in respect of their tool adoption, the author proposes three stages with two factors as following:

Stage 1 *Selection* refers to the initial steps by which students encounter, then seek more information and subsequently try the tool out. A tool might be introduced by a member who has experience of it. Some tools may be introduced because their functions match their requirements but may still not be implemented. Rossitto et al (2014) argue that members plan and discuss selection and adoption of tools based on the following criteria: the nature of the activity, people involved, location where the tasks will be performed and the time frame of the project. Every new tool introduced into the group requires negotiation; however, it can be unproductive if you have a limited time frame.

Stage 2 *Implementation* refers to what happens after a decision to adopt a tool; students may customise it and develop strategies for its use. A member of the group may assist colleagues by demonstrating or producing documentation on how to use the tool. A tool may need to be restructured or re-customised to meet evolving requirements at different phases of the project. Even though students may put a much effort into implementing a tool. It may still fail.

Stage 3 *Application* refers to the employment of the tool to conduct a project; ideally, most benefits of the tool will accrue to students during this stage most likely by automating processes which are otherwise difficult or time consuming when performed manually.

Members are individually involved at each stage; consensus of the group is required. A group consist of individuals; group performance derives from those individuals. Consensus is the agreement of all members of the group to enable them to achieve a common object. Individuals who have experience of a tool have an important role in establishing the consensus.

8.4 PRACTICE OF RULES AND DIVISION OF LABOUR

Findings relating to rules and division of labour are identified from data analysis in previous chapters. Here the author discuss them.

8.4.1 TWO DIFFERENT STRATEGIES

Groups A and B had different strategies for setting rules for the conduct of their projects. Group A, who were new to POPBL, followed the guidelines of good practice for working in groups; at the beginning of the project, they set up a shared file to maintain roles and enforce rules which were upheld strictly throughout the project; roles and rules originated neither externally nor from one member but from all members. They had had some experience of a POPBL; they understood that a good group environment and processes would expedite their project and ease their learning. In contrast, members of Group B were casual. Although they neither formulated rules nor established roles, roles and rules were innate; tasks were demarcated only when necessary and then willingly and informally. All members understood what was expected of them and processes were transparent. Three different roles affected tool adoption: Group A established a specific role for tool adoption which dominated the selection stage but extended over the second and third stages. The member who was in charge of tool selection in Group A introduced tools to the group; conversely, in Group B there were no fixed roles and all members were able to introduce tools; when a need for a tool arose, a member would search for a suitable tool and introduce it to the group; Spider introduced Zotero, Mac introduced Skype recorder and Scholar introduced Adobe InDesign.

8.4.2 NORMS AS INFORMAL RULES

Group B's socialisation was informal compared with group A's. Group B made fun of and swore at each other, talked about music and leisure activities and exercised together, a strategy which helped members bond and ensured a high level of productivity; by way of contrast, in Group A, there was a minimum of chat and socialisation and they rarely swore; communication regarding their personal interests was rare; they concentrated on their work. Group B took advantage of their freedom and conducted their project casually; antithetically, Group A maintained their bureaucracy believing it necessary for a strong performance. Based on their differing characteristics, it would be reasonable to expect Group A to have adopted institutionally provided tools more often than Group B; contrarily, neither group adopted institutionally provided tools; tools adopted by both groups were similar.

8.4.3 DIVISION OF LABOUR

Knowledge construction is the desired result of POPBL. Knowledge constructed by the group may be new knowledge only for the group (Hansen et al., 1999). Knowledge construction begins when students discus their topic; it continues through problem formulation, observation, experiment and finally expounding the solution in the report. POPBL promotes students' social skills by requiring them to work in groups; social knowledge construction is more complex than personal knowledge construction and requires practicable communication.

In this section, communication during Phase 7 Reporting is examined with particular reference to strategies resulting from demarcation and with particular reference to how communication tools are employed. Both groups demarcated tasks;

Group A maintained formal roles with a fixed structure; they were more institutionalized; group consensus was more important than their individual voices; whilst Group B maintained another strategy; they did not establish fixed roles for individual members but demarcated depending on what was required when it arose. Even when the group reached a consensus, individuals still made their own choices with the agreement of other members. Both groups differently took advantage of their communities. To gain academic competence Group A interacted with their teachers and supervisor; in contrast, Group B interacted with their stakeholder to gain professional and industrial competence. The differences between the two communities influenced how they enacted division of labour.

Groups A and B practiced their report writing similarly; they each held a meeting to agree on content, structure and language and to divide it into sections to be written individually; finally, all members of each group jointly assembled and integrated the sections and edited the report.

Interaction between group members during a task can be differentiated as either cooperation or collaboration; cooperation means working individually to achieve a common goal while collaboration means working together closely; during their report writing, Groups A and B alternated between cooperation and collaboration. During cooperation, some practical issues which arise may be solved by a member individually and be notified to the group but other issues which are more sophisticated should to be dealt during the preliminary meeting; however, they may be referred to the group if they emerge during cooperation. From the practice of Groups A and B, video transcription, writing and reviewing literature were cooperative; meetings were required before and after these actions.

Aspect	Group A	Group B
- Roles	Formal, strict, relied on group rather than individual voice	Informal, when required, group and individual voices equally respected
- Writing demarcation	Group meet to discuss the report including structure, language, and content; they wrote individually but worked collaboratively to aggregate and revise report before submission	Group met to discuss the report including structure, language, and content; they wrote individually and worked collaboratively to aggregate and revise report before submission
- Involvement of Communities	Interaction with supervisor and teacher to gain academic competence	Interaction with stakeholder to gain professional and industrial competence; less interaction with supervisor

Table8-1 Different strategies of division of labour of Groups A and B

8.5 COMMUNITIES IN PARTICIPANT-DIRECTED LEARNING

To whom do students turn for academic and professional advice whilst conducting their projects? From the analysis of his observations, this researcher has identified two strategies: academic and professional. Students new to POPBL tend to adhere to academic practice and implement the suggestions of academic staff; contrariwise, experienced POPBL students are able to seek advice from companies through stakeholders. The choice of communities with which to interact demonstrates the competencies that students want to develop. As discussed in section 2.4.1 Terminology of POPBL, Andersen and Kjeldsen (2015) define three contradictions in the implementation of participant-directed learning:

1. 'Contradictions between the needs and interests of supervisors and students'
2. 'Contradictions between the supervisory function and the obligation of the supervisors to control the result of the students' project work'
3. 'Contradictions between the students' needs and interests and the curriculum requirements'

For new students, the first contradiction might be a problem because they rely heavily on their teachers and supervisors in order to improve their academic skills; however, experienced POPBL students already have experience of the pedagogy and are able to learn from professionals in the field but they may not be taking advantage of what their teachers and institution can offer. As raised by the second contradiction, supervisors have conflicting roles; they are simultaneously facilitators and examiners; students may feel unable to reject their supervisors' advice in favour of finding solutions for themselves; and, are supervisors able to assess dispassionately students who have not heeded their advice? When dealing with POPBL-experienced students, the role of supervisors is clearer; because students seek outside, professional advice,

the supervisory role is primarily to examine although, as propounded by the third contradiction, the necessity for supervisors to ensure that the project complies with curricula requirements remains.

To promote participant-directed learning, institutions encourage students to establish their own rules for the conduct of their project and to appoint members to specific roles; initially students may follow the rules (Group A, for example) but later, they may abandon prescribed orderliness (Group B, for example); if students volunteer and perform willingly, this may prove beneficial.

8.6 THE ASSESSMENT OF INNOVATION OF TOOL ADOPTION ON PROJECTS

The author identifies a contradiction between two aspects of a project.

1. Production: the need to conduct and complete the project.
2. Learning: the new knowledge and skills acquired whilst undertaking the project.

Production may not result in learning; learning may hinder production. In conducting project students need to balance production and learning. If production dominates the project, learning may lessen; students could be adverse to risk and simply repeat established practices. If learning and the new knowledge and innovation which derive from it dominate the project, students may be unable to complete the project satisfactorily. Students need to establish parameters for their learning whilst remaining productive.

Two types of learning take place during a project:

1. Project content including application of theories and concepts deriving directly from the course and theme; and
2. Practicalities to enable the conduct of the project including methodologies, practicalities and tools.

The former is always evaluated along with the end product but the latter is not; it is assumed that the practicalities must be satisfactory. By not assessing tool adoption, students may be tempted to ignore the opportunities for innovation and the benefits which may accrue; they may simply repeat what they have done previously. This was demonstrated by the rejection of Zotero by Group A and its abandonment by Group B.

8.7 SUMMARY

In this chapter, the author has investigated why POPBL students prefer to adopt personal communication tools for their collaborative learning rather than professional ones. Even though professional tools may suite their purposes better, they still adopt single-application, east-to-use tools which must be customized for employment in a professional setting. Communication tools, whether personal or professional which students adopt in order to be able to conduct their projects may be classified into three types based on practice and requirements:

i) Tools for general POPBL requirements
ii) Tools for emerging requirements
iii) Professional tools

There are three stages in the adoption of tools:

a) Selection
b) Implementation
c) Application

A tool will have been adopted successfully students have navigated through all three stages; the adoption of a tool may be abandoned at any stage. There are three social components to the adoption of tools

1) Rules
2) Division of labour
3) Communities

This research reveals two modes of practice in the adoption of communication tools: formally structured and in accordance with what students have been taught as being 'good practice'; informal – seeking tools to meet requirements as they arise. The two approaches illustrate how students' competency develops, one academic and the other professional and industrial. The author concludes that POPBL is founded on the concept of learning through working socially. The author further concludes that learning and working socially are not the same; working socially does not necessarily result in learning; for example, when students rush to meet a deadline, they repeat established practice, thus missing out on the exploration which results in learning. If a group chooses to be adventurous they may be less productive and could fail to complete their project; in conclusion, cognitive development must be balanced against practical achievement.

CHAPTER 9
CONCLUSION

The purpose of this research is to explore how students engage in Problem-Oriented Project-Based Learning (POPBL) adopt online communication tools; effective communication is essential to enable the collaboration required for group learning; additionally, to answer this question two research questions are raised:
Research Question 1: What are the processes of communication tool adoption?
Research Question 2: How does communication tool adoption facilitate or frustrate the project?

9.1 COMMUNICATION TOOL ADOPTION IN PROJECTS

Freedom of what and how to learn are key characteristics of POPBL; proponents stress the benefits. Students, by group consensus, can choose their own approaches to learning in the context of an open-ended problem. Problem domain, assessment criteria and how the project is to be conducted are imposed on students; assessment depends primarily on the academic quality of the project report. When learning is open, i.e. not dominated by the curriculum, teachers or lecturers, students are free to follow their own inclinations. How tools are employed in an open environment is a topic of interest to the Computer-Supported Cooperative Work (CSCW) community.

9.1.1 CHANGES IN COMMUNICATION TOOLS EMPLOYED IN EDUCATION

Educational tools can be classified into two categories: professional and personal. A professional tool is multi-purpose software or groupware; it is complex, expensive and designed for an activity rather than a small task; students can employ a professional tool only if it is provided by their institution. A personal tool has limited scope, is designed for a single purpose; it is easy to use and is accessible from different platforms and devices; it is usually available on free subscription and incorporates entertainment functions; personal tools are readily available to try out and easy to adopt. A tool may be described as 'educational' if it is employed in an educational context. The literature reveals that groupware implementation had been successful in the past but that is not currently so. This researcher argues that, in education, personal tools have displaced professional tools.

9.1.2 THE THREE KINDS OF COMMUNICATION TOOL IN PROJECTS

The author proposes a model to illustrate how students adopt online communication tools in their POPBL projects. Online communication tools for POPBL projects can be classified into three types according to students' tool adoption patterns: tools for

general POPBL requirements, tools for newly emerging requirements and professional tools.

