Supporting Learning-in-Use: Some Applications of Activity Theory to the Analysis and Design of ICT-Enabled Collaborative Work and Learning

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A submission presented in partial fulfilment of the requirements of the University of Glamorgan/Prifysgol Morgannwg for the degree of Doctor of Philosophy.

Abstract. This thesis discusses some applications of activity theory to the analysis and design of collaborative work and learning processes either partially or wholly enabled by the use of information and communication technology (ICT). Activity theory (AT) is a monistic, materialistic psychological meta-theory comprising several distinct strands of historical and theoretical development. Founded in the former USSR in the early 1930s, it became a fundamental approach in Soviet psychology. In the West, AT was first adopted as a conceptual framework for human-computer interaction (HCI) and information systems design (ISD) in the late 1980s by researchers associated with the Participatory Design (PD) and Computer-Supported Cooperative Work (CSCW) movements. Mainly drawing on Scandinavian interpretations of AT, this work established a distinctive, predominantly cultural-historical approach to context-aware information technology design now known as ATIT. ATIT is widely recognised as having made significant contributions to the theory and vocabulary of HCI and ISD; the principal aim of this thesis is to further develop its usefulness for ICT design. The research discussed explored the theory, history and development of ATIT while also applying and evaluating various established and new practical ATIT methods. These included the breakdown and focus-shifts analysis approach developed by Bødker and her associates and some novel techniques based on systemic-structural activity theory (SSAT), a modern, explicitly design-oriented synthesis of the cultural-historical and systems-cybernetic strands within Soviet activity theory.

The empirical investigation involved participatory action research into the uses of ICT at an adult basic education (ABE) Open Learning Centre in south Wales, UK. A longitudinal study of an intensive ICT-enabled ABE course, *Computer Creative*, was carried out between September 2000 and May 2001 using ethnographic techniques. This was followed-up by a short video-based study in May 2002. In both cases the aim was to use activity-theoretical techniques to identify ways of improving the use of ICT to support the Centre's learner-centred, empowerment-oriented ABE practice. Using the key ATIT notion of breakdown as a starting-point, a number of factors influencing participants' effective and creative learning-in-use of and with the available technologies were identified. Among the most significant of these was learners' motivation during the ICT-enabled work-process. Conditions observed to encourage positive motivation included physical co-location in a material and sociocultural environment favouring self-regulation and mutual coordination through communicative and instrumental means and the structuring of ICT-enabled tasks so as to facilitate the formation and alignment of personally meaningful task-goals. Although user-interface (UI) design emerged as only one among many task-conditions impacting on motivation, some applications were persistently associated with recurrent and/or catastrophic breakdown. The principal UI characteristics identified as likely contributors to such breakdowns were inadequate provision of task-relevant information and under- or over-representation of task complexity. Based on these findings, the thesis presents a number of recommendations and guidelines for researchers and designers on the use of activity-theoretical techniques to create and evaluate interactive information and communication systems, ICT-enabled work-processes and tasks, and ICT use-settings. In doing so it provides further evidence of the potential applicability of AT to a range of IT-design challenges, while concluding that in order to more fully realise this potential researchers should consider revising and expanding the conceptual framework of ATIT to include ideas from SSAT.

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Steven Robert Harris
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The Structure & Language of the Thesis

Structure: The main body of the text is prefaced with a summary of publications by the author containing materials related to the thesis. A glossary and full bibliography of sources cited follow the final chapter. A series of appendices present examples of various research materials referred to in the main text.

The thesis itself consists of nine chapters. Each begins with an introductory overview and (with the exception of Chapter 9) concludes with a summary and endnotes containing additional background information. Chapters 1-3 set out the motivation for, and background to, the research. Chapters 4-8 describe and discuss the empirical investigations. The final chapter (9) summarizes the research findings, presents conclusions and recommendations, lists the principal contributions of the thesis, and offers suggestions for future work. Within chapters, numbered section headings create four levels of sub-division; where required, a fifth level is indicated by italicized, but non-numbered, headings. References within and between parts of the text use section numbers: either (Chapter 2, Section 2.4.1.1) or simply (§2.4.1.1).

Language: Throughout the text frequently used acronyms (listed on page XIX) are alternated with variations on the phrase or name concerned (*e.g.* OLC, the Centre, the Open Learning Centre). IT and ICT are treated as synonyms, while ATIT is used to refer to all aspects of ICT design and evaluation informed by activity theory. Transliterations from the Cyrillic aim for consistency with other English-language activity theory texts; where several alternative spellings are in common use, the versions used conform to Bedny and Meister (1997).

The author (SRH) is generally referred to in the text as *the researcher* or *the author*, the personal pronoun being occasionally used when judged appropriate to situating the account of *e.g.* choosing, using and evaluating methods. Several terms are used to describe other persons involved in the studies. That which occurs most frequently is *participant*, reflecting the PAR and PD traditions which underpin the research approach. As is conventional in HCI (see *e.g.* Norman and Draper, 1986, Bødker and Grønbæk, 1991, Noyes and Baber, 1999), the term *user* denotes individuals involved in direct interaction with computer applications. A third term, *informant* - derived from ethnographic studies - is occasionally used when referring to interviewees. Finally – and while respectfully acknowledging those authorities that caution against it (*e.g.* APA, 2005) - the term *subject* is used to transliterate the Russian *subjekt*, indicating the person or persons who are the agents of action.[1] This is consistent with other English-language AT literature.

All personal data is used by permission; ethical and data protection issues are discussed further in §4.3.5. In order to protect participants' privacy, fictitious codenames have been used throughout the text; in photographs, faces have been digitally blurred so as to obstruct recognition.

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[1] Science historians have highlighted the "critical ambivalence" of the term *subject* within Western psychology (see *e.g.* Danziger, 1990), where it connotes both *active agent* and *object of study*. To (explicitly or implicitly) conceive of a research subjects as objects is methodologically problematic and essentially dehumanizing (*e.g.* Nardi, 1996a, p. 13). According to contemporary interpreters activity theory employs *subject* in a sense that is positively focused on the active agency and developmental potential of the social, conscious, human being (at least in principle, but see also discussions in *e.g.* Holzkamp, 1991, Schraube, 2001).

Related Publications by the Author

Bedny, G. Z., & Harris, S. R. (2006). Triadic Schema of Activity (pp. 38-41); Structure of the Production Process (pp. 55-56); Structure of the Operational-Monitoring Process (pp. 57-59); Classification of Work Processes (pp. 59-61). All in Bedny, G. Z., Karwowski, W., *A Systemic-Structural Theory of Activity: Applications to Human Performance and Work Design.* Boca Raton: CRC Press/Taylor & Francis. ISBN: 0849397642.

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List of Acronyms

ABE. Adult Basic Education.

ACM. Association for Computing Machinery.

ActAD. Activity Analysis and Development.

AS. Animation Shop.

AT. Activity Theory.

AT-HCI. Activity-Theoretical Human-Computer Interaction.

AT-ISD. Activity-Theoretical Information Systems Design (& development).

ATIT, AT-IT. Activity-Theoretical Information Technology (design, development & evaluation).

AVI. Audio-Video Interleaved.

BDPF. Breakdowns Pro-Forma.

BSA. Basic Skills Agency.

CD. Compact Disk.

CD-R, CD-RW. CD- Recordable, ReWriteable.

CEP. Cool Edit Pro.

CHAT. Cultural-Historical Activity Theory.

CHP. Cultural-Historical Psychology.

CLAIT. Computer Literacy And IT.

CMA. Computer-Mediated Activity.

CODEC. COmpression/DECompresssion (algorithm).

CoP. Communities of Practice.

CP. (German) Critical Psychology.

CRT. Cathode Ray Tube.

CSCL. Computer Supported Collaborative Learning.

CSCW. Computer Supported Cooperative Work.

DM. Direct Manipulation.

DRS. Developmental Research Sequence.

DTP. Desk-Top Publishing.

DV. Digital Video.

DWR. Developmental Work Research.

ECE. Ecological Cognitive Ergonomics.

EU. European Union.

FE. Further Education.

FPS. Frames Per Second.

GIF. Graphics Interchange Format.

GOMS. Goals, Operators, Methods, Selection.

GUI. Graphical User Interface.

HCI. Human-Computer Interaction.

HDD. Hard Disk Drive.

HFE. Human Factors/Ergonomics.

HIP. Human Information-Processing.

HTML. Hypertext Mark-up Language.

ICT. Information & Communication Technologies.

IE. Internet Explorer.

ILP. Individual Learning Programme.

IS. Information System(s).

ISD. Information Systems Design and/or Development.

ISO. (The) International Organization for Standardization.

IT. Information Technology.

JPEG. Joint Photographic Experts Group.

LAN. Local Area Network.

MIDI. Musical Instrument Digital Interface.

MMB. Multimedia Builder.

MS. Microsoft (Corporation).

NGO. Non-Governmental Organization.

OCR. Optical Character Recognition.

OLC. The Open Learning Centre.

OS. Operating System.

PAR. Participatory Action Research.

PC. Personal Computer

PD. Participatory Design.

PSP. Paint Shop Pro.

RAM. Random Access Memory.

RCT. Rhondda Cynon Taff.

SIGCHI. Special Interest Group in Computer-Human Interaction (of the ACM).

SQL. Structured Query Language.

SSAA, SSAAD. Systemic-Structural Activity Analysis (& Design).

SSAT. Systemic-Structural Activity Theory.

TF. Technological Fluency.

TSO. Time Structure Outline.

UI. User Interface.

USD. User-centred System Design.

USSR. Union of Soviet Socialist Republics.

UVS. Ulead Video Studio.

VHS. Video Home System.

VR. Virtual Reality.

WAV. Windows Audio/Video.

WE. Windows Explorer.

WIMP. Windows, Icons, Menus, Pointing.

WWW. World Wide Web.

WYSIWYG. What You See Is What You Get.

ZPD. Zone of Proximal Development.

1. Introduction

Chapters 1-3 introduce the main themes of the thesis. This chapter discusses the background, motivation, principal topics and overall aims and objectives of the research in terms of the application of activity theory to context-aware information technology design. In order to begin to demonstrate the relevance of the research to other work in this area, later sections provide an overview of the scope, history and development of HFE, HCI and related disciplines.

1.1 Background and Motivation for the Research

1.1.1 Activity Theory and ICT-Design

This thesis discusses some applications of activity theory to the analysis and design of collaborative work and learning processes that are either partially or wholly enabled by the use of information and communication technology (ICT). Activity theory (AT) is a monistic, materialistic psychological meta-theory that incorporates several distinct strands of historical and theoretical development. Founded in the former USSR[1] in the early 1930s, it became a fundamental approach in Soviet psychology. In the West, AT was first adopted as a conceptual framework for human-computer interaction (HCI) and information systems design (ISD) in the late 1980s by researchers associated with the Participatory Design (PD) and Computer-Supported Cooperative Work (CSCW) movements. The introduction of AT to HCI formed part of a wider "move to the contextual" in technology design as practitioners and researchers increasingly recognised the importance of social and organizational factors in shaping technology use and sought to understand users as conscious, purposeful and motivated agents rather than components of information-processing systems.

In the early 1990s foundational work by Bødker, Bannon, Kuutti and others explored ways of using activity theory to inform PD and CSCW research. These efforts mainly drew on Scandinavian interpretations of AT, which have traditionally emphasised the cultural and historical aspects of the theory. This led to the establishment of a distinctive approach to context-aware information technology design (now known as ATIT - activity-theoretical information technology design, development, and evaluation)[2] which is widely recognised as

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having made significant contributions to the theory and vocabulary of the field. However, despite over two decades of development, ATIT has as yet produced only a handful of practical tools and techniques, with studies often failing to bridge the gap between analytical description and detailed design prescription (Bertelsen & Bødker, 2003; Crystal & Ellington, 2004; Bedny & Karwowski, 2004a). A principal aim of the research described here has been to identify ways of improving the practical applicability of AT to ICT design. This aim, which was pursued through both theoretical-historical and empirical research, initially arose out of the concrete need to develop improved understandings of ICT use within the specific context of adult basic education practice.

1.1.2 From CLAIT to *Computer Creative*: ICT at the OLC

1.1.2.1 ICT and Adult Basic Education

The research interventions which provide the empirical basis of this thesis emerged out of efforts to integrate ICT into teaching and learning practices at an adult basic education Open Learning Centre (OLC) in the post-industrial valleys of south Wales, UK. In Britain, adult basic education (ABE) is that part of the national education system concerned with literacy, numeracy, and language development in adults. The lead organization for ABE in England and Wales defines adult basic skills as:

> The ability to read, write and speak in English (and in Welsh in Wales)
> and use mathematics at a level necessary to function and progress at work
> and in society in general. (Basic Skills Agency, 2003)

Following the installation of a network of personal computers with broadband Internet access at the OLC in early 1997, it became apparent to teaching staff that available materials and existing procedures for general technology-based adult education were in several respects ill-suited to the specific needs of ABE. In particular, there was dissatisfaction with CLAIT (Computer Literacy And Information Technology), a nationally accepted, standardized, set of ICT skills training materials and curricula. On CLAIT courses, individual learners complete worksheet-based exercises using office software. Feedback from tutors (both at the Centre and in various UK basic skills forums) suggested that this approach offered few opportunities for directly engaging with learners' basic skills needs, and also often failed to equip learners with the kind of transferable technology

and problem-solving skills required to deliver real improvements in their future educational and employment prospects. However, at this time there was scant experience of, or research into, the use of ICT in (either basic or general) adult education; consequently, little information was available about possible alternative approaches (Harris and Shelswell, 2005, 2001a, Harris, 2002b).

1.1.2.2 ICT, ABE and the "Digital Divide"

Apart from the pedagogical issues outlined above, the development of technology-based provision at the OLC was also to some extent shaped by socio-political concerns about an emerging "digital divide" between rich and poor in the UK. For around thirty years following their initial development in the 1940s (see *e.g.* Burks *et al.*, 1946), the use of digital computing devices was principally associated with the activity of a small number of professionals with broadly similar cultures and worldviews: scientists, military personnel, and corporate accountants, mainly working in North America and Europe (Copeland, 2006). By the late 1990s, this situation had changed beyond all recognition; the creation of the World Wide Web (WWW) in 1990-2 kick-started the exponential growth of the Internet (Naughton, 1999) and by the close of the century computer-based information, communication and entertainment technologies had became standard consumer goods in most of the world's leading economies (Ceruzzi, 2003).

However, during the 1990s it also became apparent that there were demonstrable links between information technology use, socioeconomic status and civic participation (Norris, 2001), leading some commentators to identify a "digital divide" between developed and developing nations - and within nations, between rich and poor, urban and rural (Timmins, 2000, Schmitt and Wadsworth, 2002). ABE learners are in the main drawn from those marginalised communities not traditionally associated with the use of "high technology", communities whose needs, practices and perceptions may differ markedly from those for whom (and by whom) information and communication technologies were first developed (Schön, 1998, Castells, 1998, BECTA, 2001).

1.1.2.3 Integration of ICT into ABE Practice at the OLC, 1997-2004

1997   Installation of network of personal computers (PCs) & Internet access at OLC

INTERNET CLUB:
Email, chat rooms, multi-user environments WWW, Website construction; development of technology and literacy skills

CLAIT:
"Stand-alone" IT skills training: minimal basic skills content; decontextualized; exercise-based with inappropriate assessment methods; minimal social interaction.

Fragmentation of provision under impact of ICT; increasing recognition of problems

NETWISE:
Email, chat rooms, WWW, Web authoring; development of technology, literacy and numeracy skills

COMBINED STUDIES:
Traditional ABE class and "stand-alone" IT class in same room: ICT use depends on individual tutors' or students' existing skills; "traditional" low-skills students often don't access ICT facilities; fragmentation of groups

Moving toward integration; improvement of learner screening and admission procedures

COMPUTER CREATIVE
Near full-time attendance; variety of new digital media projects; group and project work on topics selected by students; integration of traditional and digital media & methods; computer programming; development of technology, literacy, and numeracy skills.

INTEGRATED COMBINED STUDIES
Single cohort; increased use of ICT while carrying out literacy & numeracy activities; office and educational software

BASIC SKILLS THROUGH ICT

WORK-BASED LEARNING

Increasing integration

COMPUTERS COUNT Numeracy & ICT

FILM WORKSHOP

DESKTOP PUBLISHING FOR A PURPOSE

INTENSIVE BASIC SKILLS THROUGH MULTIMEDIA

COMPUTER CLUB

FIRST STEPS

CYBERLAB

FAMILY LEARNING THROUGH ICT

ACCESS TO OFFICE SKILLS

2004

Key: ─ ─ ► influences development of ──────► continuing in 2004

Figure 1.1: Overview of the integration of ICT into teaching and learning at the OLC, 1997-2004. Adapted from Shelswell (2005).

These considerations were partly responsible for course development at the OLC becoming strongly influenced by ideas from the technology-based, neo-Piagetian constructivist pedagogy known as constructionism[3] and in particular by the application of constructionist ideas in ICT-based teaching projects in American inner-city areas (Kafai and Resnick, 1996, Resnick *et al.*, 1998) and rural Thailand (*e.g.* Cavallo, 2000a, Sipitakiat, 2001). The approach of these projects to helping members of disenfranchised and marginalized communities develop ICT skills was perceived by OLC staff as being directly relevant to the aims of a

socially-engaged, empowerment-oriented adult basic education practice in Wales committed to "building bridges across the digital divide" (Harris and Shelswell, 2001a).

Figure 1.1 summarizes ICT –based developments at the OLC during the period September 1997 to May 2004 (for a report on some more recent developments see Harris, 2005b). By mid-1997 the various concerns outlined above had combined to convince senior management and teaching staff at the OLC that rather than pursuing the narrower CLAIT approach to ICT use learners at the Centre should be encouraged to "express, explore, and realize ideas with the new technological media, and to take advantage of those media to enhance learning in other domains" (Papert and Resnick, 1995). This explicit aim of helping learners develop a kind of "technological fluency"[4] became increasingly central to ICT/ABE practice at the OLC, being seen as a pedagogical goal commensurate with tackling the wider concerns about a "digital divide" outlined above. In an evolutionary design process which included the active participation of centre staff, learners, and volunteers (Harris, 2002b), the remit of (non-CLAIT) ICT/ABE courses at the Centre expanded from an initial focus on the Internet and World Wide Web (WWW) to include desk-top publishing, digital video and animation, multimedia authoring, and computer programming. These activities were mainly carried out in the context of collaborative, project-based work using new digital media, with classroom organization loosely based around the ideas of situated learning in communities of practice developed by Lave and Wenger (Lave and Wenger, 1991, Wenger, 1998, Harris and Shelswell, 2005). In a parallel development, the use of CLAIT materials was phased out and ICT activities were progressively integrated into traditional literacy and numeracy classes across the curriculum.

1.2 Developing the Research

1.2.1 Initiating the Research

By 2000, the collaborative, project-based approach developed in experimental ICT/ABE courses at the OLC had demonstrated considerable success in terms of attendance, retention, and learning outcomes; participating staff and learners' feedback was also positive. It was decided that the centre would further expand

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its ICT/ABE provision by developing and delivering a near full-time course, *Computer Creative*, based on this approach. The award of Doctoral research funding to the researcher (SRH, the author, an associate of the OLC and a member of the University of Glamorgan's Hypermedia Research Unit) provided the basis for undertaking a systematic investigation of HCI and ISD issues arising from ICT/ABE practice at the Centre, using the new course as a starting point. As a consequence, a longitudinal field study of *Computer Creative* (described and discussed in Chapters 5, 6 and 7) was undertaken between September 2000 and March 2001. The following year (2001-2) technology-based provision at the centre was further expanded with the launch of 5 new ICT/ABE courses, all of which were to some extent based on the *Computer Creative* model. In order to follow up on various issues arising from the first phase of fieldwork, the researcher arranged a short, video-based field study which was carried out in May 2002 (Chapter 8). Both studies were designed and carried out within a conceptual framework informed by activity theory and related approaches. They utilised fieldwork techniques developed within ethnography and anthropology alongside a range of both established and novel ATIT data analysis methods. The process of developing an appropriate research approach, and a general research question to guide the first phases of the investigation, began at the end of the academic year 1999-2000,[5] some five weeks prior to the official commencement of the research project in September 2000. This process (which is discussed further in §4.3) was informed by some preliminary findings arising from informal observations of computer-mediated activities at the OLC, preliminary research in the ATIT literature, and consultations with OLC and university staff.

1.2.1.1 Informal Observations on Computer-Mediated Activities at the OLC

During the early stages (1997-2000, see Fig. 1.1) of integrated ICT/ABE course development at the OLC it became evident that some aspects of the courses were proving successful in supporting learners' development of ICT skills to a level that appeared to improve on results from CLAIT approach. A number of points emerged from informal observations and discussions of the activities taking place:

1. There appeared to be little correlation between learners' assessed levels of formal literacy and numeracy skills and their development of ICT skills;

2. Social interaction in shared activities involving dialogue, non-verbal communication and mutual observation appeared to be of central importance in participants' development of technology skills;

3. Participants appeared to be also enhancing their confidence and self-esteem in ways which seemed to benefit their learning in other areas;

4. However, despite frequent instruction and assistance from tutors, many participants encountered recurrent difficulties with some apparently "basic" ICT tasks such as opening and saving files;

5. Participants made little or no use of support materials (online help, manuals, or textbooks), even though they were frequently encouraged, and at times explicitly instructed to do so;

6. There appeared to be no straightforward relationship between tutors' evaluations of the usability of many of the computer artifacts in use and their learning and adoption by learners. Rather, users' previous experience, and especially their motivation - arising from the significance to them or their group of the task in hand - seemed to be more critical in this regard;

7. When offered a choice, participants would usually prefer to make use of familiar packages (that is, applications they had used at least once before) than try newer and possibly more suitable ones;

8. However, when sufficiently motivated, learners would work successfully with even the most complex applications (such as graphics editors), although often utilising only a small portion of their functionality;

9. Participants generally preferred to use combinations of several familiar packages – and also traditional tools such as paper and pencils - to complete a task rather than attempt to carry it through with any single application;

10. Participants – both individually and in groups - developed a sense of "ownership" regarding particular PCs and positions in the classroom, and preferred to use a familiar machine whenever possible;

11. The physical aspects of the computer artifacts in use (*e.g.* monitor, mouse, and keyboard) appeared to be frequently utilised as mediators of social interaction.

Initially, these findings seemed to suggest some interesting, albeit potentially contradictory insights. They provided a starting point for the systematic investigation into ways of maximizing the beneficial aspects of students' interaction with digital technologies reported in this thesis.

1.2.1.2 Theoretical Grounding of the Research Approach in AT

Both preliminary reading in the literature and experience gained from earlier projects carried out by Glamorgan's Hypermedia Research Unit suggested that the adoption of an appropriate theoretical framework can prove helpful in organising and structuring complex research. During the preparatory period preceding the beginning of the field work, activity theory (AT) was identified by the researcher as a major source of potentially useful concepts. Initially this choice was mainly based on the advocacy of AT by the "Scandinavian School" of information technology design (see §1.4.3.2 below and Chapter 3), where it had been established as an effective framework for context-sensitive, human-centred research in human-computer interaction (*e.g.* Bødker, 1991, 1996a, 1999a), information systems design (Bertelsen, 1998), computer-supported collaborative work (Bardram, 1998), and organisational change and development (*e.g.* Engeström, 1991a). During the preliminary literature search it also emerged that AT had an extensive history of use in education and training in the former Soviet Union (see Chapter 2) and was currently being utilised in the development of technology-mediated education initiatives in some US schools and after-school clubs (*e.g.* Cole, 1996a, Bellamy, 1996).

Not only did the Scandinavian researchers' concerns with user participation, skill and democracy (Bjerknes and Bratteteig, 1995), and their commitment to politically significant action-oriented research (Ehn, 1993) appear to align with socially-oriented adult basic education practices at the OLC; their search for a conceptual alternative to the dualistic and mentalist orientation of cognitive science (discussed further in §1.4.3 below & Chapter 3) also seemed relevant to circumstances at the OLC, where individual learners' human-computer

interactions were clearly embedded in, and affected by, the Centre's established culture of participation and collaboration. Furthermore, the AT-based US education initiatives noted above and the Scandinavian approach to work-oriented technology design also intersected with the constructionist movement at many points, not least through their common regard for the work of Lave and Wenger on situated learning in communities of practice (*e.g.* Lave and Wenger, 1991, Wenger, 1998). This latter approach – itself to some extent rooted in, and influenced by, activity theory - was also becoming increasingly influential on OLC practice during this period (see also Harris and Shelswell, 2005).[6] The role of theory in supporting research practice is discussed further in §4.3.2.

1.2.2 An Initial Research Question

The fieldwork began in September 2000 with the longitudinal field study of *Computer Creative* discussed in Chapters 5, 6 & 7. The first weeks were mainly spent in setting up course activities and establishing some basic data-gathering routines. At this early, largely exploratory stage of the research it was unclear to the researcher what practical and theoretical issues would emerge as important as the project developed, although the points listed in §1.2.1.1 clearly "foreshadowed" (Hammersley and Atkinson, 1995) some potentially fruitful lines of enquiry. What was evident was that the rapidly evolving nature of ICT/ABE practice at the OLC required the research approach to be flexible enough to develop in response to unfolding events. Accordingly, the initial formulation of a question to guide the research was undertaken on the understanding that it would be subject to ongoing refinement and revision as the project progressed but should be couched in very general terms, easily interpreted by potential participants and collaborators. The initial research question was thus stated as follows:

> How do we design information ecologies that will support the development of technological fluency?

The opening phrase of the question (*How do we design…*) indicates the practical orientation of the project toward generating outcomes in the form of "design artifacts" (Bertelsen, 1998 p. 86), that is, guidelines, principles, methods, and tools to support the shaping and evaluation of computer-based technologies and the activities and environments in which they were being employed in the

research setting. Nardi and O'Day's notion of *information ecologies* as integrated systems of "people, practices, values and technologies in a particular local environment" (Nardi and O'Day, 1999, p. 49) was adopted in order to emphasise a view of ICT/ABE practices at the OLC as involving multiple artifacts and actors embedded in a specific, and continually evolving, socio-cultural-historical context. It also reflected the intention to develop a naturalistic approach involving observing ICT use *in situ*.

The term *development* in the question was intended to focus attention on the utilisation of interactive technologies as a dynamic process of learning-in-use (Bødker and Graves Petersen, 2000, and see Chapter 3), a process involving not only cognitive but also motivational-emotional and behavioural aspects, and that unfolds and changes over time. This implied a need for long-term study and the bringing of historical perspectives (at various scales) to bear on the analysis of observed events. Explicitly linking development with the idea of technological fluency (see §1.1.2.2-3 above & Note 4, this chapter), which embodies not only notions of skill and expertise but also of possibility, meaning, and significance, aimed to highlight the importance of studying the personal, cultural, and organizational contexts which shape learning-in-use in ICT-enabled activities.

At this early stage of the research incorporating into the initial research question a loose conceptualisation of technological fluency as a level of ICT skill analogous with natural language fluency served to encompass both the criteria for successful interaction developed in traditional HCI (*e.g.* Card *et al.*, 1983), user centred systems design (Norman and Draper, 1986) and usability engineering (Nielsen, 1994), and the closely related family of more qualitative and learning-oriented notions, such as transparent interaction (Bardram and Bertelsen, 1995), transparent (Bærentsen, 1999) or intuitive (Bærentsen, 2000) user interfaces, and learnable artifacts (Bødker and Graves Petersen, 2000) developed within Scandinavian ATIT. This formulation was also intended to avoid the commonly made distinction in HCI between *novice* and *expert* technology users (see, for example Preece *et al.*, 1994 pp. 163-5, Shneiderman, 1998 pp. 67-70), a distinction which tends to emphasize the rapid and efficient solution of well-defined task-problems in the context of a professional workplace, an approach thought inappropriate to the research setting.

It should be noted that the initial research question did not explicitly include the notion of interaction *breakdown*, although even at this early stage it was clear that breakdown incidents provide important indicators of opportunities for design intervention in support of the development of ICT skills. Identifying and analysing breakdown incidents subsequently became central to the research methodology. The notion of technological fluency – essentially an analogy impracticable to tightly define or measure – subsequently performed only a general, heuristic function in guiding the field research. It proved useful when discussing participants' learning-in-use and skill acquisition with OLC staff, for whom the constructionist formulation of the term remained an evocative pedagogical ideal.

1.3 Aims & Objectives of the Research

At its inception the aims of the research were loosely formulated in terms of generating useful knowledge to guide future ICT/ABE developments at the OLC. One of the researcher's initial objectives was to establish a methodological framework based on activity theory and suitable for capturing and analysing data relevant to the points arising from the informal observations listed in §1.2.1. The opening months of the longitudinal study were thus spent establishing the scope, general direction, and central foci of the investigation. In line with recommendations for the effective practice of ethnographic field studies (discussed in §4.3), the researcher undertook an iterative process of gathering data, performing preliminary analyses, and generating more specific and/or additional research questions on the basis of those analyses. Consequently the aims and objectives evolved considerably as the research proceeded.

1.3.1 Aims

By early 2001, it had became possible to identify the principal object of study for the fieldwork as the technology-based practice as enacted or co-created by course participants, a practice involving ICT-enabled work and learning processes taking place through *situated* (*i.e.* emergent and context-dependent) human-computer interactions involving individual, pairs and small groups of users. From a perspective informed by AT, this practice was understood as having arisen out of a specific historical and cultural background, and as being constituted through

collective work activities with diverse technical, educational, psychological, sociocultural and organisational aspects. The overall aims of the research project at this stage can be summarized as follows:

> To study the relationships between the social, psychological, and technical aspects of interaction in creative, collaborative computer-mediated work activity; to seek to understand those relationships both practically and theoretically; and then generate activity-theory based recommendations, guidelines, methods, and principles for the design and evaluation of interactive technologies and their use settings.

1.3.2 Objectives

These research aims gave rise to four overall objectives:

1. To identify and analyse those aspects of the computer-mediated collaborative activity under observation where design intervention might be successful in providing improved support for the development of participants' ICT and other skills through learning-in-use;

2. To identify effective, activity-theory based methods by which such design interventions might be carried out;

3. To develop a coherent conceptual framework and consistent terminology to guide these efforts;

4. To evaluate to what, if any, extent the methods and findings of the research might provide support for other research, design, and evaluation efforts, both in ATIT specifically and HCI and ISD in general.

1.3.3 Detailed Research Questions

The iterative process outlined above gave rise to a number of more specific and detailed lines of enquiry. These were formulated as eight detailed research questions:

1. In the observed situations, what are the main factors contributing to the development of learners' ICT skills? Or, conversely, contributing to incidents of interaction difficulty and breakdown?

2. What are the principal objective or technological (*i.e.* hardware and software related) factors impacting on the observed situations?

3. What are the principal personal, social or cultural factors impacting on the observed situations?

4. Which of these factors appear most relevant, how are they relevant, and what are the relationships between them?

5. Within the constraints of the observed situations, which, if any, of the factors identified might be amenable to design intervention?

6. What forms might such interventions take? What might be most effective or appropriate?

7. How can the effectiveness or appropriateness of any proposed or actual design intervention best be evaluated?

8. What are the most effective and appropriate activity theory-based methods and techniques for establishing answers to these questions?

1.4 Scope, Origins, & Development of HCI

Preceding sections of this chapter have introduced the questions, aims, and objectives of the research, showing how they arose out of, and were motivated by, a specific set of circumstances. This section considers the relationship of the research to wider trends in human-computer interaction and information systems research. It reviews the scope, origins, and development of HCI as a scientific discipline, as a precursor to the detailed discussion of activity-theoretical approaches to HCI & ISD which is undertaken in Chapter 3.