9.1.2.1 Tools for general POPBL requirements

As students gain experience of POPBL projects, they appreciate how online communication tools can support their activities. Practices emerge for the adoption of tools to support various tasks during a project; when they start a new project, they can draw on these established practices; in that case, selection may be unnecessary – they can use their familiar tools immediately; likewise, they may not require support from the institution. Tools of this kind are generally not professional ones, but students discover ways to employ them professionally; the characteristics of such tools are: simple and easy to use, excellent for one type of task and they are easily shared.
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9.1.2.2 Tools for newly emerging requirements

A new project means new challenges. Whilst undertaking a project, unanticipated requirements for online communication tools may emerge. Members quickly seek and appraise new tools before adopting them. If regularly used, they become tools for general POPBL requirements. Tools for general POPBL requirements are usually adopted during group formation; in contrast, tools for newly emerging requirements may be adopted during any other phase. These tools share the characteristics of tools for general POPBL requirements.

9.1.2.3 Professional tools

Professional tools perform work-related or professional tasks; professional tools are specialised. Students tend to shun professional tools because they are complex; familiarisation and setting up take time and effort. Even after implementation and using them for some time, they may still be abandoned. Initial and ongoing technical support needs to be provided in order to encourage students to seek and adopt professional tools effectively.

9.1.3 THREE STAGES OF COMMUNICATION TOOL ADOPTION

Observation of students whilst they are adopting tools reveals three stages: Selection, Implementation and Application. Each stage is influenced by both individual consideration and consensus. 'Individual consideration' refers to a member or members of the group individually using their knowledge and experience to evaluate a tool. 'Consensus' is the sharing by the group of this knowledge and experience to reach agreement to adopt or reject the tool. A tool is fully adopted only if it is used throughout the three stages; otherwise, it can be abandoned at any stage. The time and effort which a group expends on adopting communication tools can vary according to the tool; for example, if members have experience of a tool, they may put less effort into selection and more into implementation and application;

conversely, they may expend much time and effort on searching for and selecting new tools.

9.1.4 TWO SOCIAL PRACTICES WHICH INFLUENCE TOOL ADOPTION

According to Activity Theory, there are three social components affecting activities, namely rules, division of labour and communities. This research found two different practices of the three components which can generate different outcomes at the end of the project.

One practice is to strictly follow the guidelines of good practice for working in groups; at an early stage, they set up and maintain roles and strictly enforce rules throughout the project; roles and rules derive from consensus. Members interact with their supervisor to achieve academic competence. In this kind of practice, one member will usually control communication tool adoption.

The other practice is more casual. Although members neither formulate rules nor establish roles, rules and roles are innate; tasks are demarcated only when necessary and then willingly and informally. All members understand what is expected of them and processes are transparent. In this practice, all members participate in all the main actions including introducing tools into the group. Whenever new requirements emerge, a member immediately looks for a tool and introduces it to the group.

Interaction between group members during a task can be differentiated as either cooperation or collaboration; cooperation means working individually to achieve a common goal while collaboration means working together closely. Observation during group report writing reveals that groups alternate between cooperation and collaboration. During cooperation, some practical issues which arise may be solved by a member individually and be notified to the group but other issues which are more sophisticated are dealt with during the preliminary meeting; however, they may be referred to the group if issues emerge during cooperation. Video transcription, writing and reviewing literature are cooperative tasks; meetings are required before and after these tasks.

One of the main components of POPBL is participant-directed learning; students are encouraged and taught how to formulate their own rules and appoint members to specific roles; initially students may follow the rules but subsequently they may abandon prescribed orderliness; if students volunteer and perform willingly, this may prove beneficial.

9.1.5 FAILURE TO ADOPT PROFESSIONAL TOOLS

Observation reveals that a professional tool may be abandoned during any phase; the tool may be formally abandoned during an early phase; or, it may be abandoned by members individually at different times during later phases of their project. In the

former case, abandonment follows evaluation but in the latter case does not; despite initial evaluation the tool may prove to be unsuitable in practice. Since tool adoption is not assessed, students are able to ignore opportunities for innovation and will not reap benefits which may accrue from tools; they are able to simply repeat what they have done previously.

9.1.6 CRITICAL AND CREATIVE ADOPTION OF THE COMMUNICATION TOOLS

Observation of students in this research has confirmed that there are two types of communication via online tools: 'asynchronous' and 'synchronous'. Asynchronous communication does not require correspondents to be in contact simultaneously; an example of asynchronous communication is a closed group on a social networking tool being used as a forum; the forum is usually linked to a file-sharing tool; members of a project group can independently access information and resources at any time. In synchronous communication, members communicate with each other at the same time; this enables them to perform collaborative tasks whilst they are physically apart; an example of synchronous communication is holding a meeting through the medium of a conference tool. To conduct a project, members of a group need to practise both synchronous and asynchronous communication with appropriate tools customised to meet their particular needs.

9.2 THE INFLUENCE OF TOOL ADOPTION ON PROJECTS AND LEARNING

This section investigates tool adoption in students' projects and how they aid learning. The following, from observation, are the effects of tool adoption:

9.2.1 COOPERATION OR COLLABORATION ARE NECESSARY FOR GROUP LEARNING

Tools to support collaborative learning are different from those to support cooperative learning. Groups may meet face-to-face and keep in touch with each other through the online forum. Observation reveals that practice of two of the main activities – writing and developing ideas – is initially conducted face to face but continued online, requiring, therefore, good coordination.

Collaborative learning ensures that all members work together to find solutions; however, they sometimes work individually, especially when writing; individual members' writing tasks are allocated only after discussions to ensure that the work is in line with their consensus. Knowledge is constructed during discussions; the knowledge thus gained is presented in the writing. Cooperation and collaboration in a project are not exclusive; rather, groups switch between them and combine them.

Some activities need to be performed collaboratively because they require consensus such as selecting writing tools, managing references and deciding on structure, style and layout; handling of references. Within the collaborative framework, some tasks may be more productively performed cooperatively, especially if they are time consuming such as typing, compiling tables, diagramming and placing images. Co-writing is a collaborative activity in which, for practicality, some tasks are usually cooperative.

Cooperation depends primarily on individuals and requires only limited communication; the opposite is true of collaboration. A group may adopt several tools to communicate whilst performing collaborative activities, whether face to face or online; pen and paper, display boards, black- and white boards, computers, projectors, etc. facilitate face-to-face meetings. Both face-to-face and online communication are further facilitated by online communication tools.

From the research the author found that a weak, informal, division of labour and management is good for group learning; a strong or formal division of labour and management requires collaborative rather than cooperative working in which each member performs specific tasks; members will learn much from their own assigned tasks but little from those of other members. The POPBL-experienced group did not formally appoint any member as leader; analysis of members' interaction in the online forum and during face-to-face meetings reveals that the role of leader was taken spontaneously by different individuals during different phases; no member dominated the leadership role throughout the project; not maintaining fixed roles and no leader being formally appointed does not mean that there were no leaders. 'Leadership' does not imply that other members were followers; they may have been valuable to the project as innovators, problem solvers, by resolving conflicts or by inculcating the necessity for time management. No single member dominated the project; leadership was never seized; rather, leaders emerged spontaneously. A requirement of communication tools is that they must be able to support different or changing styles of group working, whether division of labour is weak or strong and whether leadership is formal or informal. Participation by all members is a requirement for group learning; friendship can be a stimulant to participation; furthermore, if members socialise, it encourages them to be transparent with each other and by extension, communication will be more effective; members will be aware of each other's strengths and weaknesses.

The POPBL-experienced group demonstrated their collaboration, creativity, performance and results; they gained the highest possible score; in contrast, their learning approach, as revealed by their attitudes to communication tools, was insignificant. Left to themselves, the group's selection and adoption of communication tools showed that they preferred to inhabit the familiar; entertainment and inertia governed their preferences and limited their options; they chose short-term convenience over long-term advantage. It would be interesting to discover whether their learning approach with regard to communication tools is synecdoche for their learning approach in general.

9.2.2 THE CONTRADICTION OF LEARNING AND WORKING IN PROJECTS

POPBL projects enable students to learn through solving open-ended problems. The author argues that learning and working socially are not the same; working socially does not necessarily result in learning; for example, when students rush to meet a deadline, they repeat established practice thus missing out on the exploration which results in learning. If a group chooses to be adventurous they may be less productive and could fail to complete their project; in conclusion, cognitive development must be balanced against achievement.

9.3 ROBUSTNESS, VALIDITY AND LIMITATIONS

How reliable is mixed-method research? How do qualitative and quantitative research methods affect both data collection and analysis? The term 'robustness' is employed to discuss the reliability of mixed-method research. A definition of 'robustness' is provided by Baber (1994):

"The robustness/ruggedness of an analytical procedure is a measure of its capacity to remain unaffected by small, but deliberate variations in method parameters and provides an indication of its reliability during normal usage"

Discussion of the robustness of a piece of research encompasses

- validity: an indication of the reliability of the analysis
- limitations: the weak points of a piece of research; it may be impossible to overcome limitations because of practice or concepts

A piece of research is required to incorporate discussion of its own validity and limitations.

Findings in this research derive from observational data which is interpreted through Activity Theory. Activity Theory sheds light on human behavior; data from the pilot study provided an overview which indicated that the topic of this paper would be worthy of further investigation; in addition, literature searched and current knowledge are discussed alongside the findings.

9.3.1 OBSERVATIONAL DATA

The main data was analysed through activity systems to establish a deep understanding of how students employ digital communication tools to support their projects. Data from two groups was extracted from observation notes and online environments including their online fora, shared files and shared calendars. A limitations in the study of Group A was that they conducted their project in Danish, a language not understood by the author; some observational data from Group A derives from

interviews in English following their regular meetings; other data derives from translations into English of online data including their fora and shared files.

9.3.2 SURVEY

The survey provides an overview of communication tools and physical locations such meeting rooms, library and home as utilised in POPBL projects. All students surveyed employed communication tools and physical locations similarly. Three limitations are identified in this survey: it surveyed many tools along with the extent to which they were employed; as a result, questions are complex; the second limitation is the small number who participated fully: only 250 despite more than 3,000 being invited. It did cover all faculties though; the results were similar to those from the literature search and observation. The last limitation is that the survey was carried in 2011 and might be considered to be out of date; however, the results do match the practices of current students as revealed by observation and from the literature.

9.3.3 LITERATURE

The literature search was discussed in Chapter 2; the search was for communication-tool adoption by POPBL students since 1999. The search revealed that there has been a dramatic change in the communication tools employed during this period. Results of the literature search are discussed alongside the findings of the research; each offers confirmation of the other. It is a limitation of this research that only resources in English were considered; other languages including Danish were excluded.

CHAPTER 10
PUBLICATIONS OF THE RESEARCH

10.1 PAPER 1: ICT SUPPORT FOR STUDENTS' COLLABORATION IN PROBLEM AND PROJECT-BASED LEARNING

The preliminary research was analysed and presented as a symposium paper entitled "ICT support for students' collaboration in problem and project based learning" (Rongbutsri, Khalid, & Ryberg, 2011); see Appendix C.

The paper can be summarised as follows; the research found that students had positive attitudes towards using technology in their projects and had already adopted variety of tools in their private lives, e.g. a social network (Facebook), conference systems (Skype and What's app) and a file-sharing tool (Dropbox). They also adopted these familiar tools in their professional activities, namely projects. Due to the various locations at which they worked on their projects, they required communication tools. Students decided themselves whether tools met their requirements and whether or not to adopt them. They sometimes found more suitable free-subscription software. Complex tools were rejected even though they may have better suited their requirements. Students were good at adopting communication tools for their social lives but were less adept at evaluating and adopting tools with the potential to facilitate their academic or professional activities. They encountered problems adopting tools for their projects, using only a limited number with little variety. There was potential for them to adopt professional tools to enhance their projects but they lacked adequate technical support.

10.2 PAPER 2: MAPPING STUDENTS' USE OF TECHNOLOGIES IN PROBLEM-BASED LEARNING ENVIRONMENTS

The preliminary research was re-interpreted and presented as a conference paper entitled "Mapping Students Use of Technologies in Problem Based Learning Environments" (Rongbutsri et al., 2011); see Appendix D.

The paper illustrates various tools that students adopted for their projects including locations where they used them. Tools are identified along with the extent of adoption to establish whether they are part of students' normal practice or whether they are employed for special tasks only. The project room was the normal location for meetings. Computers were employed both for working together in the University and for working independently at home. Free-subscribed tools are adopted in their personal lives before coming to project group. Some easy-to-use single-purpose applications are quickly adopted while complex university-provided

ones require more time. Ease of use is the major factor in selection communication tools for adoption.