1.4.1 Scope of HCI
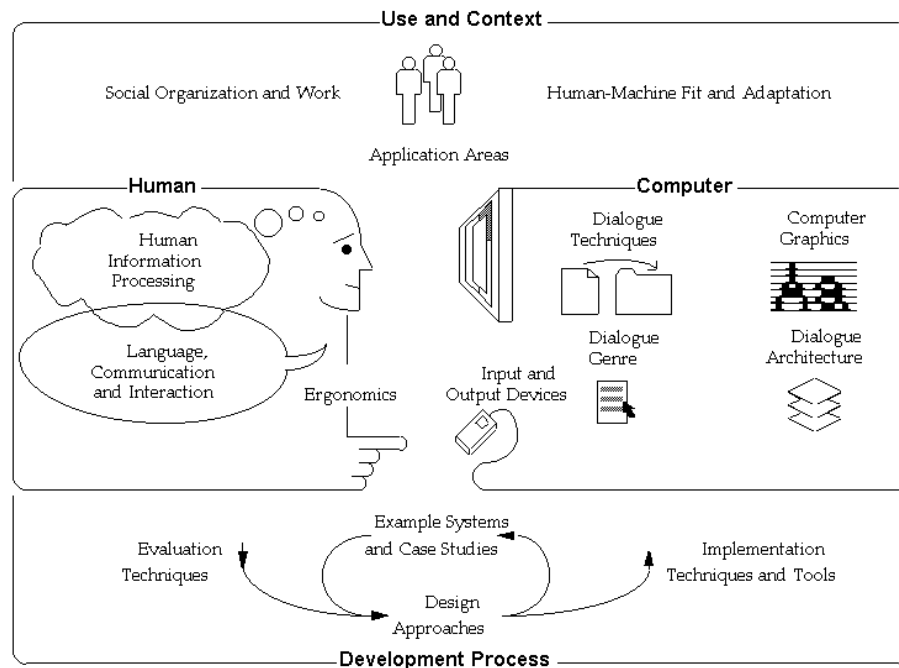
Figure 1.2: Principal research topics in HCI. Adapted from Hewett *et al.*, 1996.

Research in human-computer interaction is concerned with the human factors of interactive systems, including system engineering and the design of the user interface (Shneiderman, 1998 pp. 3-32). Its main aim is to contribute to the design of computer systems that "support people so that they can carry out their work productively and safely" (Preece *et al.*, 1994, p. 1). Figure 1.2 summarizes some of the main research topics in HCI, illustrating how the field encompasses a range of scientific, engineering, and design concerns.[6]

HCI is a relatively young, rapidly developing scientific field that is inherently multi- and cross-disciplinary (Carroll, 2003, p. 1). From the viewpoint of Newell, Perlis, and Simon's classic definition of computer science as "the study of computers and the major phenomena surrounding them" (Newell *et al.*, 1967, p.373), HCI can be considered as that branch of computer science concerned with the design of computer applications and their interfaces. However, HCI also forms a specialised area of concern within other disciplines (Dix *et al.*, 2003, Hewett *et al.*, 1996): in psychology, HCI studies focus on the application and testing of theories of cognition and the empirical analysis of user behaviour (*e.g.* Rauterberg, 1995a, Sedig *et al.*, 2001); in sociology and anthropology, on the interactions between computer-based technologies, work processes, and

organizations (*e.g.* Gärtner and Wagner, 1996, Törpel *et al.*, 2003); and in industrial design, on the development and use of computer-based products (*e.g.* Kaikkonen and Roto, 2003).

ORGANIZATIONAL FACTORS Training, job design, politics, roles, work organization		**ENVIRONMENTAL FACTORS** Noise, heating, lighting, ventilation	
HEALTH & SAFETY FACTORS Stress, risk, fatigue, etc.	**THE USER** Cognition (processes & capabilities, motivation, enjoyment, satisfaction,		**ERGONOMIC FACTORS** Seating, equipment & display layout, etc.
USER INTERFACE Input & output devices, command & dialogue structures, graphical & multimedia design, support materials – documentation and online help			
TASK FACTORS Difficulty, complexity, novelty, variety, skill content, etc.			
SYSTEM FUNCTIONALITY Hardware, software, & applications			
PRODUCTIVITY FACTORS Increasing output and quality; increasing creativity & innovation; decreasing costs, errors, production time & labour requirements			
CONSTRAINTS Costs, timescales, physical, social & organizational environment			

Figure 1.3: Design factors in HCI. Adapted from Preece *et al.*, 1994.

Figure 1.3 offers an overview - adapted from (Preece *et al.*, 1994) - of the main design factors currently taken into account by HCI. It shows that research to inform the design and evaluation of interactive systems is approached from a variety of disciplinary perspectives and is carried out at a multiplicity of levels of analysis (Eason, 1991). The primary emphases in this thesis are on design issues connected with the user, the user interface (UI), and task factors. Ergonomic and system functionality factors are also considered in some detail, while environmental and productivity factors are mainly addressed in connection with case studies from the empirical research. Organizational factors and other constraints relating to the research setting are briefly reviewed in this chapter and Section 4.2 of Chapter 4, and are discussed more fully in other papers by the author (Harris, 2002b, 2003, Harris and Shelswell, 2001a, 2005, Shelswell, 2005). Overall, the thesis explores the potential of activity theory to provide a unifying framework for all these diverse (albeit closely interrelated) concerns.

1.4.2 Origins & Development of HCI
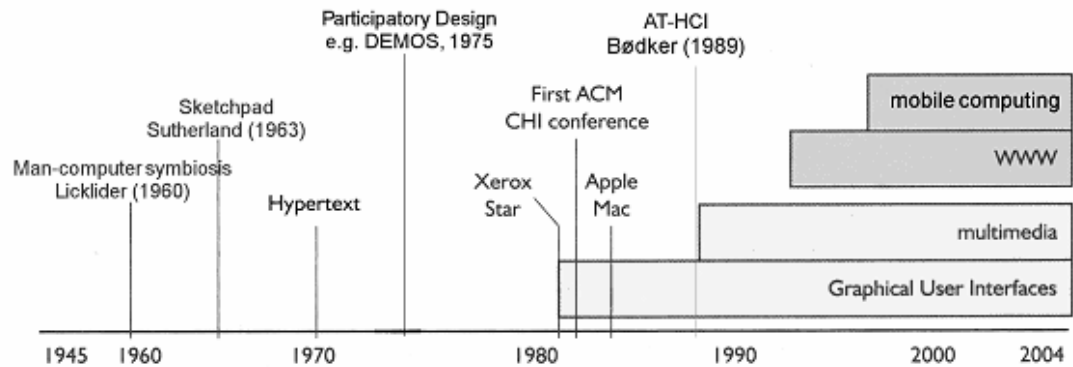
Figure 1.4: HCI timeline. Adapted from Benyon *et al.*, 2004.

Figure 1.4 summarizes some of the major milestones in the development of HCI over the period 1945-2004. Human-computer interaction was first recognised as a distinct area of research in the early 1980s, having developed out of a convergence of interests in computer science (graphics and operating systems), behavioural and cognitive psychology, human factors and ergonomics (HFE) and industrial design (Hewett *et al.*, 1996). This section briefly sketches this history, in order to show how interactions between HCI, HFE, and developments in the human and social sciences (especially psychology) gave rise to a "move to the contextual" in the 1980s (§1.4.3) which framed the introduction of activity theory into HCI.

1.4.2.1 Precursors of HCI in the US & Europe

Two early forerunners of HCI, ergonomics and industrial engineering,[7] emerged in the early years of the 20th Century in the context of attempts to raise industrial productivity in the US and Europe (Barnes, 1980, pp. 12-21). Their theoretical influences were mainly drawn from psychophysiology and Behaviorist psychology.[8] Task analysis - later a significant aspect of HCI - originated with the time-study procedures of F. W. Taylor's (1856-1915) Scientific Management (Taylor, 1911/1998). American industrial psychology began with the Harvard Business School's Hawthorne Studies of 1927-1932, which established that the industrial workplace was a dynamic social system in which workers' individual differences, beliefs, and values played a large role in determining productivity (Heizer and Render, 1999). Thus, by the early 1940s initial concerns with

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understanding and designing sensory-motor processes ("Taylorism") had developed to include more active consideration of the cognitive, communicative, and social-interaction aspects of work, including issues such as personnel selection, work methods, labour standards, and motivation (Barnes, 1980, Crystal and Ellington, 2004).

During World War II, efforts to design complex man-machine interfaces (such as in-flight displays and weapons controls) lead to the emergence of Human Factors[9] as a distinct discipline (Meister, 1999, Sanders and McCormick, 1993, Green *et al.*, 1995). Post-war, many applied psychologists in the US focused on developing formal models of human performance. Industrial engineers seeking to improve industrial efficiency, safety, and quality began to incorporate methods analyses into work and time studies (Heizer and Render, 1999). Representational devices such as linear process flow charts (Chapanis, 1959) began to be used to enable the analysis of complex control, planning and problem-solving tasks.

1.4.2.2 Emergence of HCI

The rapid development of computing technologies after WWII gave rise to design problems which further extended the concerns of the new discipline of human factors, especially following the introduction of the first graphical interfaces using pen devices and CRT monitors for input/output in the mid 1950s (National Research Council Committee on Innovations in Computing and Communications, 1999, Chapter 4). Sutherland's thesis on the graphical computer application *Sketchpad* (Sutherland, 1963), which grew out of these developments, is seen as one of the first major achievements of HCI. Through the early 1960s many new HCI technologies and techniques emerged out of research into concepts such as "man-computer "symbiosis" (Licklider, 1960), the "augmentation" of human intelligence (Englebart, 1963), and "personal dynamic media" (Kay and Goldberg, 1977). These included the mouse, bitmapped displays, desktop and laptop personal computers, windows, the desktop metaphor, point-and-click editors, and hypertext (Cunliffe, 2000, Kay, 1993, Baecker and Buxton, 1995, Hewett *et al.*, 1996).

1.4.2.3 HFE: From Work Efficiency to Job Satisfaction

In the early 1950s, UK researchers at London's Tavistock Institute of Human Relations (founded 1946) began to develop the Sociotechnical Systems Approach, which involved the use of ethnographic and participatory action methods to study and redesign the social and technical subsystems of an organization (Trist and Bamforth, 1951, Trist and Murray, 1990). As Ehn (1988, pp. 259-280, 1993) has explained, the sociotechnical approach as implemented in the Nordic countries - a movement partly initiated by Tavistock Institute involvement in the Norwegian Industrial Democracy project of the early 1960s (Emery and Thorsrud, 1976) - strongly influenced the foundation of a distinctive "Scandinavian School" of politically-engaged, participatory, information technology design.

Over the same period in the US (mid-1950s onwards), concepts such as Herzberg's job satisfaction theory (Herzberg, 1966) linked work-task analysis with workers' psychological states, building upon the hierarchy of needs proposed by the humanist psychologist Maslow (Maslow, 1943, 1954). Herzberg introduced the concept of "job enrichment," where workers are helped to fulfil higher-level needs through the introduction of newer, more difficult, or more specialized tasks, or by giving additional authority to workers. By the 1970s, Hackman & Oldham's Job Characteristics Theory (Hackman and Oldham, 1975) had identified issues such as meaningfulness of work, responsibility for work outcome, and knowledge of results as being critical to operators' quality of performance and job satisfaction, marking a further shift away from stimulus-response models of worker motivation. [10]

1.4.2.4 HCI Comes of Age

In the US and Europe, developments in user interface (UI) research accelerated following the production of the first personal computers with graphical interfaces in the early 1980s (for a contemporary account see *e.g.* Perkins *et al.*, 1997), as rapid technological development was made possible by exponential growth in microprocessor capacity according to Moore's Law.[11] At this time HCI became recognized as a research field in its own right, an event marked by the first US Association for Computing Machinery (ACM) Conference on "Human Factors in Computing Systems" in 1983 (Janda, 1983, see Fig. 1.4). By this point, for

reasons discussed further below (§1.4.3.1), US HCI research was tending toward separation from classical human factors/ergonomics, inasmuch as its main focus was on the cognitive, rather than the physical and/or sociocultural aspects of interaction.

With the advent of mass commercial markets in personal computers (PCs) and workstations in the 1990s, successful system design became increasingly tied to the quality and usability of hardware and application user interfaces. Within HCI there was a gradual evolution of theories, principles and guidelines (Shneiderman, 1998, Chapter 2, pp. 51-94), standardized interface architectures (Pfaff and Hagen, 1985, Krasner and Pope, 1988), interaction models (Shneiderman, 1983, Beaudouin-Lafon, 2000), and user interface (UI) specification testing techniques (MacColl and Carrington, 1997), as well as techniques for user-oriented system development and evaluation such as user-centred design (Norman and Draper, 1986, Noyes and Baber, 1999) and usability engineering (Nielsen, 1994).

By 2000, following the advent of multimedia and networked personal computing in the mid 1980s,[12] the increasingly rapid convergence of communications and computing technologies had brought about a "third wave" (after mainframe, then personal computing) of *ubiquitous* computing (Weiser, 1993). Several current textbooks now represent HCI as having become the art and science of designing interactive computer-based systems generally (*e.g.* Benyon *et al.*, 2004, Dix *et al.*, 2003). At the turn of the millennium, the growing multidisciplinarity and internationalization of HCI research had also led to a "differentiation" and "fragmentation" (Carroll, 2003, p.6) within the field, at least in comparison to what John Carroll has called the "golden age" of first-generation, cognitive science-based HCI between 1975 and the late 1980s (Carroll, 2003, p. 2). Some reasons for this are discussed in the next section.

1.4.3 The "Move to the Contextual" in HCI

Over the last 40 years HCI has been a rapidly growing research area (Shneiderman, 1998, p. 5). There has been a continual widening of the research topics addressed by the field (Hartson, 1997, Kuutti, 1996), to the extent that some commentators now see HCI as an effectively boundless domain (Barnard *et*

al., 2000, Rogers, 2004). This process – driven by technical and commercial factors as well as parallel developments in some of HCI's parent disciplines – has been characterised by Grudin (1990) as an outward expansion from HCI's initial focus on hardware (input and output devices), through software, toward cognitive, and latterly, social and organizational concerns - the last involving what Bannon (1991) termed a move "from human factors to human actors", that is, an increasing emphasis on issues of human agency, purpose, and motivation, and on the ways in which social and cultural contexts shape interaction. To date, the expansion of HCI as a research discipline has passed through two fairly distinct phases, or generations, of development (Bertelsen, 2004b, Bertelsen and Harris, 2005), which are discussed in the following sections.

1.4.3.1 First Generation HCI: HCI and Cognitive Psychology

For most of the period 1970-1990 the theoretical foundations of HCI were drawn from cognitive science, an interdisciplinary movement which emerged in the US in the early 1950s in the wake of advances in communication theory (Weaver and Shannon, 1949, Wiener, 1948) and computer science (*e.g.* Burks *et al.*, 1946, Turing, 1950). Cognitive science brought together emerging ideas in neuroscience, anthropology, philosophy, linguistics, psychology, and computing, precipitating a paradigm shift (Kuhn, 1962) in American and European studies of thinking and learning. By applying ideas of representational structures and computational procedures to the study of mental processes, cognitive scientists attempted to overcome the limitations of Watsonian Behaviourism and it successors (*e.g.* Skinner, 1957, see also Note 9, this chapter), which had dominated US psychology from the 1920s onwards (Neisser, 1967, Miller, 2003).

Findings from early experimental cognitive psychology, such as Miller's work on short-term memory (Miller, 1956), and the subsequent development of human information processing (HIP) models (*e.g.* Newell and Simon, 1961, Newell and Simon, 1972, Card *et al.*, 1983) helped form a vision of HCI as the application of cognitive science ideas to software development (Carroll, 2003, pp. 2-4). Under the cognitive paradigm, the interaction between human and computer was approached as a symmetrical, systemic relationship; the task of the HCI practitioner was seen as improving the computer-based side of the relationship,

attempting to ensure a "good fit" between man and machine as components in an information-processing system (*e.g.* Miller, 1968, Thesen and Beringer, 1986, Card *et al.*, 1983). US and European researchers worked within this commonly accepted framework of ideas, and, as Carroll notes, "a lot got done" (Carroll, 2003, p.3). There were significant developments in user interface software and tools (Carroll, 2001), HCI task analysis methods (*e.g.* Card *et al.*, 1980, Shepherd, 1989, Payne and Green, 1989, see review in Crystal and Ellington, 2004), and a plethora of (sometimes conflicting) guidelines for system development, including detailed recommendations for the design of interfaces (*e.g.* Smith and Mosier, 1986), manuals, tutorials, and online help systems (Carroll, 1998, Shneiderman, 1998).

1.4.3.2 Second Generation HCI: The Move to the Contextual

In the mid 1980s the widespread acceptance of the conceptual framework of cognitive science by European and US HCI researchers began to attract criticism, as the rapid expansion of computer use in the workplace (and soon after, the home) raised a series of practical issues that exposed some limitations of the human information processing approach (see Bertelsen and Bødker, 2003, for a summary of these critiques). Some contemporary surveys of the field (*e.g.* Belotti, 1988) suggested that most software development projects made little use of the results, methods, or recommendations of HCI research; and retrospectively reviewing the field of interface design in 1991, Carroll commented that "some of the most seminal and momentous user interface design work of the past 25 years made no explicit use of (cognitive) psychology at all" (Carroll, 1991). Evidence also emerged of links between the very high rate of failure of large-scale information systems projects and a lack of attention to user requirements and organizational contexts (*e.g.* Comptroller General, 1979, Lyytinen and Hirschheim, 1987, see Dalcher and Drevin, 2003, for a review). [13]

At the same time, theoretical critiques of the limitations of the cognitive approach to information systems development arose from a variety of sources and viewpoints, including the philosophical crisis in the programme of "strong" AI (artificial intelligence) of the late 70s which sparked a search for alternative models of cognition and intelligence in computer science and cybernetics (see *e.g.* Dreyfus, 1979, Dreyfus and Dreyfus, 1986, Winograd and Flores, 1986,

Heylighen and Joslyn, 2001). There was also increasing differentiation and diversity within US cognitive science itself (see *e.g.* Newell and Card, 1986), partly stimulated by the development of alternative approaches in the psychologies of perception (Gibson, 1979) and culture (*e.g.* Cole, 1985). Another factor was the introduction of social-scientific methods and theories into HCI as anthropologists, ethnographers and researchers in science and technology studies entered the field (*e.g.* Coulter, 1983, MacKenzie and Wajcman, 1985, Bijker *et al.*, 1987, Suchman, 1987, Jordan and Henderson, 1995). During this period an increasing interest in collaboration and coordination in computer-supported co-operative work (CSCW) and the development of "groupware" applications (Allen, 1990, Grudin, 1994) was often linked with a growing awareness of the social and political dimensions of ISD, a trend spearheaded by the (initially) Scandinavian participatory design (PD) movement (Floyd *et al.*, 1989, Bødker and Grønbæk, 1991, Greenbaum and Kyng, 1991, Ehn, 1993, Schuler and Namioka, 1993).

A common thread linking many of these practical and theoretical critiques was dissatisfaction with the reductive, individualistic, and asocial approach seen to underpin cognitivist accounts of human thinking and learning in computer-mediated activity. Commentators from outside the US mainstream observed that the inherently dualistic reductionism associated with Watsonian Behaviorism had simply been preserved (as "informational-cybernetic reductionism") by cognitive science (Zinchenko and Gordon, 1981, pp. 82-84); that cognitive approaches were limited and unrealistic inasmuch as they dealt only with individual use activity (Bødker, 1991); that the information-processing approach largely ignored the developmental effects of human-computer interaction on human cognitive activity (Tikhomirov, 1981); and that these theoretical shortcomings meant that HIP approaches failed to address many of the practical difficulties faced by HCI and IS designers (Ehn, 1988, 1989, Kuutti, 1991), with cognitive scientists viewing HCI research mainly as a means of testing (Bannon and Bødker, 1991) and validating (Barnard and May, 1999) their theories and assumptions about cognition.

These debates within HCI inspired efforts to improve understanding the use of computer applications in real work (*e.g.* Bannon, 1994), and to develop design

approaches based on users' needs (*e.g.* Norman and Draper, 1986), ease of learning and use (*e.g.* Gould and Lewis, 1985, Nielsen, 1994), and the integration of new applications and IS into existing work contexts and practices (Holtzblatt and Beyer, 1994). Some researchers set out to further develop cognitive science-based HCI by devising methods that also dealt with culture and context (*e.g.* cognitive task analysis, see Chipman *et al.*, 2000), and by investigating the social and organizational aspects of cognition (*e.g.* Hutchins and Norman, 1988, Hutchins, 1990). Others sought to adopt or adapt alternatives to cognitive science, including: ecological psychology (*e.g.* Gaver, 1991); symbolic interaction (*e.g.* Simone and Schmidt, 1993, Schmidt and Bannon, 1993); actor-network theory (*e.g.* Gärtner and Wagner, 1996, Monteiro and Hanseth, 1995); and ethnomethodology/situated action (*e.g.* Suchman, 1987).

One of the most effective, and influential attempts in this direction has been the work by those (predominantly Scandinavian) researchers who have sought to use the activity theory developed in Soviet psychology to frame HCI and ISD research. Section 1.1.1. & 1.2.1.2 of this chapter outlined the reasons for adopting AT as a basis for the conceptual framework of the research reported here. The following chapters (2 & 3) discuss the origins, development, principles, methods, and current problems of activity theory and ATIT. The practical challenges and benefits of using AT in the research project are explored in Chapter 4 and subsequent chapters.

1.5 Summary

Research into human-computer interaction is concerned with creating computer systems that "support people so that they can carry out their work productively and safely". This thesis describes the use of activity theory to guide empirical and theoretical investigations into the social, psychological, and technical aspects of creative, collaborative human-computer interaction involving non-professional users from low-income, low-education backgrounds. This work was carried out in order to generate recommendations, guidelines, methods, and principles for the design, development, and evaluation of interactive technologies and their use settings. The research project developed out of the author's involvement with efforts to integrate the use of information and communication technologies (ICT)

into adult basic education (ABE) at an Open Learning Centre (the OLC) in south Wales over the period 1997-2000. ABE practitioners' informal observations and reflections on this work provided a basis for formulating a general research question, which initially focused on learning how to design and develop support for learners' creative and meaningful ICT use. The process of engaging in the initial phase of field work further clarified the aims and objectives of the research and additional, more detailed research questions were formulated. At an early stage of the research activity theory (AT, §1.1) was identified as a potentially useful and appropriate conceptual framework for the investigation. AT was introduced into HCI in the 1980s by Scandinavian researchers seeking a radical alternative to cognitivism, as part of an overall "move to the contextual" (§1.4.3) that marked the inception of a second generation (§1.4.3.2) of HCI (§1.4.2) and led to the development of a distinctive approach to context-aware ICT design known as ATIT (§1.1). However, over the two decades following its foundation, ATIT had developed only a handful of practical tools and techniques. As the investigation developed, the principal aim of the research became to identify ways of improving the practical applicability of AT to ICT design.

Notes to Chapter 1

[1] Activity theory, which can be understood as "the further development of dialectical and historical materialism as a psychological and social theory" (Tolman, 1988), is one aspect of a more general *activity approach* originating in the former Soviet Union during the early part of the 20th Century. In this thesis the activity approach is understood to encompass such interconnected and overlapping traditions as Cultural-Historical Psychology (CHP, see *e.g.* Chaiklin, 2001b, Vygotsky, 1930-5/1978, 1934/1986); Sociocultural Theory (Wertsch *et al.*, 1995a); General (Leont'ev, 1978, 1981b) and Systemic-Structural (Bedny and Meister, 1997, Bedny *et al.*, 2000) Activity Theory (AT, SSAT); the cultural, critical, literary and linguistic theories of the Bakhtin circle (Voloshinov, 1973, Bakhtin, 1982); German Action-Regulation Theory (GAT) (Hacker, 2003); and the German Critical Psychology (CP) of Klaus Holzkamp and his associates (Holzkamp, 1991, Tolman, 1994). Some foundations of, and subsequent developments within the activity approach are discussed in Chapter 2.

[2] Acronym coined *c.* 2003 by O. W. Bertelsen and now in general use. See also Chapter 3, Note 1.

[3] Constructionism initially developed in the US around the use of the Logo programming language. In 1967 Logo - a subset of the artificial intelligence (AI) programming language LISP - was specifically developed as a pedagogical tool by a team from Bolt, Beranek and Newman under the guidance of mathematician and AI researcher Seymour Papert. Papert, a former student of the Swiss psychologist and philosopher Jean Piaget (1896-1980), conceived of constructionism as a technology-based application of Piaget's social-constructivist theories of child development and the nature of knowledge acquisition. During the 1970s and 80s constructionism became

influential in both US and UK education, especially at the primary level. Modern American constructionists (*e.g.* Kafai and Resnick, 1996, Resnick *et al.*, 1998, Cavallo, 2000b) have also been influenced by Vygotskian and sociocultural education theories. A useful overview of the educational uses of LOGO in the US and Europe up to the mid 1980's can be found in (Goodyear, 1984). More recent information is available from the Logo Foundation website: http://el.media.mit.edu/logo-foundation.

[4] Although already known within the UK primary and secondary school sectors (Goodyear, 1984), the term *technological fluency* was introduced into UK ABE through the research reported here (see also Harris and Shelswell, 2001b, 2001a). It first appeared in a 1995 grant application by Papert & Resnick (1995), where it was defined as:

> …not only knowing how to use technical tools, but also knowing how to construct things of significance with those tools. Technological fluency involves the ability to express, explore, and realize ideas with new technological media- and to take advantage of those media to enhance learning in other domains." (Papert and Resnick, 1995)

The concept was subsequently developed further by Papert in his book *The Connected Family: Bridging the Digital Generation Gap* (Papert, 1996). He emphasizes that successful human-computer interaction is not only a question of technical proficiency, but has much to do with problem-solving – both in terms of required skills and motivation:

> Fluency comes from use... And being fluent with computers doesn't mean that you know everything. In fact good evidence of your technological fluency would be what you do when you don't know how something works. (Papert, 1996, p. 28)

Supporting the development of technological fluency was a central aim of the seminal *Computer Clubhouse* project (Resnick *et al.*, 1998) which was particularly influential on the development of *Computer Creative*. Resnick *et al* emphasized that technological fluency involves users achieving goals that mean something to them in terms of their own lives and needs.

[5] In UK FE colleges the teaching year runs from September to July and is divided into 3 terms.

[6] In education research, situated learning, constructionism and activity theory are frequently grouped together under the rubric "social constructivism" (for an example, see Tusting and Barton, 2003).

[6] A complementary view to figures 1.2 & 1.3 is given in the outline of the PACT model (People, Activities, Context, Design) in (Benyon *et al.*, 2004, pp. 20-37, especially Fig. 1-9 p. 22).

[7] *Ergonomics* is concerned with the study of issues such as work-space organization, fatigue, vigilance, and safety (Bedny and Meister, 1997, p.374); Human Factors is defined in Note 9 below. The emphasis of *industrial engineering* has been on the design of efficient methods for manual work, the design of specialized tools to increase productivity and, to some limited extent, the design of the social and organizational environment (*e.g.* through innovations such as the suggestion box, work groups, and incentive schemes) (Karger and Bayha, 1987). For an overview from a US viewpoint, see (Barnes, 1980, pp. 21); for the history of these fields in the former USSR, see (Munipov, 1993, Bedny *et al.*, 2000).

[8] American Behaviorism was founded at the beginning of the C20th by E. L. Thorndike & J. B. Watson. It emphasized the study of observable behaviour, rejecting introspection and theories of the unconscious mind, describing both animal and human activity in terms of stimulus & responses. In both its earlier (classical conditioning) and later (operant conditioning) forms, Behaviorism was the dominant paradigm in US psychology until displaced by cognitivism in the 1970s.

[9] *Human Factors* is concerned with studying the biomedical and psychological aspects of man-machine relationships (Meister, 1999). As the boundaries between human factors and ergonomics (see Note 7) are indistinct the disciplines are now usually grouped together as Human Factors/Ergonomics (HFE).

[10] From the mid 1950s onwards Eastern Bloc researchers seeking to apply psychology to work process design also increasingly focused on issues of motivation and goal-orientation, an approach exemplified by the "humanistic work design" movement (based on AT) which became influential within East German industrial psychology during the 1970s (see *e.g.* Hacker, 2003).

[11] The prediction, made by Gordon Moore of Intel in 1965, that there would be exponential growth in the number of transistors per integrated circuit into the foreseeable future (Moore, 1965). This prediction has been confirmed by subsequent events, which have seen (roughly) a doubling of microprocessor capacity every two years since 1970. This trend is currently (2007) expected to continue until at least 2010.

[12] The 1985 Commodore Amiga, which combined advanced graphics, sound and video capabilities, is generally considered as the first commercially available truly multimedia personal computer. In 1986 the Academic American Encyclopaedia became the first to be issued on CD-ROM, and in 1988 Macromind (later renamed Macromedia) released *Director*, a multimedia authoring application for the (by now full-colour) Apple Macintosh. In 1991 the World Wide Web (WWW) was launched on the Internet and the MP3 digital audio compression format was invented at Germany's Fraunhofer Institute. 1992 saw the launch of version 3.1 of Microsoft's Windows operating system, the first to fully support both multimedia computing and networking on a PC.

[13] This continued to be the case throughout the 1990s. In 1995 31.1% of US software projects were cancelled and 52.7% were completed over the allocated time, over budget and lacking functionality, at an estimated total cost of over US $140 billion (The Standish Group, 1995). In 1996 the cancellation rate was 40%, at a cost of around US $100 billion (The Standish Group, 1997). In 1998, around 28% of projects failed, costing US $75 billion (The Standish Group, 1998), while the number of failures in 2000 was around 65 000 (The Standish Group, 2000). Surveys of the businesses involved (*e.g.* The Standish Group, 1995) indicate lack of user input and incomplete requirements and specifications as primary causes of project failure, findings confirmed by other research (Dalcher and Drevin, 2003).

2. Activity Theory

This and the following chapter draw on the published literature and other sources to discuss work in activity theory (AT) and activity-theoretical information technology design and development (ATIT). The aim is to situate the research project within a tradition of related work in AT and ATIT. This chapter sets out some of the foundations of ATIT by providing a brief introduction to, and overview of, AT and the activity approach in Soviet and post-Soviet psychology. A glossary of activity-theoretical terms used in this and subsequent chapters follows Chapter 9.

2.1 What is Activity Theory?

Activity theory (AT) is a psychological paradigm, framework, or meta-theory[1] initially developed in the former Soviet Union during the first half of the Twentieth Century. Over the course of around 60 years of continuous development, AT became established as a fundamental approach within Soviet theoretical and applied psychology (Bedny, 2004, p. 249). Since the fall of Communism in 1991 AT has continued to develop and diversify around the world: in the Russian Federation (Russia) itself; in other countries of the former USSR[2] such as Ukraine and Estonia; in ex-COMECON[3] states such as Cuba; in Scandinavia and Europe; In the United States, Canada and South America; and in the countries of the Far East (*e.g.* Singapore and Korea) and Australasia.

This chapter offers a brief historical overview of the origins and development of AT in the Soviet and post-Soviet eras. While not attempting an exhaustive exposition - such a large undertaking falls outside the scope of this thesis[4] - the aim is to elucidate some key ideas which have shaped the development of activity-theoretical information technology design and development. It is common practice for English-language ATIT papers and articles to provide a précis of the history, principles, and concepts of activity theory by way of introduction to the main topic under discussion (see *e.g.* Barab *et al.*, 2001a, Benyon *et al.*, 2004, pp. 178-185, Helle, 2000, Honold, 2000, Korpela *et al.*, 2000, Macaulay *et al.*, 2000, Mwanza, 2002a, Quek and Shah, 2004, Turner and McEwan, 2004). It should be noted that the account that follows differs in some respects from many such introductory overviews, which are in the main based on

a few well-known articles from the Finnish cultural-historical school of AT (discussed in §2.5.2 below) such as (Kuutti, 1996) and (Engeström, 1999d). One finding of the literature review undertaken in connection with the research reported here is that these accounts tend to neglect or under-emphasize some important lines of development and key ideas within Soviet and post-Soviet AT. One suggestion that emerges from the findings of the research project as a whole (discussed in Chapter 9) is that some of these lesser-known aspects of AT – such as the systems-structural tradition discussed in Sections 2.4.2 & 2.5.3 - may prove useful for addressing some current problems in ATIT. Accordingly, it is on these aspects of activity theory that the explanatory effort in this chapter is principally focused.

2.1.1 Names & Terms

A central issue in any exposition of AT is that of nomenclature, particularly when defining and discussing methods and units of activity analysis (see §2.6.1.1). At the most general level, its complex history of overlapping (and at times contradictory and/or competing) strands and schools has produced a variety of definitions for the term *activity theory* itself. For clarity, this chapter makes a number of general (and thus necessarily somewhat arbitrary) distinctions, as follows:

- Here, the term *activity approach* is used to denote all activity-oriented psychology and philosophy (nominally or actually) based on Marxist-Leninist dialectical materialism. This category thus excludes other arguably related approaches such as American Pragmatism (see also Note 2, Chapter 1);

- The *general activity theory* founded by A. N. Leont'ev, S. L. Rubinshtein and others in the 1920s and 30s (§2.4) is portrayed as conceptually and historically distinct from the closely related *cultural-historical psychology* (CHP) of L. S. Vygotsky (§2.3);

- In the development of activity theory, a distinctive *systems-cybernetic* approach is noted (§2.4.2); this is seen as an important contributor to a *systemic-structural* synthesis within AT (SSAT, §2.5.3) developed by

(mainly) Russian ergonomists and work psychologists which emerges in the late Soviet era;

- In post-Soviet developments of the activity approach, the *sociocultural psychology* and *cultural-historical activity theory* (CHAT, §2.5.2) developed by psychologists, educationalists and organization researchers in Scandinavia, Northern Europe and the US are understood as being mainly derived from CHP - which they tend to identify with AT - and as standing apart from the systemic-structural synthesis.