10.3 PAPER3: FACILITATING ADOPTION OF TECHNOLOGIES FOR PROBLEM AND PROJECT BASED LEARNING ACTIVITIES

The author and his colleagues mapped tools into the project phases of Model IV; the concept was proposed at the Networked Learning Conference 2013 in a paper entitled "Facilitating Adoption of Technologies for Problem and Project Based Learning Activities" (Khalid et al., 2012); see Appendix E.

The paper is summarised as follows; POPBL students need technical support to allow them to adopt tools effectively and productively. One way to support them is to provide lists of tools. The authors broke the project phases down into sub-activities; there two main kinds of activity: phase activities and common activities. Some activities carried on for the entire project are called common activities, e.g. reading, file sharing and discussion; other kinds of activity are performed only during a particular phase of a project. The author lists tools from literature and other sources which have the potential to be employed in projects; the list could be provided to students to enable them to appreciate the variety, benefits and potential of a tool-mediated project.

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APPENDICES

Appendix A. Student contract

Contract for group observation

Under PhD project 'ONLINE COLLABORATIVE TOOLS IN POPBL'
At Faculty of Humanities, Aalborg University
Recordings:
During Fall semester of 2012. I have agreed with the researcher - Mr.Nikorn Rongbutsri that when I work with my project group during the semester I may be recorded by voice recorder, camera, but not video camera. I give access to the researcher to my group's environments e.g. Facebook group, Dropbox shared folders, Zotero folders and etc which are used during the project.
Data Security:
I understand that the raw data is stored subsequently under the responsibility of the researcher. It is retained a non-anonymised raw data. Raw data are archived indefinitely unless an individual agreement concluded on deletion of raw data.

Use of data for research purposes: Use of raw data for research purposes including processing of raw data, analysis and transcription, but does not include *research dissemination.*
Raw data version will be used for *research purposes* only with explicit authorization from the steering committee for the project. Thus, the authorization is not given to research groups or centers and individual researcher may under no circumstances disclose, display or leave the material to others unless they also have acquired individual explicit permission to access the material.
Research Dissemination: The dissemination of research purposes such as reproductions of audio and / or visual material, for example, articles or conference presentations. In any type of research dissemination material will be anonymized, visually, aurally and textually. Therefore my face is obscured in any visual representation, auditory references to the name or other identification options removed. This also applies to textual representations, such as transcripts or article text.
Data Use:
I am aware that data which is collected from my project group are thus used only for research purposes and may **not be** used for example in connection with any examination complaints.
Data can be used in academic publications and can be used by researcher associated with the project, once established agreement with the researcher.

Signature: ……

Name: ……

Date: ……
Email: ……

Appendix B. Online tool in POPBL project Suyvey questions

Dear AAU Student,

We would like to design and develop new integrated computer and mobile application for AAU students to support project collaboration.
Your response would help us learn how students at AAU use web-based and mobile-based communication tools for project collaboration. This questionnaire is expected to take about 15-minutes to fill in. Questions are about your use of online tools, computer and mobile for project collaboration.

Responses will be strictly used for academic and research purposes only, data will be anonymized for dissemination.

Thank you for your time.

Md. Saifuddin Khalid, Nikorn Rongbutsri, Thomas Ryberg
eLearning Lab, Department of Communication and Psychology, Faculty of Humanities

1. Background

Gender

(1) ❑ Male

(2) ❑ Female

Nationality

(1) ❑ Danish

(2) ❑ Other_____

Faculty

(1) ❑ Faculty of Social Sciences

(2) ❑ Faculty of Humanities

(3) ❑ Faculty of Engineering and Science

(4) ❑ Faculty of Medicine

Semester

(1) ❑ 1-2

(2) ❑ 3-4

(3) ❑ 5-6

(4) ❑ 7-8

(5) ❑ 9-10

Student type

(1) ❑ Full Time

(2) ❑ Part Time

(3) ❑ Exchange Student

(4) ❑ Other

How many semesters have you been in Problem Based Learning Environment (e.g. Aalborg, Roskilde) including Spring 2011?

(1) ❑ 1

(2) ❑ 2

(3) ❑ 3

(4) ❑ 4

(5) ❑ 5

(6) ❑ 6

(7) ❑ 7

(8) ❑ 8

(9) ❑ 9

(10) ❑ 10

(11) ❑ 11

(12) ❑ 12

2. Mobile life style

Which kind of mobile do you have?

(1) ❑ Apple iPhone

(6) ❑ Apple iPad

(2) ❑ Android Phone

(3) ❑ Other kind of Smartphone

(7) ❑ Other kind of tablet (e.g. Samsung tab)

(4) ❑ Not a Smartphone

(5) ❑ I am not sure

(8) ❑ I don't use a mobile device.

Do you access internet on you mobile?

(1) ❑ Yes, I use data package (e.g. Pay separately for 2 GB internet monthly)

(2) ❑ Yes, I use “Pay as I go” (e.g. Charged every time I use)

(3) ❑ Yes,use WiFi only

(6) ❑ Yes,included in my subscription (e.g.monthly fee includes voice, SMS and internet cost)

(4) ❑ No, I do not use internet on my phone, but it is possible

(5) ❑ No, internet is not possible on my phone

Have you downloaded any extra application on your phone?

(1) ❑ Yes, I do it myself

(2) ❑ Yes, with the help of friends

(3) ❑ Yes, with the help of technicians

(4) ❑ Not yet, but it is possible in my mobile

(5) ❑ No, it is not possible for my phone

(6) ❑ No, I am not sure about it

For how many years have you been using internet on your mobile? ____ years.

3. Nature of Collaboration

How many members were there in your last project group (Spring 2011)?

Group Size

__

Where and how often did your group meet to do project work (Spring2011)?

	Almost Always	Often	Sometimes	Seldom	Never
Project/Meeting Room	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑
Supervisor's Office	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑
Canteen	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑
Library	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑
Other Places within AAU	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑

	Almost Always	Often	Sometimes	Seldom	Never
Home	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑
Cafe	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑
Other Places Outside AAU	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑

Where and how frequently did you work on your project activities alone (Spring2011)?

	Almost Always	Often	Sometimes	Seldom	Never
1. Project / Meeting room	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑
2. Supervisor office	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑
3. Canteen	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑
4. Library	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑
5. Other place within AAU	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑
6. Home	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑
7. Café	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑
8. Other place outside AAU	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑

Personal mobile (mobile phones, smartphones, tablets, iPads) functionalities can facilitate project collaboration

(1) ❑ Strongly Agree

(2) ❑ Somewhat Agree

(3) ❑ Not sure

(4) ❑ Somewhat Disagree

(5) ❑ Strongly Disagree

Where do you use "online tools" using mobile or computing devices?

	Almost always	Often	Sometimes	Seldom	Never
Project / Meeting room	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑
Supervisor office	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑
Canteen	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑
Library	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑
Other place within AAU	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑
Home	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑
Café	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑
Other place outside AAU	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑

4. Tools

Please select your state of use for the following web applications.

	I don't know about it	I know about it BUT I am not interested	I know about it AND I plan to try it someday	I tried it BUT I don't need it	I tried it AND I might use it later	I am using it BUT I shall stop soon	I am using it AND I shall continue using it	I stopped using it anymore	I stopped using it but I may use it later
Wiggio	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑	(7) ❑	(8) ❑	(9) ❑
Google Groups	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑	(7) ❑	(8) ❑	(9) ❑
Google Docs	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑	(7) ❑	(8) ❑	(9) ❑
Google Calendar	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑	(7) ❑	(8) ❑	(9) ❑
MindMeister	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑	(7) ❑	(8) ❑	(9) ❑
Mindmap.com	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑	(7) ❑	(8) ❑	(9) ❑

	I don't know about it	I know about it BUT I am not interested	I know about it AND I plan to try it someday	I tried it BUT I don't need it	I tried it AND I might use it later	I am using it BUT I shall stop soon	I am using it AND I shall continue using it	I stopped using it anymore	I stopped using it but I may use it later
Dabbleboard	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑	(7) ❑	(8) ❑	(9) ❑
Delicious.com	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑	(7) ❑	(8) ❑	(9) ❑
Digg	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑	(7) ❑	(8) ❑	(9) ❑
Diigo	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑	(7) ❑	(8) ❑	(9) ❑
Dropbox	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑	(7) ❑	(8) ❑	(9) ❑
Box.net	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑	(7) ❑	(8) ❑	(9) ❑
Flickr	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑	(7) ❑	(8) ❑	(9) ❑
FastStone	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑	(7) ❑	(8) ❑	(9) ❑
SlideShare	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑	(7) ❑	(8) ❑	(9) ❑
Doodle	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑	(7) ❑	(8) ❑	(9) ❑

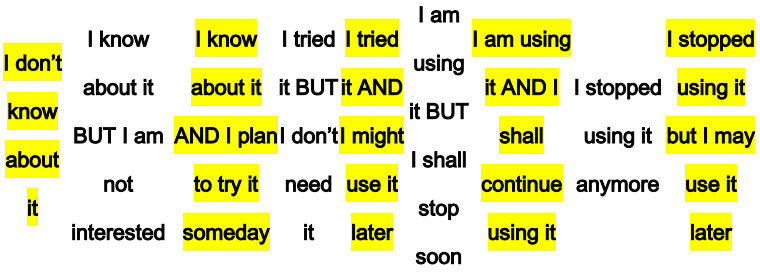
	I don't know about it	I know about it BUT I am not interested	I know about it AND I plan to try it someday	I tried it BUT I don't need it	I tried it AND I might use it later	I am using it BUT I shall stop soon	I am using it AND I shall continue using it	I stopped using it anymore	I stopped using it but I may use it later
SignApp Now	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑	(7) ❑	(8) ❑	(9) ❑
Facebook	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑	(7) ❑	(8) ❑	(9) ❑
LinkedIn	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑	(7) ❑	(8) ❑	(9) ❑
Blogger.com	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑	(7) ❑	(8) ❑	(9) ❑
Wordpress	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑	(7) ❑	(8) ❑	(9) ❑
Twitter	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑	(7) ❑	(8) ❑	(9) ❑
EtherPad	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑	(7) ❑	(8) ❑	(9) ❑
Evernote	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑	(7) ❑	(8) ❑	(9) ❑
MS OneNote	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑	(7) ❑	(8) ❑	(9) ❑
Skype	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑	(7) ❑	(8) ❑	(9) ❑

	I don't know about it	I know about it BUT I am not interested	I know about it AND I plan to try it someday	I tried it BUT I don't need it	I tried it AND I might use it later	I am using it BUT I shall stop soon	I am using it AND I shall continue using it	I stopped using it anymore	I stopped using it but I may use it later
MSN Messenger	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑	(7) ❑	(8) ❑	(9) ❑
Yahoo Messenger	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑	(7) ❑	(8) ❑	(9) ❑
Basecamp	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑	(7) ❑	(8) ❑	(9) ❑
iGroups.dk	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑	(7) ❑	(8) ❑	(9) ❑
Lectio.dk	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑	(7) ❑	(8) ❑	(9) ❑
Gmail	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑	(7) ❑	(8) ❑	(9) ❑
Hotmail	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑	(7) ❑	(8) ❑	(9) ❑
Live.dk email	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑	(7) ❑	(8) ❑	(9) ❑
Zotero	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑	(7) ❑	(8) ❑	(9) ❑

	I don't know about it	I know about it BUT I am not interested	I know about it AND I plan to try it someday	I tried it BUT I don't need it	I tried it AND I might use it later	I am using it BUT I shall stop soon	I am using it AND I shall continue using it	I stopped using it anymore	I stopped using it but I may use it later
TeamViewer	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑	(7) ❑	(8) ❑	(9) ❑
LogMeIn	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑	(7) ❑	(8) ❑	(9) ❑
SoundScriber	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑	(7) ❑	(8) ❑	(9) ❑
Prezi	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑	(7) ❑	(8) ❑	(9) ❑
Pageflakes	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑	(7) ❑	(8) ❑	(9) ❑

Please select your state of use for the following AAU provided web applications.

	I don't know about it	I know about it BUT I am not interested	I know about it AND I plan to try it someday	I tried it BUT I don't need it	I tried it AND I might use it later	I am using it BUT I shall stop soon	I am using it AND I shall continue using it	I stopped using it anymore	I stopped using it but I may use it later
FirstClass	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑	(7) ❑	(8) ❑	(9) ❑
Moodle	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑	(7) ❑	(8) ❑	(9) ❑
Quickr	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑	(7) ❑	(8) ❑	(9) ❑
Adobe Connect	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑	(7) ❑	(8) ❑	(9) ❑
Mahara	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑	(7) ❑	(8) ❑	(9) ❑
AAU email	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑	(7) ❑	(8) ❑	(9) ❑
AAU Library online database	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑	(7) ❑	(8) ❑	(9) ❑
Projekter	(1) ❑	(2) ❑	(3) ❑	(4) ❑	(5) ❑	(6) ❑	(7) ❑	(8) ❑	(9) ❑



VBN (1) ❑ (2) ❑ (3) ❑ (4) ❑ (5) ❑ (6) ❑ (7) ❑ (8) ❑ (9) ❑

Please write names of AAU provided web applications which are not mentioned above.

Which other web applications have you TRIED for any academic use or communication?

Is there anything that you would like to share with us?

_____

Please provide your name and email for prize competition or further research on the project.

Name

_____

Email

_____

Appendix C. Conference paper 1

MAPPING STUDENTS USE OF TECHNOLOGIES IN PROBLEM BASED LEARNING ENVIRONMENTS

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This paper was included in Proceedings of the 19th International Conference on Computers in Education -ICCE 2011 at Chiang Mai.
Thailand, 2–4 December 2011. Yu, F-Y., Hirashima, T., Supnithi, T., & Biswas, G (eds.), ISBN: 978-61612-0-189-0.

Abstract

This paper aims to understand how students use technology to enhance their learning in problem-based learning environments. The research methodology is based on both qualitative and quantitative studies. The results are based on students' interviews, a survey and students' reflections in course-related blog posts; they show that students have positive perceptions toward using technologies in problem-based learning environment.

Introduction

There are number of studies concerning the digital natives or the "Net generation" (Sandars & Morrison, 2007). Some researchers claim that the Net generation- they have different brain structure, different learning practice, and different knowledge perception from the previous generation (Prensky, 2001). This is because of the impact of technologies in daily life since they were born. The digital natives or the Net generation, are argued to be a part of the creative and participatory culture where they produce, re-mix and develop advanced-learning capabilities through their informal use of technologies. Therefore, it has been claimed that we need to fundamentally rethink about the entire educational system to accommodate and cater to the needs of the digital natives or the Net generation (Prensky, 2001). Firstly, because of their advanced skills of using technologies, but also because they are bored with traditional education; they want learning environments which respond to their rich, varied and advanced use of technologies. However, it has become increasingly clear that the notion of a homogenous group of young people with particular traits and a general disinterest in education is somewhat misleading. While we can find differences between generations, there are equally pronounced differences within the generations assumed to be the Net generation. Likewise, empirical studies seem to suggest that their use of and creativity with technology is of a more mundane nature. Therefore, there is a need for more detailed knowledge on how students actually use technologies within a higher education context than these metaphors can provide us with. Students have come to study and within higher education we educate and train people to be ready for their future profession, whether to industry, public sector or academia (Moesby, 2002). Nowadays, students use many kinds of technologies in their daily life including for learning activities in both formal and informal learning contexts. As institutions or educators, we need to provide support for students to let them use what tools they are comfortable with. It is a challenge for student to use technologies for academic purposes. Therefore, in order to provide better facilitate and support, we need to understand how students use technologies to enhance their learning. To understand the particular setting in which the study took place we will briefly present some notes on the pedagogical model of Aalborg University (the Aalborg PBL model).

Problem-based learning in Aalborg University

Aalborg University has employed a PBL model since its establishment in 1974. This has been become known as the Aalborg PBL-model and also referred to as problem oriented project pedagogy (POPP)(Lone Dirckinck-Holmfeld, 2002a). In POPP, the students define real-life problems, plan and perform to achieve the projects' goal by themselves, but work closely with the project supervisor who acts as a facilitator. This is where POPP differs from traditional PBL(Lone Dirckinck-Holmfeld, 2002a) which students have to work in pre-defined problems or tasks and under control of teachers. Students in the POPP environment do not only learn about the domain content but they construct their learning from group by working collaboratively in their project time. However, they rather aim at the learning outcome, not to solve the project problems.

Methodology

We have engaged in different types of data collection (both qualitative and quantitative) to understand how students use technologies to support their learning. We launched an online survey on 30th May 2011 for the entire university, as to get an overview of students' use of technologies in different domains - across four faculties. We have analyzed or roughly categorized more than a hundred blog posts (narrative analysis) which were about how students use technologies in relation to courses and to support their problem oriented group work. The aim of this analysis was to gain an overview and a better understanding of the tools they use, and their attitude towards the various tool. The blog posts were written in Danish and were translated using *Google translator* (also cross-read by a native Danish speaker to avoid misinterpretations (one of the authors). We will discuss the results of the narratives in section 4. In addition we have followed a project group from April to May 2011 to get a deeper understanding of how they use technologies in different situations. We discuss their learning practices in section 5. In this way we have gathered data at three different levels of scale and for different analytic purposes – across faculties (survey - quantitative), within a semester (blog posts – analysis – semi-quantitative categorisation coupled with more analytic, interpretavist readings of the posting) and an ethnographical inspired observations and interviews with a small group of students (group work – qualitative deeper understanding of particular uses of technology)

Survey result

On 30th May 2011, we had launched the survey by sending email invitations to more than 3,000 students randomly from 15,000 students in the university. After the deadline (10th June 2011) we had got 254 completed replies. We have got replies from all 4 faculties: Social Science 25.7%, Humanities 28.1%, Engineering and Science 41.6%, and Medicine 4.6%. Engineering and Science is the big faculty and Medicine is a new faculty. There were 80% of Danish students. However, most of the foreign students were from European countries. The survey was divided into 4 sections: Background (gender, nationality, faculty, number of years of PBL experienced), Mobile life style (owning mobile, Internet on mobile), Nature of collaboration (size of working group, places to work, places to use computer devices for working), and Tools (level of awareness to personal-acquired tools, and institution-provided tools) but we will not discuss about mobile life style in this paper. In the Nature of collaboration, we found that mostly students they form group with 5 members but that is because most of them are in the early year of study and group will be smaller when they go in the higher year. Students meet and work together at different places. Mostly students prefer to work at a project or meeting room at the university but it was small number in faculty of Humanities because they cannot provide enough project rooms for students so the Humanities-students prefer to work together at one of their homes. After assigning task, they prefer to stay home to work alone. It reflects to our interview which found that most of students have the internet connection at home. They can stay connected when they work alone at home. In the last section about tools that they acquire and the university provides for them. We gave them a list of tools which can be classified into 2 categories: personal tools and academic tools. Personal tools are used for their personal life but they also can be adopted to be used for academic purposes, for example, Facebook, Skype, MSN messenger, Dropbox, Twitter, and etc. The second kind of tools is academic tools which are specially for collaboration or academic use, for example, Google docs, Wiggio, Diigo, Prezi, and etc. The survey result shows that students use varieties of personal tools for their academic task, for example, they use Facebook, Skype,

Please select your state of use for the following AAU provided web applications. - AAU email	Percent
I don't know about it	3.5%
I know about it BUT I am not interested	7.7%
I know about it AND I plan to try it someday	2.7%
I tried it BUT I don't need it	6.2%
I tried it AND I might use it later	4.6%
I am using it BUT I shall stop soon	7.7%
I am using it AND I shall continue using it	66.2%
I stopped using it anymore	0.8%
I stopped using it but I may use it later	0.8%
Total	100.0%

Figure 1: States of using the institution (AAU) provided email system

Dropbox for their collaboration and communication. The email system has been used as a common communication tool within an organization. From the interview we found that the email system is used for communication between students and also with teachers or supervisors. We have asked the students from a survey question about the use of the institution-provided email system. The result is shown in figure 1. It is quite surprise that some students do not even know or they have stopped using it. They may have some way else to get information about the classes without using the email system.

Students who are in the Net generation, they use varieties of digital tools for their personal life. However, they do not use or know much about academic tools when they are new to academic as their professional life. The institution expects students to use collaboration tools to support their work. Even though, the tools have been proved and have potential to enhance their work, but students need to be facilitated in order to adopt the tools.

Students' narratives

We have collected narratives from the first semester students. We have got 133 student's replies with 51 males and 82 females. They were asked to write blog about using tools for their learning and project collaboration at the end of the semester. At the beginning of the semester they had been introduced to a number of tools for project collaboration by the institution, for example, Moodle and Mahara which are provided services by the university. Apart from this institution-provided tools, they were very briefly introduced to some web 2.0 tools e.g., Evernote, Skype, Etherpad, Google services (Google docs, Google wave, Google calendar), Doodle, and Wiggio. Students wrote in different stories under the theme of using tools for project collaboration. We have divided attitude of each tool from each postings into 8 categories as follows 1) Know it, 2)Tried it, 3) Like it, 4) Dislike it, 5) Indifferent, 6) Use but not specify attitude, 7)Use or know but still confuse, and 8) Use or know but not for this semester. From these states, we can identify the students' level of the using for tool. We (2 researchers and 1 Danish researcher) read the blogs individually and classify them into either one of the eight states for each tool, then we compared the result and adjusted into a single table. The following is the result of the narrative analysis.

- *Moodle*. The institution provides Moodle service for communication, and sharing course materials between teachers and students. There were 127 students wrote about the use of Moodle and most of students like Moodle but anyway, there are some comments about difficulty to navigation and accessing to information as in the quotation '*Moodle is well structured, but it is messy in the way that documents and PowerPoints are not in one place. I think I spend more time on Moodle than it really is necessary because I often have problems and to find the various files.*'(a female student's blog).

- *Mahara*. The institution provides the Mahara service for students and teachers and expected it to be used as a social network and to support group work. There were 128 students wrote about the Mahara service. Most of students have *bad impression* on the Mahara service. They reflected it was too complicated and most of them have already used Facebook as a social network so they did not find any need for the Mahara services.
- *Dropbox*. The students were introduced to Dropbox to share files. It is quite successful. Most of students wrote about using Dropbox and almost of everyone like it especially user-friendly aspect. There was a person did not like it because his group wanted tool which allows editing documents simultaneously then they preferred to use Google docs.
- *Facebook*. There were 115 students who wrote about using Facebook and Almost everyone like it. There was a person did not like Facebook because he afraid of losing his privacy, but he prefers to use Skype which is not opened to unknown person.
- *Skype*. There were 51 wrote about using Skype for their project work. Most of students like it and others know it but do not use it.
- *Google services* (includes Google docs, Google wave, Google Calendar, and Google group). There were 94 replies about using Google services and most of students like Google and there are 2 students dislike Google because did not see any useful for the project.

From the narratives, we can see that institution-provided tools were highly adopted into practice. The pressure from teachers or institutions may be the reason of the adoption. However, if students did not find needs, they also reject to use. Personal tools which are familiar for students also were adopted into academic activities. They learn fast to use the tools for professional activities. Personal-acquired collaboration tools are also adopted into their project work collaboration; they may know about the tools from institution, friends, or other social. However, it takes sometimes for students to learn and make sure about tools before adoption to their practice.