2.2 Foundations of Soviet Psychology

At the time of the founding of the Moscow Psychological Society in 1885,[5] Russian psychology, led by scientists such as reflexologist V. M. Bekhterev (1857-1927), neurophysiologist I. M. Sechenov (1829-1905) and the physiologist I. P. Pavlov (1849 - 1936), was at the forefront of (and fully integrated with) global developments in the field (Nalchajian *et al.*, 1997, Kozulin, 1984, Kozulin *et al.*, 2003). The Bolshevik revolution of November 1917 began a period during which psychology in what was now the USSR was to develop its own unique and distinctive approach, in part based on the foundational work of Pavlov, and which in general embodied a resolutely materialist philosophy and epistemology (Simon, 1957b, pp. 1-22, Cole and Maltzman, 1969c, pp. v-vii, 3-10). Over the next 40 years Soviet psychology was to become somewhat isolated from the international scientific community, not only conceptually but also physically and professionally, as both Russian science and society were engulfed by the collective tragedy of Stalinist totalitarianism (see Young, 1996, Graham, 1993).

In the years immediately following the establishment of the Soviet state, the challenge for Russian scientists and technologists was to address the pressing material and manpower needs of their beleaguered country in ways that conformed to the strategic aims and ideology of Soviet Communism (Graham, 1993, pp. 79-98). For psychologists – many of whom were personally committed to the ideals of the revolution[6] - this meant (re)constructing their discipline (and indeed all of the human sciences) on the basis of Marxist-Leninist historical and dialectical materialism[7] (Haenen, 1996, p. 69). Toward this end the 1923 All-Union Congress on Psychoneurology resolved to create a specifically "Marxist

psychology" (Luria, 1979, Wertsch, 1981b, Bakhurst, 1991). Subsequent developments in Soviet psychology proceeded from the basic dialectical materialist position that:

> …even the most complex manifestations of mental life are formed in the process of active reflection of reality. (Luria, 1969, p. 122, and see discussion in Bedny *et al.*, 2004).

Dialectical materialism asserts unequivocally that an objective reality exists external to the human mind, and obeys natural laws. Knowledge is thus seen as deriving from the influence of the externally existing material world on the knowing subject (through reflection), who is considered as an entirely material being. The non-material (or *ideal*) aspects of the human world (broadly, culture, more specifically concepts, word meanings, rules and norms of behaviour, *etc.*) are regarded as: (1) being produced out of subjects' interaction with the material world through human (collective, social) activity; and (2) as being "objectified", that is, made manifest for later generations in tools, stories, myths, procedures, *etc;* and (3) as being "objective" inasmuch as they are supra-individual rather than simply subjective phenomena. Further discussion of the philosophical underpinnings of Soviet psychology can be found in (Bakhurst, 1991, Blunden, 1997, Davydov, 1981, Kozulin, 1984, Lethbridge, 1992, Newman and Holzman, 1993, Rubinshtein, 1935, Simon, 1957b, Wertsch, 1981b, Abulkhanova-Slavskaya and Brushlinsky, 1996).

In outlining their views on consciousness as the specifically human reflection of reality, both Marx (*e.g.* Marx, 1886/1976) and Engels (Engels, 1927/1987) stressed - albeit in only general terms - the importance of purposive, social work activity and tool use as determinants of human cultural-historical development (Bedny *et al.*, 2000). While Kornilov's (1879-1957) reactology is generally credited as providing the initial theoretical foundation for Soviet psychology (Cole and Maltzman, 1969a, p. 5, Haenen, 1996, pp. 70-71), it was M. Basov, a founder of Soviet pedology,[8] who first suggested that the concept of *deyatelnost* (specifically human activity, rather than the more universal "behaviour" of Pavlov's physiology)[9] should serve as its pivotal concept (Basov, 1931, cited in Gindis, 1993). In making this proposal, Basov not only drew on Marxist-Leninist ideas but also on the German Idealist tradition from which they sprang, and acknowledged the influence of the activity-oriented psychology of

Wilhelm Wundt (1832-1920), one of the founding fathers of the discipline (van Rappard, 2004). The subsequent development of this line of thought lead to the central tenet of the activity approach – depicted graphically in Fig. 2.1 - which is that the fundamental object of study for psychology is the activity of living beings in the world; life activity (rather than simply passive reactivity in response to external stimuli) provides the essential mediating link between organism and environment, subject and object (Leont'ev, 1978, p.45 ff.).
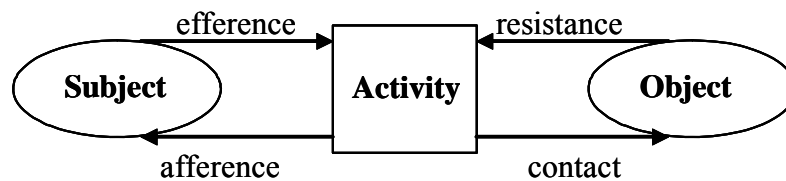
Figure 2.1: Subject-object relations mediated by activity. After Bærentsen & Trettvik, 2002, p. 53.

2.3 The Cultural-Historical Theory of L. S. Vygotsky

L. S. Vygotsky (1896-1934), a significant figure in the history of Soviet (and world) science, developed a cultural-historical theory of the origins of human consciousness which provided the foundation for the cultural-historical school of Soviet psychology, one of the most significant strands in the activity approach. His work fused insights from diverse sources such as the Würzberg School, Gestalt, and Piagetian constructivism into a concrete programme of psychological research with a distinctively Marxist foundation and methodology (Haenen, 1996, p. 71, Bedny *et al.*, 2000, pp. 169-172) (Kozulin, 2000).

2.3.1 Mediation by Tools & Signs

Vygotsky's theory built on Marx's assertion that the origins of human consciousness lay in collective work labour mediated by purpose-embodying artifacts – tools. Beginning with his work on the role of art in shaping the personality (Vygotsky, 1928/1971), Vygotsky focused on understanding the relationship of culture to behaviour and cognition (Vygotsky, 1930-5/1978, pp.39-40), suggesting that the origins of the specifically human "higher mental functions" of logical memory, selective attention, decision-making and comprehension of language lay in the use of *signs* as tools to mediate mental activity (Vygotsky, 1934/1986, pp. 68-95). This view of consciousness as having

a predominantly social-historical-cultural, rather than biological, origin established Vygotsky's cultural-historical theory as a cornerstone of social constructivist approaches in psychology, and provided one of the principal foundations for the development of activity theory (Bedny *et al.*, 2000, pp. 169-172).

Vygotsky's work also investigated the ways in which tools and signs - as historically-developed and developing cultural artifacts - implicitly impose constraints and prescriptions on activity, which in turn socially determine both practical actions and mental operations. He reasoned that communities at different stages of technological development should exhibit identifiably different ways of thinking. This idea, which was initially investigated through cultural-psychological field research in under-developed areas of the Soviet Union (Luria, 1976, and see discussion in Cole, 1996a, pp. 111-5 & 168-177), was later the subject of much controversy (Joravsky, 1989, pp. 364-5). However, it was further developed in activity theory through the concepts of *objectification* and *appropriation*, and recent work in ATIT has continued to investigate the ways in which technological artifacts both shape, and are shaped by, practical and mental activity (see §3.5.1).

2.3.2 Internalisation

In his work on the relationship between thinking and speaking, Vygotsky elaborated the concept of the *internalisation* of various sign-systems (primarily through dialogic and self-directed speech) as an explanatory mechanism for the process by which, during ontogeny, individuals' participation in socially-situated external, practical activity fosters the development of the higher mental functions (Vygotsky, 1930-5/1978, pp. 52-57). Empirical research into the role of speech in semiotic internalisation was pursued by several of Vygotsky's collaborators and students, in particular by R. E. Levina (*e.g.* Levina, 1981) and the founder of Soviet neuropsychology, A. R. Luria (1902-1977, see *e.g.* Luria, 1969). Investigations into the phenomenon of internalisation have subsequently occupied a central place in the development of the activity approach in Soviet psychology; to some extent, differences in the way in which internalisation is

understood serve to differentiate different schools of thought within the activity tradition (Haenen, 1996, p. 102, Bedny and Meister, 1997, pp. 352-354).

2.3.3 Learning

Vygotsky's studies of the child's development of conceptual thinking led him to make important distinctions between "spontaneous" concepts arising from everyday experience gained through participation in social activities and those "scientific concepts", containing systematic knowledge, which can only be appropriated through participation in structured teaching and learning activity (Vygotsky, 1934/1986, pp. 146-209). Asserting (in contradistinction to Piaget, *cf.* Piaget and Inhelder, 1969) that "learning precedes development", he also postulated a "zone of proximal development" (ZPD) where the difference between a child's independent and assisted problem-solving ability indicates their true "learning potential" (Vygotsky, 1930-5/1978, pp. 84-91). The notion of the ZPD, albeit often interpreted in ways very different from Vygotsky's original formulation (for a critique see Chaiklin, 2003), has been widely utilized in Western educational theory, and is frequently cited in ATIT research (*e.g.* Bardram and Bertelsen, 1995, Bellamy, 1996).

Emphasising "the *historical method* which underlies all Soviet psychological investigations" (Leont'ev *et al.*, 1969, p. VI) as established by Pavlov, Vygotsky's approach to psychology necessitated the establishment of new investigative techniques. Using the concepts of cultural-historical theory, Vygotsky and his collaborators evolved an "instrumental method" for the "historic-genetic" (Vygotsky, 1930/1981) study of developing psychological functions, through techniques such as the "functional method of dual stimulation" developed by Vygotsky, Luria and Leont'ev (see Vygotsky, 1930-5/1978, pp. 58-75, Vygotsky, 1929/1981, pp. 195-200, Levina, 1981, Leont'ev, 1981b, pp.340-365, and Haenen, 1996 pp. 73-74).

2.4 Origins & Development of Activity Theory

The origins of activity theory can be traced to several sources, each of which has subsequently given rise to various complementary and intertwined strands of development. The (necessarily) abbreviated account which follows (see Note 4, this chapter) focuses on two of the most important of these strands. The first is

closely associated with Vygotsky's cultural-historical psychology and was founded by Vygotsky's collaborators and students (Leont'ev, Luria, Elkonin, Zaporozhets and others, see §2.4.1 below), who both continued and reacted against his work. The second, much less well-known strand involves research (by scientists such as Anokhin and Bernshtein, §2.4.2) more directly concerned with the physiological bases of activity, and later strongly influenced by the ideas of (both Western and Soviet) cybernetics; the initial conceptual underpinnings for this work were mainly provided by the ideas of the Soviet philosopher of psychology S. L. Rubinshtein (1889-1960), generally credited in Russia as the principal founder of activity theory.

As Soviet activity-based psychology was arguably in some ways a more unified science than its Western counterpart (Wertsch, 1981b), the concerns of these strands overlap and coincide in many places. However, one way in which they may be initially differentiated is according to their approach to the analysis of activity (see §2.6.1). Whereas the approach to AT founded by Leont'ev tended to focus on the structural (morphological) analysis of activity in terms of activities, tasks, actions and operations (see §2.4.1.1), and on cultural-historical accounts of the genesis and development of mental functions, researchers in what can be loosely referred to as the systems-cybernetic tradition emphasized the functional analysis of activity as a self-regulating system (in terms of function blocks and feedback loops, see §2.4.2.2 & 2.5.3) and on psychic processes as functional systems involving series of temporally limited sub-processes (Bedny and Meister, 1997, pp. 10-18).

As noted above, another feature that differentiates schools of thought within the activity approach is their approach to internalisation. In contradistinction to Vygotsky's formulation (§2.3.2), both the Leont'evian and Rubinshteinian strands of AT developed an "object-practical" concept of internalisation as a process by which internal, mental functions and their mediating means primarily emerge out of participation in external, practical activity with material objects (Leont'ev, 1978, pp. 57-62, Haenen, 1996, pp. 72-73).[10] M. A. Kotik, O. A. Konopkin, V. P. Zinchenko and others working in the systems-cybernetic tradition later developed a view of the formation of cognitive functions as an active process distinct from, but interconnected with (by feed-forward and

feedback loops) participation in practical activity, and which involves both object-practical and symbolic activities (Bedny and Meister, 1997, pp.50-92 & 352-354).

2.4.1 A. N. Leont'ev & the Kharkov School

The research of Vygotsky's close associate A. N. Leont'ev (1904-1979) [11] and the "Kharkov School", (see Wertsch, 1981b, pp. 14-17) mainly focused on the role of social, practical, object-oriented activity (as opposed to Vygotsky's predominantly semiotic orientation, see Kozulin, 2000, pp. xliv-liv, and Rubinshtein's focus on communicative activity, see Wertsch, ibid, p. 12) in the formation of psychological functions (Lethbridge, 1992, p. 85). Leont'ev's group sought to transcend what were perceived to be some serious limitations of the cultural-historical theory (see Leont'ev, 1981b, p.283, Kozulin, 2000, pp. xlv-xlviii).   Whereas Vygotsky's work was concerned with the sociocultural determination of the mind, the Kharkov group set out to establish the idea of tool-mediated *practical* activity as the fundamental, systemic process connecting humans and the (objective and subjective) aspects of the (material and sociocultural) world; and of consciousness not as some subjective addition to human life activity, but as a form of that activity (Lethbridge, 1992, p. 86, Davydov, 1981). Methodologically this approach, which encompassed investigations in general, child/developmental, and educational psychology, involved the use of *mediated action* - rather than Vygotsky's *word meaning* - as a basic unit of psychological analysis (Wertsch *et al.*, 1995b, Wertsch, 1995, Bedny and Meister, 1997, pp. 16-17, Bedny *et al.*, 2000, p. 174).

2.4.1.1 Human Activity as a Structured System

Activity level	Motive	Not conscious
Action level	Goal	Conscious
Operation level	Condition	Not conscious – automatic processes

35
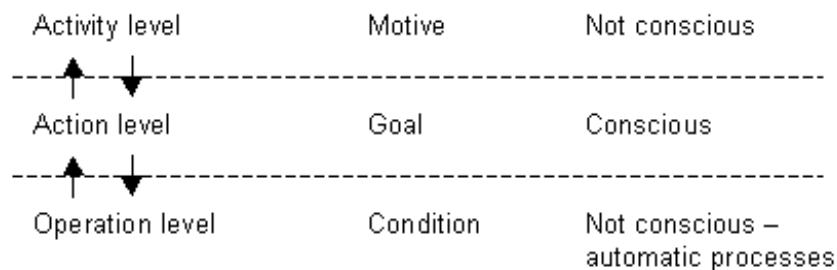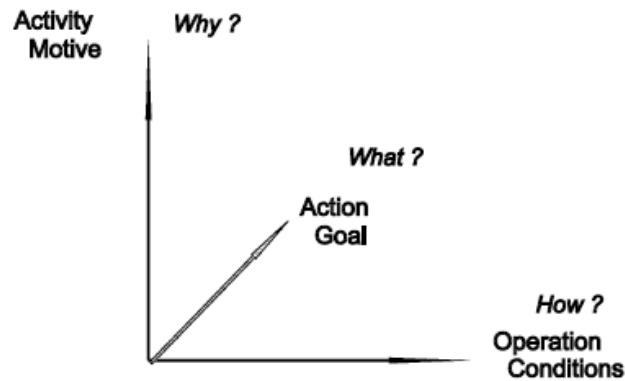
Figure 2.2: Graphical depictions of the hierarchical and dynamic structure of human activity according to Leont'ev (1978, pp. 62-68). 2.2a (above) showing the dynamic relationship between levels (after Kuutti 1996, p.30); and 2.2b (below) the levels as three dimensions for the description of consciousness (from Bærentsen, 2002, p.42).