Focus group observations and interviews

We had followed a group with 5 members. They were in the second semester of the first year. They had got project about work place communication. They decided to apply video analysis as the main methodology for the project. They made a video clip on interview a company-manager. They started their project from February and ended in May 2011. They maintained 3 strategies of working namely: the group assignments, sub-group assignments, and individual assignments. There were 2 from different city which takes 45 minutes by train to arrive the university so face-to-face meeting every time is expensive. The faculty cannot provide students enough project rooms. They met at university twice a week at a meeting room, canteen or some common area which can sit and work together. Many times they worked at home. They use tools for communication when they were at different locations. They defined a closed-group in Facebook to discuss and keep track of the project. They usually put assignments, schedule, feedback from the supervisor on the closed-group Facebook. Skype was used when they need conference. Dropbox was used all the time for file-sharing. To avoid concurrent editing, they had to maintain version of files on Dropbox. They were very impressive on Dropbox and Facebook for project work support. They wanted to try new tools, for example, Zotero but they thought they did not have time to try. Even though, they know it will benefit their working. There was a member in the group who usually introduced new tool to the group. They need to make sure before adopting any new tools into their working. The group has a good impression on using technologies to support their group work. They can use different technologies in different situations and for different purposes. However, if they know a new tool; even though, they know it is useful for their work but they need time to learn before adopt the tool; sometimes they reject to use the tool. In order to let students adopt a tool for their academic activities, we need to provide facilitation. They can get help, if they are not sure about using the tool.

Conclusion and Discussion

The results of survey, the narratives analysis, and focus-group observation and interview show that these students, who are claimed as the Net generation; they have good attitude on using technologies. Technologies have become a part of their daily life. They are good in using technologies which they use for their personal life (e.g. social network, communication tools, and social-media sharing tools) and then they can also to some degree adopt these tools into their professional life (e.g. document editor, reference management tools, reflection tools, file sharing tools, conference tools, resource management and scheduling tools). The survey result shows that student work at different location, they need to stay connected by using technologies (e.g. social network, conference tools, and file sharing). The narrative analysis shows that even we provide tool for students but they may not adopt if they cannot find any need (Mahara). On the other hand, if they find needs and it is easy to use, they will adopt it very soon (Dropbox). The observation says even though they aware about the useful of a tool for their professional but if it is complicated or they have no

experienced, they also reject to use. Therefore, they still need guidance to adopt more advanced technologies into their professional. It is opened for students in Problem-based learning environment (Aalborg PBL model) to use any tool to support their learning. However, institution should provide facilitation for students who need on both institution-provided and personal-acquired tools. They should be introduced into varieties of tools with how to get facilitation then there is higher possibility that they will adopt the tools to their professional life.

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Appendix D. Conference paper 2

ICT SUPPORT FOR STUDENTS' COLLABORATION IN PROBLEM AND PROJECT BASED LEARNING

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Abstract

This paper reports and analyses quantitative and qualitative data from a study, which seeks a better understanding of how students use various technologies to support their project collaboration activities in a problem and project based learning environment. More generally the aim of the study, and the present paper, is to shed light on students' technology practices within higher education – particularly in relation to problem and project based learning. The reasons for undertaking these studies are that we aim to develop a mobile application to support the students' problem and project based learning. The methods are an online survey, narrative reflections, observations and interviews. The analysis reports the differences in collaboration practices of students with different levels of experiences with the pedagogy and students from different faculties at Aalborg University. The results show students in problem and project based learning environment use several tools to support their group work and they have potential to adopt mobile technology to enhance their group work collaboration. Additionally, the results also lead to discussions about how to provide a better group working environments, whether institutions should provide applications with full functionalities or facilitate students to use tools which are available on market either free or commercial services.

Introduction

A number of studies have discussed the notion of digital natives or the "Net generation", i.e. the generation who were born after 1982 (Sandars & Morrison, 2007). Some have claimed that the Net generation kids have different brain structures, different learning practices, and different knowledge perception from the earlier generation (Prensky, 2001). This is attributed to the impact of technologies in their daily life since their birth. Digital natives or the Net generation are argued to be part of a creative and participatory culture where they produce, re-mix and develop advanced learning capabilities through their informal use of technologies. Therefore, it has been argued, that there is need for fundamentally rethinking the entire educational system to accommodate and cater to the needs of this generation (Prensky, 2001). Firstly, because of their advanced skills, but also because they are bored with traditional education and want learning environments which reflect their proclaimed rich advanced use of technologies. . However, it has become increasingly clear from many studies that the idea of a whole generation of digitally very literate students is problematic and misplaced. While students do use a variety of technologies, it is also becoming clear that they find it more difficult using technology as a means to support their learning than the notion of 'digital natives' would suggest (Bennett & Maton, 2010, pp. 321–331). Rather than assuming that there is a generation of digitally literate students entering the university, there is a need to enhance our understanding of how university students actually use technologies to enhance their learning. This study therefore aims at exploring the patterns of students' collaboration (project work) and their use of e.g. web 2.0 tools in problem and project based learning environments. The aim is to achieve a better and more nuanced

understanding of university students' use of technology and with a particular focus on learning in problem and project based learning environments.
Some of the main characteristics of problem and project based learning (e.g. as practiced in Aalborg University) are that students collaborate in groups over an extended period of time to produce a shared written product (project report) reflecting their work with their problem. This is self-directed and student-centred learning, where students are in charge of the learning process. For example they choose what problem to work with and how (both in terms of choosing theory and methods, but also in relation to managing the collaboration as a process)(Kolmos, K.Fink, et al., 2004).
As mentioned, one of the goals of the research project in which these data have been collected is to develop a mobile application to support students problem and project based learning group work collaboration which may support either face to face or distance group work. A high level of student-control combined with a high level of technological competence would seem to suggest that questions of how to use technology for project work are better left to the students. However, as indicated above, and as our data and analysis reveal, this might not be so straightforward. Therefore, we will discuss what strategy institutions should take in relation to providing virtual space for problem and project based learning group work collaboration, which are relevant when aiming to develop new software for the students. Should institutions provide applications with full function services or should they provide support for and guide students in taking advantage of external services which are available?

Problem and Project Based Learning

Problem based Learning (PBL) is based on social constructivist theory. It provides framework to form pedagogies take strategy on self-direct learning, and social interaction as its strategy. Students not only get the respective knowledge of academics but also acquire social skills and critical thinking. Aalborg University has employed this PBL model since 1974, which is also referred to as problem oriented project pedagogy (POPP)(Lone Dirckinck-Holmfeld, 2002a). In POPP, the students themselves define the problems to engage with and also how to organize this project work (theoretically, methodologically and practically), but work closely with a project supervisor. Ownership of the problem is where POPP differs from traditional PBL (Dirckinck-Holmfeld, 2002). This is what we refer to as problem and project based learning – there is a product (project) which is based on continuous inquiries into a particular problem and discussions and negotiations of the problem itself.
Students in Aalborg University have to do group projects every semester. Aalborg University therefore has some experience adopting technologies to support student groups e.g. by using Lotus Quickplace, Moodle and Mahara (Kolb & Kolb, 2009). The university has a strong infrastructural support for physical space for group work discussions within each department and libraries, uninterrupted wireless Internet connectivity and discipline specific technological resources in different departments.

Methodology

To answer the research question, we chose a multi-method approach combining quantitative and qualitative methods to understand how students use technologies to support their problem and project based learning.

- ***Tools and collaboration Questionnaire:*** An online questionnaire was developed on basis of an initial test phase with paper questionnaires and short interviews with students to test and refine the scope of the questionnaire and test the relevance of the questions asked. The final questionnaire had 4 sections, namely: background (6 questions), mobile life style (4 questions), project collaboration (5 questions), and web 2.0 tools (4 questions). In the web2.0 tools section there were 40 tools and questions about the diffusion stage of each tool. Based on Roger's (1995) 5 stages the researchers made 9 response categories for each tool students use. These options were: (1) I don't know about it, (2) I know about it BUT I am not interested, (3) I know about it AND I plan to try it someday (4) I tried it BUT I don't need it, (5) I tried it AND I might use it later, (6) I am using it BUT I shall stop soon, (7) I am using it AND I shall continue using it, (8) I stopped using it anymore, (9) I stopped using it but I may use it later. Responses to these categories or diffusion stages will enable identification of how the prospective users should be approached by the change agent. Names of tools against which students responded were identified through initial list of tools from introduced tools by an institution (mentioned in the narrative reflections section), students' reflections, test phase of questionnaire, and interviews. The questionnaire was distributed to students across four faculties. The director of study administration at AAU approved and assisted in the random selection.

- ***Narrative reflections (blog posts) as part of course work:*** In Fall 2010, first semester students of "Humanistic Informatics" program (in the Faculty of Humanities) followed a course taught by one of the authors. Furthermore, with support from E-learning cooperation at Aalborg University (ELSA) (Official site of ELSA, 2011), students were introduced to a number of web applications (Møller, 2010) which they might find useful and consider exploring for academic purposes. The semester course was conducted in Danish and at the end of the semester students were asked to submit reflections and respond to the following questions.
  "*What technologies have you met and which do you actually use - both in relation to courses, project work and for social purposes. What is the role and importance of technologies in relation to studying and in relation to student life, learning and socialization? Give an overall assessment of the benefits of the various technologies that have been made available (and the ones you actually use). (Moodle, Mahara, Dropbox, Facebook, Google services, Wikipedia, etc.)*

and also add suggestions for improvements. Max 2-3 pages."
The students used the university's installation of the open source Mahara system as part of the course activities and to write their blog posts. Students were asked whether their contribution could be used for research or not. The posts of those agreeing were anonymised by one of the authors before they were made available to the research group. Then the reflections were translated by Google Translator (Google Inc., 2011) with proving from one of the author who is a native speaker. A sample reflection was thoroughly read for identifying names of web applications frequently mentioned and for exploring positive comments, negative comments and reasons behind such comments about the applications.

- ***Observation and Focus Group Discussion:*** In the spring 2011 semester (February to May 2011), the researchers followed a group of students who were in the second semester in *Humanistic Informatics* program. We were allowed to observe, interview, access to their discussion on Facebook, and access to their shared documents on Dropbox. There were 5 members in the group with 3 female and 2 male students. The researchers started following them after they had formed their group and began project activities.

In this way we have gathered data at three different levels of scale and for different analytic purposes – across faculties (survey - quantitative), within a semester (analysing blog posts through semi-quantitative categorisation coupled with more analytic, interpretavist readings of the posting) and ethnographical inspired observations and interviews with a small group of students (to attain a qualitative deeper understanding of particular uses of technology in a project groups).

Analysis
Questionnaire

Sample and Respondents:

The survey was activated from 30th May to 10th June 2011, and sent by email invitation to 3,000 randomly-selected students out of approximately 15,000 students at Aalborg university. 365 visitors visited the link, 310 students participated and 253 students completed. There were more male (57.6%) participants than females (42.4%). Relatively higher degree of respondents were from the faculty of Engineering and Science (41.7%), followed by faculty of Humanities (28.1%), faculty of Social Science (25.5%) and Medicine(4.6%); the ratio reflect to the actual number of each faculty. About 28.4% are in the end of first

Place	%
Project/Meeting room	66.01
Supervisor's room	0.99
Canteen	0.99
Library	4.93
Other place within AAU	1.48
Home	18.23
Cafe	1.48
Other place outside AAU	5.91
Total	100.00

Figure 1. Percentage of students who always meet to do project at different places

year and 24.8% are in the end of fourth year and the others are in second, third and fifth year. 94.4% participants are fulltime students, 5% of part time students. In terms of PBL experience, 32.2% have 2 semesters, 18.8% have 4 semesters, 10.1% for 6 semesters, and 11.4% have 8 semesters experience in PBL. We can see that most of the participants were relatively new to the PBL environments. However, they had been at least 2 semesters of the study and they at least had experienced on 2 PBL projects. Therefore, they were supposed to understand some level of nature of PBL project collaboration.

Results:

- Student Working places

Student project groups mostly comprise 4-5 members and the maximum group size is 7.

To understand how students work in groups we first looked at where they work, as this is of particular relevance in relation to potentially developing a mobile application for students. We look fore both group and individual activities.

	meet group	work alone	use tools
Social Science	17.91	10.71	22.73
Humanities	6.72	3.57	15.91
Engineering and Science	70.90	78.57	56.06
Medicine	4.48	7.14	5.30
Total	100.00%	100.00%	100.00%
Overall	49.10%	10.40%	48.50%

Figure 2. Percentage of students perform different project activities at project room by faculty

Figure 1 demonstrates where students meet to do project work. We can see that the main places that students work are in project rooms at the university (66.01%) or at home (18.23%). While the university provides project rooms and maintain good environment for working (privacy, whiteboard/blackboard, and furniture), but there are not enough rooms for all students. This becomes visible if we look closer at these two settings which are displayed in figure 2 (working at university) and 3(working from home).

	meet group	work alone	use tools
Social Science	16.22	30.89	25.00
Humanities	64.86	34.15	29.76
Engineering and Science	13.51	29.27	41.67
Medicine	5.41	5.69	3.57
Total	100.00%	100.00%	100.00%

Figure 3. Percentage of students perform different project activities at home by faculty

From these figures it becomes clear that while approximately 70% of the students from Engineering and Science work at the University the numbers for the other faculties are significantly lower. Engineering and Science students also perform activities at project rooms 49.0%; and they use web tools to support their work 48.5%. When look into different faculties, students from Engineering and Science faculty are the most active to do project at project rooms (70.90%). They do not only perform group work activities in project rooms, but after dividing tasks they also work in the project rooms individually and they are active to use web tools to support their project activities in the project rooms more than other students from different faculties. Figure 3 draws in different picture, at home students work on project alone 44.6% and use tools to support 60.60%. When we look into different faculties, students from Humanities faculty (64.86%) are active to perform their project activities at their home. It is because the faculty cannot provide enough project rooms for students. When looking at the number of students doing project alone at home students from Social Science, Engineering and Science, and Humanities are almost equally active (30.89%, 29.27%, 34.15%). Engineering students still has higher percentage to use computer or mobile devices to support their project work from home (41.67%). Humanities and Social science are equally active to use tools to support their work at home (25%, 29.76%). It is maybe because of nature of Engineering and Science students which always work with technologies so they are active to use tools to support their group work. Overall students trend to use tools to support their group work when they are away from each other (at home). They use tools to contact each other. On the other hand, when they come to face-to-face meeting, they seem to use less technologies to support their work. In fact technologies have potential to support both face to face and distance project group activities.

Category	Web Tool	%
Groupware	Wiggio	96.1
	Google Groups	54.4
	iGroups.dk	91.4
Google Tools	Docs	29
	Calendar	19.7
Brainstorming	MindMeister	93
	Mindmap	77.9
Diagram	Dabbleboard	95.3
Bookmarking	Delicious	87.5
	Digg	81.6
	Diigo	94.6
Document Management	Dropbox	10.8
	Box.net	92.6
	Slideshare	88.4
	Evernote	79.7
	Etherpad	92.6
	MS OneNote	65

Category	Web Tool	%
Others	FastStone	94.9
	Doodle	57
	SignAppNow	96.1
	Lectio.dk	73.8
	TeamViewer	70
	LogMeIn	89.1
	SoundScriber	95.7
	Prezi	91.4
	Pageflakes	97.7
Blog	Blogger	70.4
	Wordpress	60.5
	Twitter	14.7
Messenger and Chat	Skype	5.1
	MSN	5
	Yahoo	40.3
Project Management	Basecamp	93
	Gmail	8.1

Figure 4. Percentage of respondents ‘do not know’ about web applications

- Students' web tools using for PBL project collaboration

There were questions about web tools for collaboration differing between institutionally-provided tools and self-acquired tools. In relation to the responses about the knowledge of or use of web applications we explored these through nine multiple choices provided building on Roger's diffusion theory. The significant observations are summarized here. According to figure 4, it is interesting that significant number of students do not know about the existence of tools which benefit in learning activities and collaboration. Therefore, strong initiatives have to be taken to facilitate students to know about emerging tools and the prospective benefits in efficiently handling learning activities. Regarding the online services operated and maintained by the university these appeared to have less success. One of the 'diffusion confirmation' is expected from the answer choice 'I am using it AND I shall continue using it' shows to be lower for Mahara, AAU email, AAU library database, and Projekter which is the students' project database.

- Students' use of mobile devices

Figure 5 shows that a quarter own an Apple iPhone or iPad, as handheld mobile device, which is the priority as the project is related to the Apple's initiatives. The largest group does not have a smartphone while a few are not sure if their mobile phone is a smartphone or not. It is interesting that some respondents do not use a handheld mobile device (among the options in the question). In terms of the Internet connection with mobile devices, in general, more than half of students use the Internet on mobile devices with 3G connection and some use only WIFI connection. A quarter connects to the Internet on a mobile device by using data package. These users have higher possibility of 'trialability' (Rogers, 1995) and thereby adoption of mobile applications. However, university provides WIFI connectivity in all establishments. WIFI connection is available in most of the places that they study, work or spend leisure (i.e. home, project room, library, and canteen). Data package, 'pay as you go' and subscription users can use WIFI connection in all these places. In order to introduce a new mobile application, it is good to consider WIFI connection which can cover more users and bigger bandwidth. Figure 6 shows that half of respondents have installed extra application(s) in their mobile devices and some more are potential mobile application users but have not experienced. Therefore, 63.3% are prospective users of mobile applications.

	%
Apple iPhone	17.28
Apple iPad	4.63
Android Phone	20.06
Other kind of Smartphone	10.19
Other kind of tablet	2.47
Not a Smartphone	41.98
Not sure	2.47
Not having any phone	0.93
Total	100.00

Figure 5. Ownership of mobile devices

An open-ended question on listing use of web tools which were not mentioned in the questionnaire and the university provided are: Refworks (a reference management tool), Agenda.aau.dk, and studentersamfundet.aau.dk. Tools which are self acquired and were used for collaboration or other academic activities are: Google scholar, Google wave, Google book, ResearchGate, Gliffy, Blogspot, Fronter, Mendeley, and Springpad.

	%
Download by themselves	45.18
Downloaded with the help of friends	1.66
Downloaded with the help of technicians	0.33
Not yet, but it is possible	16.28
No, it is not possible	29.24
Not sure	7.31
Total	100.00

Figure 6. Installation of mobile applications

From the result of location of group working, location of working alone, unknown the existence of tools, owning mobile devices, and mobile application self-installation can tell us about their need and potential for group work facilitation tools. They work at different locations mainly project room for Medicine, Science and Engineering students and at home for Humanities students. From number of owning mobile devices (smartphones and tablets), there is potential to promote students to use web 2.0 tools for their collaboration. The tools should be accessible from both mobile and non-mobile devices. Mobile devices can provide more functionality.

Students' Narratives

There were 133 student narratives from 51 male and 82 female. The reflections were analyzed using model of *Stages in the Innovation-Decision Process of Rogers* (E. M. Rogers, 1995, p. 163) by reading the narratives and identifying their reflection to understand their level of adoption of each tool. Following is the brief analysis of the narratives.

- *Moodle*. The institution provides Moodle service for communication, and sharing course materials between teachers and students. There were 127 students wrote about the use of Moodle and most of students like Moodle.
- *Mahara*. The institution provides the Mahara service for students and teachers and expected it to be used as a social network and to support group work. There were 128 students wrote about the Mahara service. Most of students have *bad impression* on the Mahara service. They thought it was too complicated and most of them have already used Facebook as a social network so they did not find any need for the Mahara services.
- *Dropbox*. The students were introduced to Dropbox to share files. It is quite successful. Most of students wrote about using Dropbox and almost of everyone like it especially user-friendly aspect. There was a person did not like it because his group wanted tool which allows editing documents simultaneously then they preferred to use Google docs.
- *Facebook*. There were 115 students who wrote about using Facebook and Almost everyone like it. There was a person did not like Facebook because he

afraid of losing his privacy, but he prefers to use Skype which is not opened to unknown person.

- *Skype*. There were 51 wrote about using Skype for their project work. Most of students like it and others know it but do not use it.
- *Google services* (includes Google docs, Google wave, Google Calendar, and Google group). There were 94 replies about using Google services and most of students like Google and there are 2 students dislike Google because did not see any useful for the project.

They adopt Moodle but not Mahara (too advanced and complicated); they adopt Dropbox but not Zotero, Diigo, Etherpad; they adopt Facebook and Skype, and Google services. It appears that introducing tools with a presentation does not significantly encourage and enable trial and adoption of tools. Rather, there has to be a continuous facilitation for appropriating use of tools for different activities. There were contradicting comments about use of some tools by students working in different groups. Regarding university provided services students had greater volume of comments and criticisms for the expected improvements.

Observation and Focus Group Interview

These methods help gaining an insider viewpoint in doing a project. This section describes the process of group work rather than the support availed from the ICTs. Every semester students at Aalborg University have to do projects in groups. When the researchers came to observe them the group was discussing about theories on the project which .The room that they used as the project room was not fixed; they had to book project rooms every week. The group members were Ann, Marie, Janis, John and, Kevin (nick names). They have separate

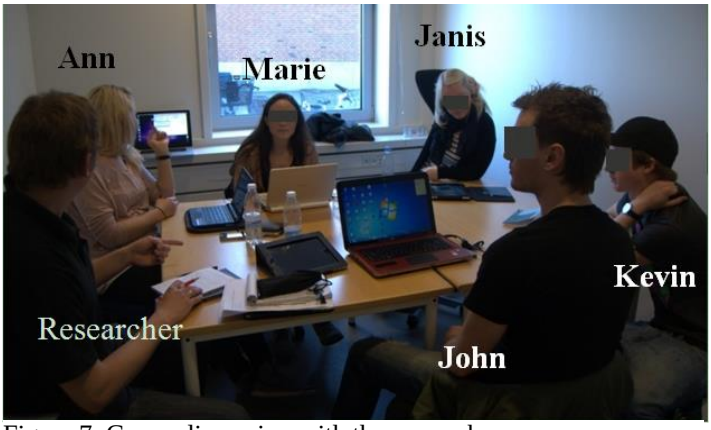

Figure 7. Group discussion with the researcher

roles in the group as an organization. Kevin had been elected to be the group leader who makes final decision. Marie was a secretary for the group who took note and kept track of every discussion. Ann was the most active member in the group, she maintained about schedule and agenda of meetings. Janis and John did not get any specific task but helped everyone. Female members stayed in a city which takes 45 minutes by train to Aalborg University and two male members live in Aalborg. Because of distance and commute time, they cannot meet everyone at the university every time; they managed to work with subgroup and individual. Sometimes they worked at home and communicated through Skype and put commitments on Facebook and shared meeting files in Dropbox. Kevin seems to be active for tool adoption (a technology agent); he had tried Zotero and wanted to use for this semester project. However, the group did not use Zotero as part of reference management or for the report writing. They created a closed-group in Facebook and they discussed through Facebook. Many topics were discussed on Facebook, for example, theories used in analysis, meeting time, meeting with supervisor, task assignment etc. It was also observed that Facebook was used for discussion all along the project life. However, they did not use group work facilities which Facebook provides; for example, group chatting, document creation and event creation. Skype was used when they have both scenarios: working alone and subgroup activities.

From the observation, the group implemented technology to support distance collaboration. They implemented technologies which they are already familiar with. However, they use these tools only basic functions even though the tools have potential to enhance project collaboration. Dropbox is only a new technology that they adopted which was introduced by social (classmates) and the institution (ELSA). In fact, they had been introduced to several tools which are both institution-provided (e.g. Mahara service) and free access services (e.g. Zotero, Diigo, EverNote, and Etherpad) but they did not adopt these tools.

Summary and Future Work

The research methods explored that the use of ICTs by the students, including web applications, mobile devices and the Internet connectivity, is not significantly advanced to claim their ability to efficiently adopt or explore to facilitate academic or professional activities. The result shows the students who are claimed as digital natives, they still have problem with implementing digital tools into their professional life. Thus they can be made efficient by appropriate facilitation. Compared to access to resources significantly less number of web tools are known to students. Apart from facilitation for learning by supervisor, a separate facilitation for technology adoption appears to be important. In order to facilitate student work group, it is necessary to discuss about whether institutions should provide software with full functionalities to support the group works or let students use tools which are available on software market and the institutions will take roles of a facilitator instead of a provider. We can see a significant number of students who already have experience on both using tools for learning using internet on mobile. They have potential to adopt mobile technology for their project collaboration.