Leont'ev formulated some of the most basic general principles and philosophical concepts of the theory of activity. On the basis of an evolutionary account of the origins of human consciousness in tool mediated labour activity (Leont'ev, 1981b, esp. pp. 203-340), he elucidated a tripartite, dynamical model of human (collective, social) activity (Fig. 2.2). Activities are portrayed as hierarchically organized structures which are motivated (that is, energized) by needs. Activities are made up of chains of individual *actions*. Actions, which are processes characterized by being oriented toward achieving conscious goals (Leont'ev, 1978, p. 153), also have unconscious, operational aspects through which the actor responds to (internal and external) environmental factors; thus, the specific methods through which actions are accomplished are determined by the specific conditions under which they are carried out. Leont'ev's general model of activity thus incorporates the dyads motive-activity, goal-action, conditions-operations, and the dynamic process of transformation from one to another (Fig. 2.2a). These levels of activity also provide three dimensions for the description of human activity in terms of its emotional-motivational, cognitive, and behavioural components (Fig.2.2b). Thanks to their relatively widespread availability in translation (*e.g.* Leont'ev, 1977, 1978, 1981b, 1981a, all in English) Leont'ev's definitions of the fundamental concepts of AT are probably the most well-known interpretations of Soviet activity theory in the West.

2.4.1.2 Activity & Motives, Actions & Goals, Conditions & Operations

Leont'ev and his associates argued that biologically- and culturally- shaped human needs produce the motives which energize activities, that is needs and motives combine to create a "system of inducements" (Bedny and Meister, 1997, p. 3) which stimulate individuals to engage in activity directed toward attaining certain goals. In activity theory, needs and motives are conceptualized as being hierarchically ordered, and as being capable of either synergistic or antagonistic relationships; the dominance of any given motive at any given time depends on both personal and situational factors. Leont'ev carefully distinguished between needs and motives, and the conscious goals which guide actions (*e.g.* Leont'ev, 1978, pp. 115-125). Needs are transformed into, or give rise to, motives only in cases where they acquire the capacity to induce a person's activity, that is, when the possibility arises of carrying out exploratory or transformative actions on some (material or ideal) object in such a way that a human need can be (directly or indirectly) met. From this viewpoint it is clear that motives can arise not only from physical, animal needs (*i.e.* for food or shelter) but also from those desires, intentions, aspirations *etc.* associated with human communality and culture.

Actions are always guided by (partly or fully) conscious goals (Leont'ev, 1978, p.63, Wertsch, 1981b, pp. 21-23), a goal being some more or less precise representation (as *e.g.* an image or concept) of the future desired result of actions or activity. Actions can be both mental/internal and external/practical: mental actions manipulate images and symbols; practical actions explore and transform real material objects (Bedny and Karwowski, 2004a, pp. 146-147). Any action forms part of one or more activities.

Actions are themselves constituted through smaller units, operations, which are the automatic and unconscious aspects of action. The specificity of operations is largely determined by (somatic and external) environmental conditions. The *orienting basis* for operations is established through repeated experience with concrete material conditions; through frequent repetition, what must initially be conscious, goal-directed actions become unconscious, automatic operations triggered by specific conditions. In Figure 2.2a, arrows indicate the continuous possibility of such transformations between levels of activity; for example, if the conditions under which some familiar task is carried out change, established

operations may fail to produce the desired result (*i.e.* breakdown occurs; see §1.2.2 and discussions in Chapters 3 & 4), necessitating that conscious attention be paid to formerly automatic aspects of the task (Leont'ev, 1978, p.66). This idea of the continuous dynamic translation between, and interpenetration of, different levels in the hierarchical structure of activity is fundamental to the activity-theoretical approach to HCI founded by Bødker (discussed in the following chapter, §3.2.1).

2.4.1.3 Meaning & Sense in Activity

Another of Leont'ev's important contributions to the development of AT was his work (*e.g.* Leont'ev, 1978, pp. 85-95) on the relationship between "objective meaning" and "personal sense" (significance) as constituents of human consciousness, a problem first addressed by Vygotsky in semiotic terms. Leont'ev explored the connections between sense, meaning, motivation and intentions, and sensory input as evidenced in practical, object-oriented activity (Fig. 2.3). These issues were shown to be directly relevant to goal-formation and subjects' relationships with tools and tasks in work processes (see discussions in Bedny and Meister, 1997, pp. 37-42 and, Bedny and Karwowski, 2004c). This work became an important foundation for applications of the systemic-structural approach in AT (§2.5.3) to problems of motivation in work psychology (see *e.g.* Bedny and Karwowski, 2004c). This and other major features of Leont'ev's formulation of general activity theory are concisely summarized in (Leont'ev, 1981a).
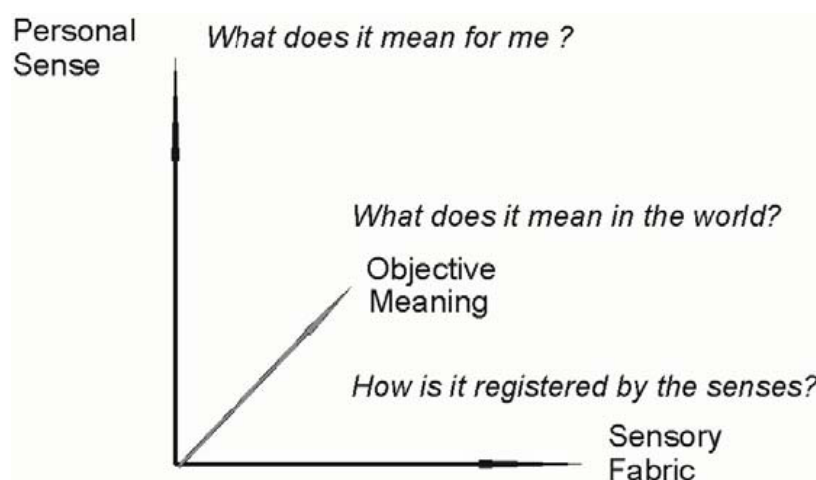
Figure 2.3: Meaning, sense, and the sensory fabric as three constituents of human consciousness. From (Bærentsen, 2005, unpublished manuscript). *Cf.* Fig. 2.2b.

2.4.2 The Systems-Cybernetic Approach

S. L. Rubinshtein (1889-1960) was one of the major theoreticians and philosophers of Soviet psychology and psychophysiology, and is widely acknowledged by Russian scientists, alongside Leont'ev, as the principal founder of activity theory (see *e.g.* Leont'ev, 1978, Wertsch, 1981b). Among Rubinshtein's major contributions to AT was his work on *the unity of cognition and behaviour* and *object meaning*. Researchers influenced by Rubinshtein's approach and Pavlovian physiology made fundamental contributions to the development of both theoretical and applied AT from the 1930s onward (Bedny *et al.*, 2000). Initially using data from laboratory studies of voluntary movements and actions, N. A. Bernshtein (1896-1966) and Pavlov's student P. K. Anokhin (1898-1974) introduced notions of feedback from which they evolved detailed explanations of non-homeostatic (that is, goal-directed) self-regulation processes in human activity in physiological, psycho-physiological, and cybernetic terms (*e.g.* Anokhin, 1935, 1955, Bernshtein, 1935).

Bernshtein mainly researched the control of physical behaviour (*esp.* locomotion) through feedback mechanisms, introducing concepts of a hierarchy of levels of self-regulation of movements and actions (Bernshtein, 1967), and of the self-regulative process as containing dynamically related external and internal contours of self-regulation, involving feed-forward and feedback from external receptors and (typically) unconscious proprioceptive systems (Bernshtein, 1966, 1967, 1969). Bernshtein in particular was associated with the development of a "physiological cybernetics", one strand of the wider Soviet cybernetics movement described in (Gerovitch, 2002, esp. pp. 218-226). The Pavlovian Anokhin's work in "neurocybernetics" - which began in 1935 with the study of feedback in animal behaviour - involved the development of the notion of anticipatory reflection (Anokhin, 1955), the theory of functional systems (Anokhin, 1962), and the concept of afferent synthesis (Anokhin, 1969).

Research in the systems-cybernetic approach to activity theory continued to flourish until the dissolution of the Soviet Union; important contributions included the methods of functional micro-analysis and models of the self-regulation of motor activity developed by V. P. Zinchenko, N. D. Gordeeva, and their associates (*e.g.* Zinchenko and Gordon, 1981, and see Bedny and Meister,

1997, pp. 57-61); and the models of individual mechanisms of psychological self-regulation developed by O. A. Konopkin (Konopkin, 1980) and G. Z. Bedny (Bedny and Meister, 1997, Chapter 2, and see §2.5.3 below). This tradition – which incorporates elements of all the major strands of Soviet psychology and also closely parallels developments in Western cognitive science - underpins the more recent development of systemic-structural activity theory which is described in §2.5.3. However, at the time of writing Soviet research in the cybernetics-systemic-structural tradition is largely unfamiliar to, and little used by, Western activity-theorists.

2.4.2.1 The Unity of Cognition and Behaviour

Among Rubinshtein's major contributions to the foundation of activity theory was his formulation – initially as a philosophical concept, later on the basis of experimental evidence - of *the principle of the unity of cognition and behaviour* (Rubinshtein, 1935, 1959, 1973). This fundamental tenet of AT[12] points to the interaction and interdependence of the cognitive and motor components of activity (Wertsch, 1981b, pp. 11-13, and see Bedny *et al.*, 2001a for a detailed discussion of the relevance of this principle to HFE). Through his analyses of a series of psychophysiological studies Rubinshtein demonstrated that the practical manipulation of material objects through direct contact provides continuous control for the cognitive processes regulating manipulation; that is, that mental processes emerge from motor processes and *vice versa* (Bedny and Karwowski, 2004a, p. 137). Rubinshtein also introduced the concept of "object meaning" to describe the network of feelings and experiences that individuals associate with particular objects in particular situations through their experience of interacting with them during the performance of a particular action (Bedny and Karwowski, 2004c, p. 124).

2.4.2.2 Functional Systems, Afferent Synthesis, & Anticipatory Reflection

Anokhin first developed the concept of *functional system*[13] on the basis of experimental findings which established that the neurophysiological basis of an activity is a dynamic organization that selectively integrates different central and peripheral neural mechanisms (see summaries in Bedny and Meister, 1997, p. 11, and Cole *et al.*, 2006, pp. 123-5). The notion of *afferent synthesis* describes that

stage of the behavioural act involving "…the processing, comparison, and synthesis of all the data which an organism needs in order to perform that adaptive action …most adequate to the given circumstances" (Anokhin, 1969, p. 833). Anokhin's model of *anticipatory reflection* based on the afferent synthesis between perception and memory gives a general model for understanding the forward-looking element present at all levels of activity (Fig. 2.1): there is anticipation in the motive of the activity, in the goal of an action and in the orienting basis of an operation. Anticipatory reflection thus guides activity by making an afferent synthesis between (extero- and proprio-) perception of the situation and memories (*i.e.* personal experience), forming an anticipation of the future state which may result from the activity about to be performed (Bardram, 1997, pp. 20-21). As activity is performed feedback mechanisms compare the result of activity with the prediction; the detection of incongruence gives rise to a learning situation through which personal experience may be expanded. This understanding is at the heart of the self-regulation models of activity developed by systems-structural activity theorists which are described and used in later sections of the thesis (see *e.g.* §2.5.3.2 & Chapter 8)

2.4.3 Developments in Application and Theory in the USSR

AT has been described in the West as "a powerful and clarifying descriptive tool rather than a strongly predictive theory" (Nardi, 1996a, p.8, and see also §3.5.2.1, next chapter). One finding of the literature and historical research reported in this thesis is that this view is not entirely accurate; in fact, over the course of its long developmental history, AT has frequently been used to make and test predictions in the applied human sciences, including education, medicine, human factors/ergonomics and work psychology, with the experience derived from such applied work often driving further development of the theory (Bedny, 2004). This section provides a very brief overview of developments of AT in application and theory in the former USSR, beginning by providing a few specific examples of applications of the activity approach to practical problems. More extensive accounts can be found in the literature cited in this chapter.

2.4.3.1 The Activity Approach in Education and Medicine

The activity approach was under continuous development throughout the Soviet era; although researchers were frequently obliged to couch their ideas in the ideologically acceptable scientific terminology of the day (Cole and Maltzman, 1969a, pp. 5-10). In the pre-war period one major applied contribution of the activity approach was Vygotsky's reform of special needs education (Gindis, 2003), work continued by Z. I. Shif and others (*e.g.* Shif, 1969). Later, P. I. Gal'perin (1902-1988), went on to make contributions to Soviet elementary and secondary education in the post-war period, articulating methods of "developmental teaching" based on his theory of the orienting basis of activity (Haenen, 1996, Haenen *et al.*, 2003). Through the 1950s and 60s Gal'perin continued to develop activity-theoretical understandings of learning activity with co-workers such as V. V. Davydov and N. F. Talyzina; in the 1960s Davydov and D. B. Elkonin formulated national curricula for primary schooling in various subjects, including mathematics (Davydov, 1988).

During WW2 researchers in AT and CHP provided scientific and medical support for the Soviet war effort. Vygotsky's associates Luria and Leont'ev headed rehabilitation clinics where, the help of large research groups, they developed techniques for the restoration of cortical and motor functions in wounded servicemen and women (Luria, 1979, Haenen, 1996, Levitin, 1982). This work (in what came to be known as neuropsychology) produced major advances in the study and treatment of physical trauma and brain lesions using activity-theoretical constructs such as the concept of functional systems (see *e.g.* Luria, 1967, 1957). In the post-war period AT was also used in psychiatry and psychotherapy, for example in the treatment of alcohol addiction (*e.g.* Bratus, 1990).

2.4.3.2 Engineering Psychology, Human Factors and Ergonomics

Throughout its existence one of the most pressing concerns of the USSR was the improvement of industrial productivity and the health, skills and education of the workforce (Noskova, 1996, Munipov, 1993). It was also one of the most politically sensitive areas of research, especially in the Stalinist era (1924-1953). In those periods when such research was permissible, cultural-historical psychology and activity theory played an important part in the study of human

labour processes and vocational training, through what was at first called psychotechnics, then work psychology, and later engineering psychology and ergonomics (Bedny *et al.*, 2000). In the 1920s and '30s, scientists such as Dobrotvorsky and Gellerstein broke new ground in the ergonomics of aircraft design while Bernshtein and others developed distinctively Soviet approaches to the design of work organisation and the production process (Ponomarenko, 2004, Munipov, 1993, p. 155). However, despite its value - both economically and as a source of data for the development of psychology in general - this type of research was halted in 1936 as part of the Stalinist suppression of "bourgeois pseudo-science" (*ibid.*, p. 157) – which began in the applied human sciences as a reaction against the use of aptitude testing in schools (see editor's introduction to Lomov, Cole and Maltzman, 1969a, and Kozulin, 1984) – following on from the "Great Break" in Soviet society initiated by Stalin in the period 1928-31 (Graham, 1993, pp. 93-98).

Until the death of Stalin in 1953 both ergonomics and engineering psychology remained highly suspect (Noskova, 1996); overtly activity-theoretical psychology was frequently eclipsed by the official support given to the "patriotic science" of the Pavlovians (see Cole and Maltzman, 1969a, pp. 6-10). Despite these problems many scientists using the activity approach continued to work creatively, finding it relatively easy to present their work within a Pavlovian conceptual framework less reductionist and more conceptually complex than its US Behaviorist equivalent (Cole and Maltzman, 1969a, p. 12, Haenen, 1996, pp. 176-177).[14] However, in 1955 a review of recent work in Soviet psychology noted "an almost complete lack of studies of the psychology of labour, though the tasks facing industry and agriculture call for special attention to this question" (Smirnov, 1955/1957, p. 43). During the "Khrushchev Thaw" (*c.* 1956-62) belated official recognition of the dire state of the economy and the increasing technological demands of the Cold War and its related space program brought about a revival in engineering psychology and ergonomics, usually dated to the 1959 opening in Leningrad of the first university laboratory of engineering psychology (Cole and Maltzman, 1969c, p. 574, Munipov, 1993, p. 157). During the early '60s, after a hiatus of 25 years, the concepts of US human factors

theorists once again began to be openly incorporated into Soviet thinking (Bedny and Meister, 1997, p. 143).

2.4.3.3 Post-Stalin AT

The relatively liberal intellectual climate in the post-Stalin era allowed for increasing official recognition of the contribution of AT. This process was accelerated by the rise of Soviet cybernetics in the mid-1950s (Gerovitch, 2002), which had a profound impact on the further development of systems thinking within AT. One important event at this time was the 1958 publication in Russian to wide acclaim of Wiener's work on cybernetics (Wiener, 1948), Soviet commentators being quick to point out that the work of Anokhin and Bernshtein (§2.4.2) anticipated many of Wiener's ideas by more than two decades (Bedny *et al.*, 2000). Research in applied psychology was resumed, and from around 1964[15] onwards activity-oriented systems thinking became increasingly central to Soviet engineering psychology, particularly in relation to issues of training and operator performance (for an overview see Lomov, 1969), but also again in areas such as aviation and the space sciences (Ponomarenko, 2004, Gerovitch, 2002, p. 226). By the mid 1970s the activity approach had become the pre-eminent conceptual framework for research in ergonomics (*e.g.* Bedny and Zelenin, 1980), engineering psychology (*e.g.* Kochurova *et al.*, 1975/1981), training (*e.g.* Novikov, 1986), and education (*e.g.* Bozhovitch, 1969).

For the last three decades of the Soviet era (1960-1990) AT was recognized as a fundamental scientific approach in both general and applied psychology, encompassing a range of interests, approaches, and theoretical concepts (Bedny, 2004). The 1970s and 80s saw the rehabilitation of Vygotsky's work, partly as a result of its growing influence on by Western researchers, but also due to the efforts of a new generation of Soviet philosophers of activity led by Evald Ilyenkov (*e.g.* Ilyenkov, 1977). Theoretically, AT was under development in several new directions, including efforts to formulate a rigorous approach to the analysis of collective activity (*e.g.* Petrovsky, 1983, 1985) and the refinement of the systemic-structural synthesis discussed in §2.5.3 below. AT was also under simultaneous development by scientists in other Eastern bloc countries, such as Z. Tomaszewski in Poland and M. A. Kotik in Estonia.

2.4.4 AT & the Collapse of Soviet Science

Rapidly worsening economic and social conditions across the USSR during the 1980s and 90s - leading up to and then following on from the final collapse of Communism in 1991 (see Watson, 1998, and Volkogonov, 1999, for general historical accounts of this period) - seriously affected research in psychology, as in other disciplines. Between 1989 and 1999, tens of thousands of Soviet scientists emigrated, changed profession, or retired from what was at this time the largest scientific establishment in the world (Graham, 1993, Dezhina and Graham, 2002, pp. 9-11).

These circumstances, which affected the whole Soviet sphere of influence, meant that many scientists working in AT were forced to suspend or discontinue their research as the entire system of Soviet science and education fell into disarray. The dire economic climate also effectively halted any further progress in Soviet computer science, which although theoretically advanced had continually lagged behind its Western counterparts in terms of technological developments, arguably at least partly due to the lack of the kind of enterprise culture which had driven developments in the US (Graham, 1993, Feigenbaum, 1961, Gerovitch, 2002).[16] Thus, Soviet activity theorists were unable to directly contribute to the development of human-computer interaction research during the period in which it rapidly expanded in the West (see Sections 1.4.2 & 1.4.3, Chapter 1).[17] Current evidence suggests that, pre-collapse, only a few Soviet scientists began to explore HCI issues from the AT viewpoint, one such being the psychologist O. K. Tikhomirov, who undertook work in the 1970s and 80s investigating the impact of ICT on the structure of activity in medical diagnostics (Tikhomirov, 1981).

2.5 Extra- and Post-Soviet Developments in Activity Theory

Prior to and during WW2, and for much of the Cold War period (1945-1991), communication between Russian scholars and the outside world was sporadic and tightly restricted.[18] Some important translations of the work of Luria (*e.g.* Luria, 1932) and Vygotsky (Vygotsky, 1939) appeared in the 1930s (Kozulin, 2000, p. liv). However, in general the achievements of Soviet psychology remained largely unrecognised in the West until the 1950s, when the

"Khrushchev thaw" allowed some resumption of normal dialogue between Soviet scientists and their colleagues in the international community. In the late 1950s there were several important exchanges of visiting delegations of psychologists, a doctoral/postdoctoral academic exchange opened (Cole, 1996b) and research papers began to be translated and published. One significant early episode in this post-Stalinist warming of relations was the 1955 visit to the Soviet Union of a party led by the British educationalist Brian Simon, who subsequently published (in 1957) an important collection of research papers (Simon, 1957b) documenting the state of contemporary Soviet psychology. This volume - which contains chapters by many leading exponents of the activity approach including Elkonin, Gal'perin, Leont'ev, Luria, Rubinshtein, and Zaporozhets – appears to be virtually unknown among Western AT scholars today. [19]

It was not only the general political and cultural climate that was unfavourable during the inter- and post-war period; in the human sciences, the dominance of American neo-behaviourism and learning theory meant there was little audience for cognitive and cultural-historical approaches among UK and US psychologists (Kozulin, ibid. and also see Cole and Maltzman, 1969b). However, in those parts of Europe and Scandinavia with closer ties to Russia, activity theory (particularly as developed in the work of A. N. Leont'ev) was more influential. In Germany, both Action Regulation Theory (Volpert, 1989, Hacker, 2003) and Critical Psychology (Tolman, 1991, Holzkamp, 1991) were developed upon the basic principles of general activity theory, while some branches of Scandinavian (especially Danish) social and cognitive psychology were strongly influenced by the activity approach (see Chapter 3). But it was not until the "cognitive revolution" (Miller, 2003) in American psychology had begun that Anglophone scientific audiences became more receptive to Soviet psychological approaches. Work on theoretical and applied AT began to be more widely translated and published in English in the 1960s and 70s, when the growing popularity of social constructivist, humanist and cognitive approaches in Europe and the US (partially fuelled by the burgeoning radical left-wing student movement) coincided with the rehabilitation of Vygotsky's work in the USSR.

1963 saw the publication of further collection edited by Simon (and his wife Joan) on educational psychology (Simon and Simon, 1963). New American journals focusing on translations from the Russian were launched: *Soviet Psychology* (in 1966) and *Soviet Neurology & Psychiatry* (in 1968). Alongside books by Luria (*e.g.* Simon, 1959/1975), new translations of Vygotsky's books and papers were made (Vygotsky, 1962, 1930-5/1978) and had a considerable impact on Western audiences, especially among educational researchers. The 1969 paper collection *A Handbook of Contemporary Soviet Psychology* edited by Michael Cole and Irving Maltzman (Cole and Maltzman, 1969c), and various English-language titles from state-controlled Russian publishers - *e.g.* Anokhin (Anokhin, 1962), Bernshtein (Bernshtein, 1966), Rubinshtein (Rubinshtein, 1973), and Leont'ev (Leont'ev, 1981b, 1977) - continued this process through the 1970s. During this period translations were also appearing in various European languages, notably German and Danish.

One factor affecting the dissemination of AT in the West that was to have a direct bearing on the subsequent development of AT-HCI was the nature of institutional relationships within Soviet psychology in the 1960s and '70s.[20] From the mid-1950s, Leont'ev, Luria and other former colleagues and students of Vygotsky held influential positions in the Moscow research institutions (Wertsch, 1981b) while at the same time, AT researchers in the non-Vygotskian tradition of AT influenced by Rubinshtein - such as the engineering psychologist B. F. Lomov - were in positions of power at the national level of the Soviet scientific apparatus (Cole, 1996b). During the 1960s and 70s these two "factions" (very broadly, cultural-historical AT and systems-cybernetic AT) within Russian AT were locked into a series of bitter intellectual and professional disputes over concepts, methods, and principles (Cole, *ibid.*; G. Z. Bedny, personal communication).[21] The legacy of this period is still felt among the global AT community. Historically, some of the most active proselytizers and developers of CHP and AT in the West, such as Michael Cole and Yrjö Engeström (see §2.5.1 & §2.5.2 below), have been more closely associated with the Leont'evian strand of (Muscovite) Soviet AT, a factor which may have contributed toward this aspect of the activity approach being currently by far the most well-known and influential among Western researchers (Harris, 2005a).

2.5.1 Cultural-Historical, Sociocultural, and Cultural Psychology

Cultural-historical psychology (CHP, §2.3) has continued to develop both within and outside the former Soviet Union. In the mid 1990s, at least two Russian universities began to offer systematic education in CHP (Chaiklin, 2001a). In the West, Vygotskian approaches in developmental psychology and education have become increasingly popular, as evidenced by a continuous stream of publications (*e.g.* Chaiklin *et al.*, 2003, Chaiklin, 2001b, Cole, 1996a, Daniels, 1996, Forman and Cazden, 1985, Hedegaard and Lompscher, 1999, John-Steiner *et al.*, 1994, Kozulin *et al.*, 2003, Newman and Holzman, 1993, Wertsch, 1985, Wertsch *et al.*, 1995a) and the steady growth of the International Society for Cultural and Activity Research[22] from its origins at an international conference (in Finland) in 1982.

The post-Soviet tradition in CHP and AT is marked by its eclecticism; various schools of thought within the activity approach are combined in various ways, as well as being brought into dialogue with related approaches in Western psychology and social theory. Although demarcations are shifting and unclear, approaches include the "sociocultural theory" associated with James V. Wertsch and his collaborators, which emphasizes the semiotic aspects of Vygotsky's work, drawing on sources such as Burke's symbolic action and the Soviet sociolinguistics of Bakhtin (see Wertsch *et al.*, 1995b, which also discusses the issues of nomenclature touched on in the opening section of this chapter); and the "cultural psychology" associated with a group of (mainly) US-based researchers led by Michael Cole, which brings together ideas from CHP, AT, cognitive science, and American Pragmatism (Cole, 1996a). There are flourishing schools of Vygotskian cultural-historical thought in Europe, especially in the Netherlands and Scandinavia. These groups are also strongly influenced by the Soviet educational research and reforms of Gal'perin and his successors, and tend to more explicitly identify themselves as "cultural-historical psychologists" (Chaiklin, 2001b).

Among these various strands, Cole's project in particular has been influential on, and influenced by, the emergence of a distinctive post-Soviet version of AT - Engeström's Cultural-Historical Activity Theory (CHAT) - which is discussed in the following section. Closely connected with all these groupings, but somewhat

outside the mainstream of the cultural-historical tradition, is Lave and Wenger's theory of situated learning in communities of practice (Lave and Wenger, 1991, Wenger, 1998, and see Chapter 1, Section 1.1).

2.5.1.1 Signs, Speech, & Adult Learning

Much recent work in cultural-historical psychology has focused on semiotic mediation (through *e.g.* the written and spoken word, mathematical symbols, and other signs) and internalisation (§2.3.2), particularly in relation to teaching and learning in the classroom (*e.g.* Ahmed, 1994, John-Steiner *et al.*, 1994, Miller, 1994, Ramírez, 1992, Santamaría, 2001, Hasan, 2002). These studies have demonstrated that the semiotic aspects of sociocultural activity play a fundamental role in skill acquisition and self-control, highlighting the importance of dialogue and discussion (and social interaction generally) to learning. Efficient instruction is seen as beginning by taking the initial level of the learner into account, and then going beyond this by allowing a more capable peer to support (or, as Bruner, 1974, expresses it, "scaffold") them as they work in their "zone of proximal development" (see §2.3).

One set of findings in this area with particular relevance for the research reported here have been those carried out by Juan-Daniel Ramírez Garrido and his group, who have conducted research into adult literacy programmes in rural southern Spain (Ramírez, 1994, Ramírez Garrido *et al.*, 1996, Ramírez Garrido *et al.*, 1999). Their findings extend the classic Vygotskian view of the linguistic basis of the process of internalisation, a process understood as beginning from activity regulation by more capable others through social speech, then self-regulation through self-directed but still-audible ("private" or "egocentric") speech, to self-regulation through highly abbreviated verbal thinking actions. Hitherto, this process had mainly been studied in connection with the physical and emotional development of individuals during childhood and adolescence (see *e.g.* Luria, 1961, 1969). Through their studies, the Spanish group have extended this model of internalisation to include learning during adulthood (Azevedo dos Santos *et al.*, 2002). What they found was that when adults are confronted with the need to master new sign-systems (such as written language, mathematics, or the symbols of a computer interface) both social and self-directed speech actions are implicated in their learning processes. When taken in conjunction with findings

which suggest that there is a higher probability and actual incidence of egocentric speech in situations where social dialogue is possible and encouraged, these observations point to the impact of social-environmental factors on skills development, especially when those skills involve semiotic mediators.

2.5.2 Cultural-Historical Activity Theory (CHAT)
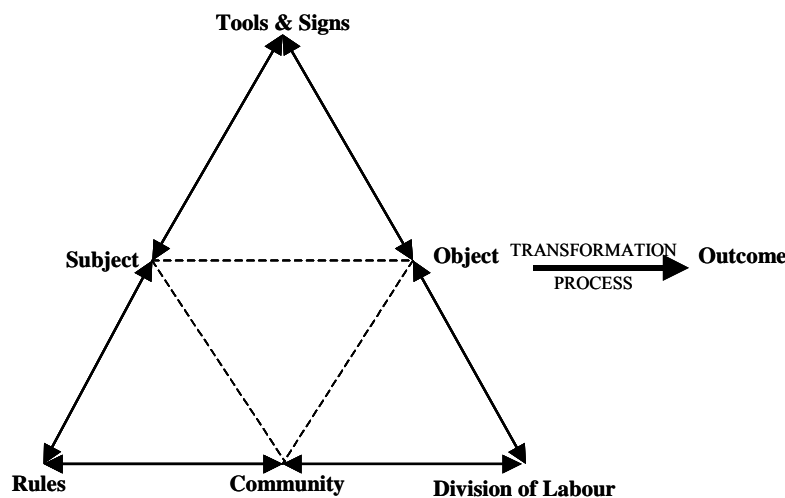
Figure 2.4: The CHAT "activity system", or basic schema of activity. After Engeström (1987, 1999).

From the point of view of developments in AT-HCI and ATIT, the most influential recent formulation of activity theory is the cultural-historical approach to collective and organizational learning developed during the 1980s by the Finnish educational psychologist Yrjö Engeström (Engeström, 1987, Engeström and Middleton, 1996). From his early thesis work (Engeström, 1987) onward, through a series of books and papers addressing problems in various disciplines (Engeström, 1991a, 1999b, 1999a, Engeström, 1999d, Engeström, 2000, 2001, Engeström and Middleton, 1996, Engeström and Miettinen, 1999, Engeström *et al.*, 1999), including human-computer-interaction (Engeström and Escalante, 1996), the work of Engeström and his associates has been central to the dissemination and popularization of activity theory in the post-Soviet era.

2.5.2.1 Activity System as the Basic Unit of Analysis

Engeström's doctoral thesis, *Learning by Expanding* (Engeström, 1987), synthesized a number of the basic ideas of CHP, AT, Marxist-Leninist historical materialism and Western systems theory/cybernetics to produce a generalized

model of processes of learning and transformation in collective human activity. Based on a review and critique of developments in the Leont'evian tradition of AT, Engeström set out to "derive a model of the structure of human activity through genetic analysis" (Engeström, 1987, p. 34). He expressed his interpretation of Vygotsky's work on tool mediation (§2.3.1) and Leont'ev's elucidation of the structure of activity, (Fig. 2.1) as triangular diagrams (Engeström, 1987), pp. 33-36], which were then combined with a similar graphical representation of the Marxist-Leninist exegesis on the fundamental contradiction between production and consumption as the driver of growth and change in capitalist economies to produce the model or schema (depicted in Figure 2.4) which has become widely known as the "Engeström triangle". This schema claims to depict a holistic, collective "activity system" which is "actually the smallest and most simple unit that still preserves the essential unity and integral quality behind any human activity" (Engeström, *ibid*., p. 38).

2.5.2.2 Conflict & Contradiction as Drivers of Change & Learning

Table 2.1: Typology of contradictions. After Engeström (1987).

Level	Nature of Contradiction
1. Primary	Contradiction within each constituent component of the central activity
2. Secondary	Contradiction between the constituent components of the central activity
3. Tertiary	Contradiction between the object/motive of the dominant form of the central activity and the object/motive of the more advanced form of the central activity
4. Quaternary	Contradiction between the central activity and its neighbouring activities.

Drawing on Vygotsky's formulation of the ZPD (2.3.3), the work of Bateson (esp. Bateson, 1972, on the "double bind"), and the philosophy of Wartofsky (Wartofsky, 1979), Engeström has used the activity system schema (Fig. 2.3) as the basis for elaborating a multi-level model of change and learning. Individual, collective and organizational learning are portrayed as linked phenomena driven by contradictions and conflicts both within and between past, present, and future activity systems and involving mediation by a hierarchy of artifacts (Engeström, 1990). "Expansive learning" takes place when old forms of practice are transcended and a qualitatively new type of collective activity is created. This argument involves the elaboration of a 4-level typology of contradictions, which is set out in Table 2.1 and depicted graphically in Figure 2.5.