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Appendix E. Conference paper 3

FACILITATING ADOPTION OF WEB TOOLS FOR PROBLEM AND PROJECT BASED LEARNING ACTIVITIES

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Abstract

This paper builds on research directions from 'activity theory' and 'learning design' to provide 'facilitation' for students standing within decision making related to selection of web 2.0 tools and university provided web-based applications for supporting students activities within problem and project based learning. In the area of problem and project based learning, facilitation is the core term and the teacher often has the role as facilitator or moderator instead of a teacher teaching. Technology adoption for learning activities needs facilitation, which is mostly absent. Sustainable adoption might be facilitated based on tool appropriation with activities associated with courses and projects. Our mapping of different tools in a framework is reported based on interviews, observations, narratives and survey. A direction towards facilitation process for adoption is discussed as part of future scope of work.

Problem and Project Based Learning

Problem and project based learning (PBL) and teaching has become a widely adopted method in higher education for more than four decades (A. Kolmos, Du, Holgaard, & Jensen, 2008). The main pedagogical principles within the PBL model of Aalborg University (AAU) is shaped around problem-orientation, project work, inter-disciplinarily, and participant controlled learning. The ideal here is built around the students' enquiry into scientific and social problems as part of their entire learning process. Students need to identify or build hypotheses around problems. Further they need to understand and find a solution to the problem. Through this process the students go through different stages of systematic investigations: preliminary enquiries, problem formulation, theoretical and methodological considerations, investigations, experimentation and reflection (Lone Dirckinck-Holmfeld, 2002b).

In AAU, each semester is therefore organized around approximately 50% course work and 50% project work in groups, where students collaborate on writing their semester project. The students work closely together for an extended period of time. This time period is depending on their study programme, as different studies have different set-ups for the relation between courses and project work. Students work on formulating, identifying and 'solving' their problem, and writing a final project report based on integrated theoretical perspectives from their courses, experiments, reflections, etc. to their specific problem (A. Kolmos et al., 2008). Kolmos et al. (2008) have summarized PBL culture and practice, theories, models, and tools for reflection, analysis and development of staff role in the facilitation for students in their learning activities, specifically for Danish context and AAU saying that:

> "We have chosen to conceptualize this role of facilitation in a PBL environment in order to stress that in PBL culture, the students are playing an active part and make core decisions on their own. The role of academic staff is to motivate learning processes, to point out possible directions, to help in difficult situations, to empower the students and sometimes to

> answer students' questions. The difficult part is to find out which strategy is the right one for a given situation?" (A. Kolmos et al., 2008, p. 5).

"Facilitation" literally means "easing". The art of facilitation is in drawing out the wisdom already embedded and lying dormant in the psyche of the learner, and make the learner reflect, consider and aware of own knowledge. Facilitators are people with the skills to create conditions within which other human beings can, so far as is possible, select and direct their own learning and development. A facilitator is a "process guide" who works with a group to assist it to achieve self-defining purpose. The facilitator's philosophy informs their approach and it's manifested as a concern with the psychological growth of the person" (Gregory, 2002). This paper takes 'the complexity of facilitation' (A. Kolmos et al., 2008, p. 22) in consideration and urge the need for initiating strategies for 'facilitation for adoption of web 2.0 tools and university provided web-based applications in students learning activities', as "supervision" (A. Kolmos et al., 2008, p. 10) for academic disciplines do not ensure this role. While the versatility of diverse web 2.0 tools in academic activities has proven records as shown by Rongbutsri, Khalid & Ryberg (2011), the application context in PBL and facilitation for the same needs emphasis.

Problem and Scope of Work

Technology adoption projects of tertiary academic institutions lack focus on pedagogical and academic activities, teacher & student centeredness, and methodical approaches to prioritize web 2.0 tools for facilitation both in general and in a PBL approach. Simply, the problem is, that in the continuously evolving and changing web 2.0 world students and teachers adopt their own selection of tools as they encounter, experiment and exercise. At the same time there are focus on the students attending higher education as being the generation of digital natives having high information and communication technological (ICT) skills, but this approach to students can be discussed (Thomas Ryberg, Dirckinck-Holmfeld, & Jones, 2010). Using both quantitative and qualitative methods, an AAU-wide study showed that the majority of students 'do not know' about many of the web 2.0 tools that are being effectively used by some PBL project groups and students of different departments (Rongbutsri, Khalid, & Ryberg, 2011). Methods used and data collected in the work of Rongbutsri, Khalid & Ryberg (2011) are also considered as part of the primary data of this paper. From the data it was identified that appropriation of tools require significant amount of effort and different members of same group using different tools for same activity require adoption time to collaborate. These sometimes take away effort for the "collaborated academic activity" to the "tool testing and selection for collaborated activity".

'E-læringssamarbejdet ved Aalborg University (ELSA)' i.e. 'E-learning cooperation at Aalborg University' is responsible for providing technical, organizational and pedagogical support in the commissioning and operation of e-learning systems for education at Aalborg University (ELSA, 2011), who require a methodical approach

to 'facilitate' students in appropriating PBL activities with web 2.0 tools. Technical teams of universities around the world intending to facilitate web 2.0 tools are in need of selecting tools, which they would train themselves and diffuse to facilitate learning activities. To address these problems and requirements, the authors attempted to build on research directions from 'activity theory' and 'learning design' in decision-making about web 2.0 tool selection for learning activities to provide 'facilitation' ELSA to the students and teachers.

Current research considers the changes in higher education, to draw strong attention towards students' learning activities. Educational institutes are not solely contributing to knowledge creation and dissemination, and learning of different forms occurs from the large sphere of society (Barnett, 1994). Educational institutes are no longer self-sufficient system in which students acquire knowledge, which they apply outside these institutes; instead, they are part of a broader and larger learning system (Wenger, 1998). Higher educational institutes have changed from 'producing and reproducing' to 'student-centred' learning. In teaching-learning practices, emphasis is given on the process of learning knowledge rather than the teaching process (Barnett, 1994; Bowden & Marton, 1998; Jarvis, 1995; A. Kolmos, 2002), which essentially is a facilitation process for self-paced learning. However, while emphasis is given on the importance and use of mobile devices (Weber, Yow, & Soong, 2005) and applications on the web (including web 2.0 tools) in academic activities, there appears a lack of "making awareness" about this. Along with the need to further support this awareness by a strategic 'facilitation process' which would enable students to make their decision to cater to needs of 'learning activities'.

The adoption of learning technologies for supporting higher quality learning activities than traditional approaches must be based on the psychological and pedagogical theories. Furthermore, in case of PBL, activities of student groups differ with discipline and background, but the underlying activities can be generalized. Therefore, this study focuses on the learning theories, learning activities and the PBL. The intention is to cover the aspects of individual learning and collaborative learning theories and generalize activities for associating relevance and importance of evolving web 2.0 tools.

Learning within Different Perspectives - Review of Literature

Looking into literature Mayes and Freitas (2007) elaborated "the theoretical underpinning of e-learning, and to argue that, to be comprehensive, e-learning design must consider three fundamental perspectives, each of which leads to a particular view of what matters in pedagogy". They identify three broad perspectives of psychological theories into learning being: the associationistic/empiricist perspective understanding 'learning as activity', the cognitive and/or constructivist perspective understanding 'learning as achieving understanding' and the situated perspective understanding 'learning as social practice' (Greeno, Collins, & Resnick, 1996; Mayes & de Freitas, 2007). Seen from these perspectives our research takes the perspective of empiricist i.e 'learning as activity'.

According to these theoretical perspectives, learning could further be understood as:

1 Building concepts or competences in steps of increasing compositeness, such that they are manifested in external behaviour and internal representation is less important (i.e. associative);
2 Achieving understanding through experimentation or active discovery (i.e. constructive - individual);
3 Achieving understanding through dialogue and collaboration —in the zone of proximal development (i.e. constructive - social);
4 Developing practice in particular community and less attention is paid on the formal learning activity (i.e. situated)

These four understandings are based on the theoretical approach Mayes and Freitas have mapped in their analysis of how people learn and the context of e-learning design. (Mayes & de Freitas, 2007, pp. 221–227). In PBL each of the four perspectives are central referring to 'learning as activity' as central. For mapping web tools this paper takes 'activity' as its core.

Learning Activity and Learning Design

Several decades of research support the view that it is the activity in which the learner engages, and the outcomes of that activity, that are significant for learning (Tergan, 1997). "Design for learning should therefore focus primarily on the activities undertaken by learners, and only secondarily on (for example) the tools of material that support them" (Conole, 2007). Based on these research directions we map the web 2.0 tools students used for their learning activities within the problem and project based learning or AAU PBL pedagogical model as partially reported by (Rongbutsri, Khalid, et al., 2011)).

Taking directions of Tergan (1997) and Conole (2007), and primary data of the work of Rongbutsri, Khalid & Ryberg (2011) we attempt to look into the web 2.0 tools students had decided to use, or ELSA had suggested and the learning activities could be performed using those tools. We further attempt to ground the activity-tool mapping with 'learning activity' and 'learning design' theories. In PBL context we perceived "a learning activity in a way that supports the design process, including the design decision to be made, the information to support these decisions, and how theories or principles can be applied" (Conole, 2007).

Our work is shaped by the activity theory (Engeström, 1999), which was proved as a productive approach in recent learning technology researches (Isssroff & Scanlon, 2002) It might be argued that a student would be able to state the activities (s)he performed for learning and generalize the activities as activity type. For example,

collaborative writing of a report may include brainstorming and mapping the thoughts, managing notes, collaborative writing, reference management, scheduling tasks and giving reminders, receiving notifications, communicating with each other, group meeting, data collection and analysis, translating information, publishing the report and getting feedback etc. It is therefore more productive to plan, conduct and measure the parameters of the activities.

The trend of e-learning research and development has shifted from 'learning object' (Polsani, 2003) to 'learning design', while passing though four levels of increasing complexity (Duncan, 2003; Littlejohn, Falconer, & Mcgill, 2008). Surveys reported on the multi-faced and complex ways of appropriating and personalizing technologies by the students (Gráinne Conole, de Laat, Dillon, & Darby, 2008; Creanor, Trinder, Gowan, & Howells, 2006), which have contributed to this shift alongside the technological innovations. These four levels of increasing complexity (Littlejohn et al., 2008), which have been summarized and adopted from (Conole, 2007) are:

- Digital assets – typically referred to a single file (e.g. an audio clip, image or a video), in some cases called a 'raw media asset';
- Information objects – are structured collection of digital assets, which are designed particularly to present information for pedagogical or academic administration purposes;
- Learning activities – include the tasks performed by learning to achieve learning outcomes in a learning environment while interacting with people or resources
- Learning design – are structured and interdependent sequences of information and activities to promote learning.

Our work puts emphasis on 'learning activities' and not 'learning design', as we focus on the learning outcome and especially on the interaction going on among students themselves and students and teachers (as facilitators). In PBL both teacher facilitated activities and collaborative group activities are flexible in nature, where the learning activities are the building blocks. We believe that with learning activities use and adoption of web 2.0 tools are possible, while generalizing using 'learning design' becomes more complex. It had been consistently reflected in the studies and reviews of virtual learning environments (VLEs) that systems' design approaches promote content of learning materials or non-pedagogical course administration activities (Britain & Liber, 1999). Previous researches had reported some directions for facilitating or assisting teachers but not targeted to students (Barnett, 1994; Bowden & Marton, 1998; Jarvis, 1995) in facilitating them in their choice of web 2.0 based tools. Current paper is based on students' activities for learning and current process of facilitating web 2.0 tool adoption at AAU, with data and findings contributed by (Rongbutsri, Khalid, et al., 2011)).

Diane Laurillard (Laurillard, 2001) mapped different learning mediating technologies and looked upon these related to which tasks or activities these technologies will be able to support and categorised them into six different categories. As a mapping technique, Grainne Conole (Conole, 2007, pp. 226–229) developed a tabulating tool which is 'the learning activity taxonomy' to relate 'traditional examples' and terminologies with 'electronic and mobile examples. The task or activity types are: narrative (assimilative, productive, both), communicative (synchronous, asynchronous), interactive, productive, adaptive, and integrative. However, the work did not map only web 2.0 tools as the technologies but included both online and offline tools. It was a theoretical approach to present a concept and not about making decision, the work was not based on data on currently used tools by students or teachers. Our paper attempts to bridge such gap by mapping only web 2.0 tools that are currently used by PBL engaged students at AAU, tools that are recommended by ELSA and based on the findings reported by (Rongbutsri, Khalid, et al., 2011)).

Mapping Online Tools with Learning Activities

(Rongbutsri, Khalid, et al., 2011)) reported a list of online tools used by or introduced to the students at AAU. The findings can be divided in two broad categories. These are (a) personally subscribed or used web 2.0 tools and, (b) university administrated or subscribed tools. These tools are summarized in table 1 and mapped based on task taxonomy of Grainne Conole (Conole, 2007, pp. 226–229). In Conole's taxonomy map, we narrow down by defining the following: Environment is 'web-based', pedagogical approaches include 'cognitive problem-based' and 'situative project based learning', interaction (who) is 'group-based' and role (which) is 'group participant'. We map the web tools against the task taxonomy 'type (what)'and 'technique (how)'.

Table 1. Web-based tools mapped to the task taxonomy ('type' and 'technique') for AAU students

Type (What)	**Technique (How)**	**Personally subscribed or used web 2.0 tools**	**University administrated or subscribed web tools**
Assimilative: Reading, Viewing, Listening	Reading, Viewing, Listening	All - by all we refer to the tools mentioned in this table	All - by all we refer to the tools mentioned in this table

Information Handling: Gathering, Ordering, Classifying, Selecting, Analysing, Manipulating	Concept mapping, Brainstorming, Buzz words, Crosswords, Defining, Mind mapping, Searching	MindMeister, Mindmap, Wiggio, Diigo, Etherpad, Doodle, Facebook, Box.net, Basecamp, Delicious, Digg, Lectio, Zotero, Twitter, Google Translator, Google Docs	Mahara, Moodle, Quickr, Adobe Connect, First class, AUB digital library, VBN (vbn.aau.dk), Projecter (Projektbiblioteket)
Adaptive: Modelling, Simulation	Modelling, Simulation	Dabbleboard	SecondLife
Communicative: Discussing, Presenting, Debating, Critiquing	Articulate reasoning, Arguing, Coaching, Debate, Discussion, Fishbowl, Ice breaker, Interview, Negotiation, On the spot questioning, Pair dialogues, Panel discussion, Peer exchange, Performance, Question and answer, Rounds, Scaffolding, Socratic instruction, Short answer, Snowball, Structured debate	Google Groups, Google docs, Skype, SignApp Now, Messenger (MSN, Google & Yahoo), Facebook, LinkedIn, Twitter, Prezi, iGroups.dk, Wiggio, Google calendar, MindMap, MindMiester, Blogger, Wordpress, Lectio.dk, Mail (Gmail, yahoo, MSN etc.), TeamViewer, LogMeIn	AAU mail, Mahara, Moodle, Quickr, Adobe Connect, First class
Productive: Creating, Producing, Writing, Drawing, Composing,	Artifact, Assignment, Book report, Dissertation/thesis, Drill and practice, Essay, Exercise, Journaling,	Dropbox, Evernote, Slideshare, Google Docs, One Note, Box.net,	Mahara, Moodle, Quickr, Adobe Connect, First class, VBN (vbn.aau.dk), Projecter (Projektbiblioteket)

Synthesizing, Re-mixing	Presentation, Literature review, MCQ, Puzzles, Portfolio, Product, Report/paper, Test, Voting	Dabbleboard, Wordpress, Blogger.com, Etherpad, LinkedIn, Prezi, Pageflakes, Blogger, Zotero	
Experiential: Practicing, Applying, Mimicking, Experiencing, Exploring, Investigating, Performing	Case study, Experimental, Field trip, Game, Role play, Scavenger hunt, Simulation	SecondLife	SecondLife

PBL activities can be classified into two main activities: course work activities and project work activities. As mentioned earlier this paper investigates on activities in project work only. Web tools to support learning and group work collaboration are mapped into different learning activities. From this perspective we have looked further on the list of tools presented in table 1 both self-subscribed tools and institution-provided tools and compared these with the phases in PBL project work. Table 2 shows mapping of web tools in the different phrases of PBL project work. There are some common activities, which students usually do in most of the phases are shown in table 3.

Table 2: Samples of tools mapped to PBL project work activities

Phases	**Activities**	**Web tools**
Group Forming	Brainstorming	Twitter, Etherpad, Blogger.com, Wordpress
	Group creation	Email, Twitter
Problem Formulation	Brainstorming	Mindmap, vue.tufts.edu, Mindmeister,Google docs, EtherPad
	Literature searching	AAU digital library, Google scholar, Google, Bing
	Literature Storing	Dropbox, Zotero groups,Diigo, Digg, Mendeley
	Referencing	Wiggio, Refworks, Zotero, Mendeley

	Argumenting	Table3: Common activities
	Writing	Table3: Common activities
	Presenting	Table3: Common activities
Task formulation	Scheduling	Google calendar, Doodle
	Diagramming	Table3: Common activities
	Resource allocation (tools, spaces, locations, people)	Basecamp, MS project
Data gathering	Data Collection	surveyexact.dk, Google docs
	Data Transformation	surveyexact.dk, Google docs
	Data Storing	surveyexact.dk, Google docs
	Data representation	surveyexact.dk, Google docs
Analysis	Data analysis	surveyexact.dk, MS Office
	Argumenting	Table3: Common activities
	Diagramming	Table3: Common activities
Design	Development/Production / Testing	Etherpad
	Experimenting	None
	Modeling	Dabbleboard
	Writing	Table3: Common activities
	Simulating	SecondLife
	Prototyping	Dabbleboard
	Diagramming	Table3: Common activities
Reporting	Report writing	Table3: Common activities
	Report submitting	Email, Google project, AAU project
	Presenting	Table3: Common activities
	Argumenting	Table3: Common activities
	Publishing	AAU projekt Projekter (Projektbiblioteket)

Table 3: Samples of tools mapped to PBL common activities

Common activities	**Technologies**
Sharing	Dropbox, Zotero, Diigo, Youtube, Facebook, Flickr, twitter, Blogger, Delicious, Digg, Box.net, Slideshare, LogMeIn, TeamViewer, LogMeIn
Discussing	Facebook,LinkedIn, Skype, MSN, Yahoo messenger, twitter, Blogger, Doodle, SignAppNow, Mahara, Moodle, Quickr, Adobe Connect, Lectio.dk, Microsoft OneNote, FirstClass
Reading	Google
Presenting	Prezi, Google docs
Writing	Google docs, Typewith.me, MS Office with Dropbox
Communicating	Facebook, LinkedIn, Youtube, Flickr Skype, MSN, Yahoo messenger, twitter, Blogger, Doodle, SignAppNow, Mahara, Moodle, Quickr, Adobe connet, Lectio.dk, Microsoft OneNote, FirstClass
Reflecting	Facebook, LinkedIn, Youtube, Flickr Skype, MSN, Yahoo messenger, twitter, Blogger, Moodle, Mahara, FirstClass
Argumenting	Facebook, LinkedIn, Youtube, Flickr, Skype, MSN, Yahoo messenger, twitter, Blogger, Mahara, Email, Microsoft OneNote, FirstClass
Diagramming	Gliffy, Diagramly, Dabbleboard

Table 2 and table 3 can be used as a guideline for students to look for tools to support their learning activities. These also can be used for PBL group supervisors and IT support department e.g. ELSA to understand phases of PBL group work and tools which can be applied to each activity in each phase. Therefore, it can be a guideline for the supervisors to facilitate their students to pick up appropriated tools for each activity either based on PBL work group phases or the task taxonomy. Tools which are mapped into common learning activities in the task taxonomy in table 1 can be mapped to different learning pedagogies for different strategy to facilitate students' group work. However, the PBL phases shown in table 2 are for a general PBL group workflow.

Scope of Future work

This research has focused primarily on the collaborative project activities and not on the teacher facilitated classroom activities. Seen in relation to problem and project based learning we therefore could cover 50% of the activities performed by the students. Further research in this area could be to explore and map the web 2.0 tools used or recommendable for teaching-learning activities in classroom settings. In proportion to this it could be interesting to look further into what kind of activities going on around AAU in lectures (classroom settings) as part of the problem and project based learning model. Learning design may limit the opportunities of learning for students since the alternative to apply tools is based on the design and the designer, who may be a teacher. PBL institutions (e.g. Aalborg University) should guide students to number of tools to support each possibly learning activity instead of leverage the use by putting them in learning activities from learning design processes. Students should have the liberty to select tools from a pool of suggestions given to them. This paper makes a pool of tools mapped against the types of activities. This is to facilitate students. However, in future a systematic process has to be identified for providing students with some guidelines or tech support to ease adoption. About most universities including AAU has a team to provide facilitation for support design of e-learning (pedagogical, organizational and technical), yet teachers and students often state that "I do not know where to look for support, whom can I mail or call to get a pre-scheduled support". We are aware that this also influences the overall organizational politics within an institution, but we haven't gone into this discussion in this paper. Only stating that it will have some impact to establish and facilitate a pool of tools, and a policy around that will be needed in an institutional level.

In future, the authors intend to explore facilitation requirements for teachers in the PBL context, particularly in the Danish environment, based on primary data collection methods deployed at AAU.

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Appendix F. TOOL DESCRIPTION

There are terms and tools mentioned in the above tables; here are their descriptions.

- *BSCW* stands for '*Basic Support for Cooperative Work'* (http://www.bscw.de/english/) is a web-based groupware that was developed in Germany and Roskilde University provides the service to students to support their group work activities.

- *Lotus QuickPlace* is a web-based groupware, developed by IBM Company. Aalborg University provides the services to support collaborative project work ("IBM Lotus QuickPlace - Wikipedia, the free encyclopedia," n.d.).

- *Lotus Learningspace* is a content delivery platform by IBM; Aalborg University used to provide the service for teacher-student interaction in courses.

- *Moodle* is a web-based content-delivery system. Moodle can be downloaded and installed on a web server to give the service. Aalborg University provides the service for teacher-student interaction during courses. (http://www.moodle.org/)

- *ELGG* is an open source social-networking engine which can be downloaded, installed, and customized to give social network service. Aalborg University customized ELGG called 'Ekademia' (T. Ryberg, 2008) to provide the service and expect to students to adopt the service for their project work. (http://www.elgg.org/)

- *Virtual-U* is an asynchronous conference tool to support interaction and dialogue between students and teacher-student (H. Tolsby et al., 2002).

- *PLE* stands for Personal Learning Environment refers to web tools or services from different providers and developers that learners adopt them for their learning. (Attwell, 2007)

- *iGroup* is a 30-day free try, web base groupware. It has functionalities to support collaborative project work e.g. share documents, conference, messaging, calendar. It is developed by Danish and aim to serve Danish with only Danish version (http://www.igroups.dk/).

- *Mendeley* is a reference management tool which has social media features; it is free self-subscribed, personal and sharable. It provides word processor integration program.

- *Refworks* is an online reference management tool which can be both self-subscribed and institution-subscribed with payment. It provides word processor integration program. Aalborg University provides Refworks with facilitation by the library.

- *Endnote* is an online reference management tool; users can use it to format references, search for reference. It can be purchase individually or institutionally.
- *Instagram* is a popular and simple photo sharing tool as a social media on smartphones. It provides several feature to manipulate photos.

- *Popplet* is iPad and web application to capture and organize ideas in a graphical display e.g. mindmap. It is free-subscribed tool.

- *Twitter* is a free social networking tool; it provides micro-blogging service allowing members to broadcast their post which can be a short text (no longer than 140 characters), photos, and links. A post of twitter called tweets; they are public by default; however, users can put hashtag to identify keywords which are searchable.

- *Sharepoint* is a Microsoft Office product, designed to support organization or group work to store, organize, share, and access information. The service can be purchased.

- *Trello* is an online project management tool. It supports collaborative tasks in a project. It is provided with three packages including a free version.

- *WeekPlan* is an online project management providing three packages including a free version.

- *GranttProject* is a free project management and scheduling desktop application; it is available on Windows, Linux and Mac platform.

- *Mahara* is a web application providing electronic portfolio service including social service for team collaboration and file storage. Institutions need to install the application on a web server to provide the service; customization can be made in the institutional version.

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