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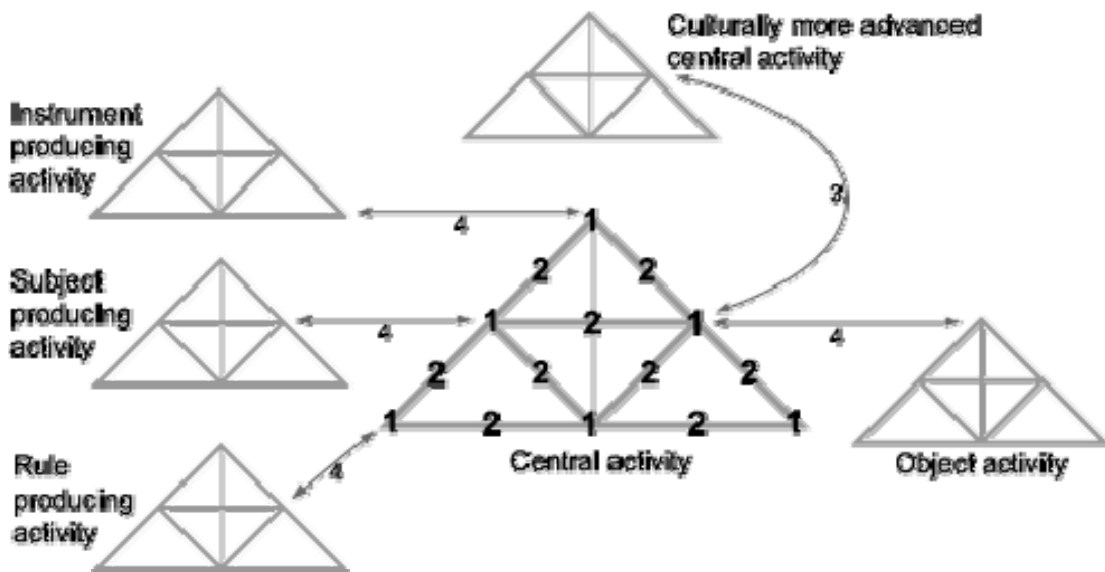
Figure 2.5: Relations between activity systems in terms of classes of contradictions. Notation as per classification in Table 2.1. Triangles represent activity systems as shown in Fig. 2.4. From (Bertelsen and Bødker, 2003)

2.5.2.3 The Hierarchy of Mediating Artifacts

Table 2.2: Hierarchy of mediating artifacts according to Engeström (1990, 1999).

Category	Type	Function
Primary	What	Contributes a means of achieving the object
Secondary	How	Contributes to understanding how to achieve the object
Tertiary	Why	Motivates achievement of the object
Quaternary	Where-to	Motivates evolution of all elements in the activity system

Wartofsky (Wartofsky, 1979) proposed three primary types, or categories of artifact that mediate human action; Engeström (Engeström, 1990) developed this idea into a three- level hierarchy, mapped onto the hierarchical structure of activity (Fig 2.1). Primary artifacts are those tools used directly in production to mediate the relationship between the subject and "object" [23] of activity; secondary artifacts are representations of modes of action – models - used to preserve and transmit skills in the production and use of primary artifacts; tertiary artifacts are imaginative or visionary artifacts which give "identity and overarching perspective to collective activity systems" (Engeström, 1990, p.174). In later work, this artifact schema was extended to include a fourth type, quaternary or "where-to" artifacts, which are considered as motivating the evolution of whole activity systems (Engeström, 1999c). This approach has been

influential on the development of ATIT, where it has been taken up in work by Bertelsen (*e.g.* Bertelsen, 1998, 2004b, 1994) and others.

2.5.2.4 Developmental Work Research

Engeström's theoretical project has been operationalized through a program of participatory action research (Blanton, 1995). The resulting empirical experience has been formulated into a methodology called developmental work research (DWR, Engeström, 1991a). This has involved developing and applying Engeström's ideas about "cycles of expansive learning" in educational (Engeström, 1991b), legal (Engeström, 1996), medical (Engeström, 1999b), and commercial (Engeström, 1999c) organizations, and on bringing his activity-theoretical ideas into contact with other theoretical approaches such as actor-network theory (Engeström and Escalante, 1996).

The starting point of DWR is that the organisation within which work is carried out exerts a continuous influence on those working within it, and that work activity develops through the relations and contradictions of its components, with change in one component affecting all the others. Practically, in doing DWR workers and researchers engage in the joint analysis of ethnographic data on existing work practices. A model of the overall activity system is developed by means of an historical analysis, and the model is used and tested against specific examples of problems, disturbances and innovative practices in the work situation.

Since the late 1980s Engeström's work has been significant in terms of promoting CHAT among the global research community, both because of the accessibility and clarity of his texts, graphical schema, and typologies (Figs.2.4 & 2.5, Tables 2.1 & 2.2) and his efforts in organizing conferences, projects, and research groups. Indeed, for many in Western academia the approach of US/Finnish[24] school of cultural-historical activity theory has become virtually synonymous with activity theory as a whole (see, as a typical example of this trend, the overview of AT given in Benyon *et al.*, 2004, pp. 178-185). This has led to the widespread adoption of a formulation of activity theory - embedded in the CHAT acronym - which asserts the essential identity of cultural-historical psychology and activity theory. In the CHAT literature, this argument is

supported by historical accounts of the development of activity theory which make little or no mention of contributions from outside the Vygotsky/Leont'ev strand (see for example Engeström and Miettinen, 1999, Engeström, 1999d, Cole, 1996a, p. 36).[25]

2.5.3 Systemic-structural activity theory (SSAT)
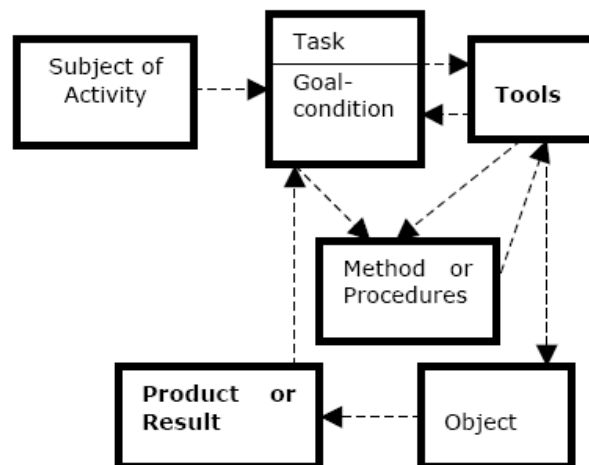
Figure 2.6: The major elements of work activity according to SSAT. From (Bedny and Karwowski, 2004a).

At the end of the 1990s, a group of Russian and American scientists working in the systems-cybernetic tradition of Bernshtein and Anokhin began to publish English-language articles and books dealing with topics in human factors/ergonomics (Bedny and Meister, 1997, Bedny and Seglin, 1997, Bedny, 1998, Bedny and Meister, 1999, Bedny and Seglin, 1999b, 1999a, Bedny *et al.*, 2000, Bedny *et al.*, 2001a) and, latterly, human-computer interaction (Bedny *et al.*, 2001d, Bedny *et al.*, 2001b). Under the rubric of systemic-structural activity theory (SSAT), this work is presented as a modern synthesis within activity theory which brings together the cultural-historical and systems-structural strands of the tradition (as well as other work within Soviet psychology such as the Psychology of Set)[26] with findings and methods from Western human factors/ergonomics[27] and cognitive psychology.

The development of SSAT has been specifically oriented toward the analysis and design of the basic elements of human work activity (Bedny, 2004): tasks, tools, methods, objects and results, and the skills, experience and abilities of involved subjects (Fig. 2.6). SSAT has developed techniques for both the qualitative and

quantitative description of work activity (Bedny and Meister, 1997, pp. 232-297). Its design-oriented analyses specifically focus on the interrelationship between the structure and self-regulation of work activity and the configuration of its material components. As such, many of its ideas are directly relevant to the design and evaluation of information and communication technologies, although SSAT has not as yet been widely taken up by the ATIT community.

2.5.3.1 Units of Activity Analysis in SSAT

In SSAT, human work activity (perceiving, acting, learning, thinking, *etc.*) is understood as a multi-dimensional, multi-level, dynamic and structured system in which cognitive, behavioural, and motivational-affective elements are integrated and organized toward achieving conscious goals (Bedny *et al.*, 2000). SSAT presents a scheme of the procedural components of activity and units for their analysis which differs somewhat from the other post-Soviet AT traditions outlined above inasmuch as it explicitly integrates the notions of *task* and *function block*. This scheme is depicted graphically in Fig. 2.7.
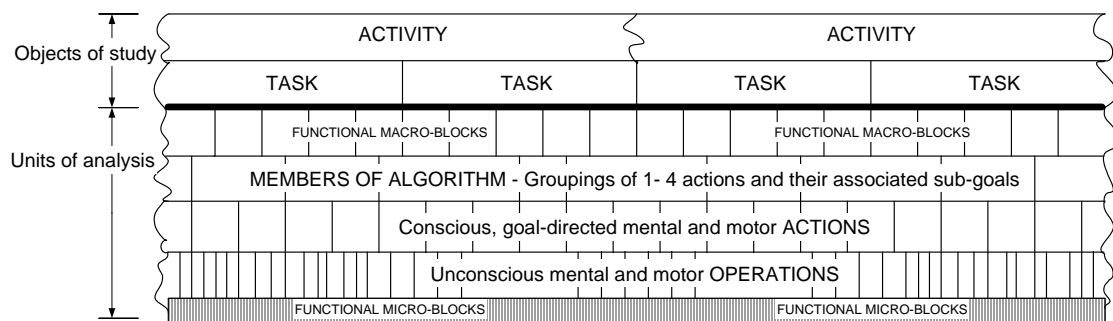
Figure 2.7: Objects of study and units of analysis in SSAT.

The first two components of this schema (activity, task) are considered primarily as the objects studied by activity theory, the remainder as the units of analysis employed for their study. Activity is understood as a continual flow, sub-divided into, or constituted through, individual actions. A task is understood as some fragment of activity *i.e.* a specific chain or sub-set of related actions organized around a task goal. Actions are the principal units used for the morphological (structural) analysis of activity during task performance, and, as in activity theory generally, are understood as being oriented toward conscious goals while also having unconscious aspect (operations; see also Fig.2.1). Function blocks, which may be used for either macro- or micro-analysis according to the focus of the

study, are the principal units used when undertaking the functional description of activity as a self-regulating system (see §2.4.2). It should be noted that in SSAT, meanings and signs are treated as the psychological tools of mental actions, but (in contradistinction to cultural-historical psychology) *not* as units of analysis. Rather, meanings are considered as products of action that, in turn, become tools for action (*cf.* §2.4.1.3).

SSAT portrays activity as a highly complex, structured, self-regulating system and claims that effective analysis of this complexity demands the use of multiple analytical perspectives and multiple interdependent methods. Toward this end Bedny (Bedny *et al.*, 2001b, Bedny *et al.*, 2001c, Bedny and Karwowski, 2004a, 2003b, Bedny and Harris, 2005), Ponomarenko (Ponomarenko, 2004), Zarakovsky (Zarakovsky and Sengupta, 2003), and their associates have developed a recursive, multi-stage, methodological framework which utilizes a standardized terminology and carefully defined units of analysis. Techniques include the identification and categorisation of work processes, tasks, actions, and the technical components of activity; the production of algorithmic descriptions of activity during task performance; detailed chronometric analysis and the generation of time-structures; the quantitative evaluation of task complexity; and functional analysis using self-regulation models.

2.5.3.2 Work Activity as a Self-Regulating System
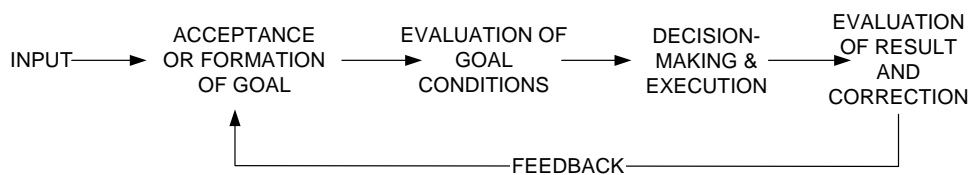
Figure 2.8: Simplified model of action as a one-loop system. From Bedny & Meister (1997, p. 17).

Activity theory claims that, in general, any human activity involves four stages: (1) goal-formation (or goal-acceptance), (2) orientation, (3) execution, and (4) evaluation. As noted above, in SSAT *action* is the principal unit used for the morphological (structural) analysis of activity. Actions have a temporal dimension, and (on the basis of empirical work by Anokhin, Bernshtein, Zinchenko, and others, see § 2.4.2) can be described in functional terms as having a recursive loop structure, with multiple feed-forward and feedback

interconnections. Figure 2.8 presents a (highly simplified) model of action as a one-loop system. The initiation of a conscious goal (goal acceptance or goal formulation) constitutes the starting point of an action; the action is concluded when its actual result is evaluated in relation to the goal. In SSAT, various methods for the temporal description of the structure of activity during task performance in terms of the types, duration and logical interrelationships of simultaneous and sequential cognitive and motor actions forms the basis of morphological activity analysis (see *e.g.* Bedny *et al.*, 2001c).
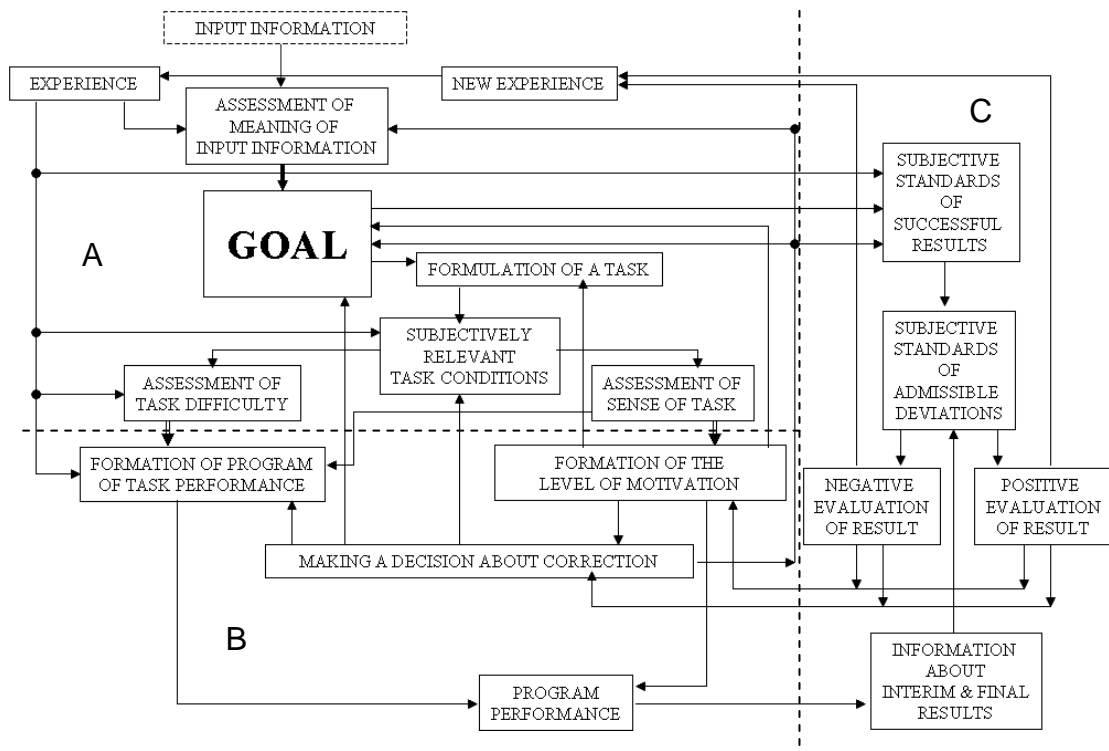
Figure 2.9: General model of human activity as a self-regulating system, showing principal functional subsystems as function blocks. Dashed lines sub-divide diagram into zones indicating the (A) goal-formative & orienting, (B) executive and (C) evaluative stages of the self-regulation process (*cf.* Fig. 2.8). Redrawn and adapted from Bedny & Meister (1997, p. 77).

As activity unfolds, subjects continuously reconsider and adjust their goals and strategies in response to changing conditions. The principal functional components or sub-systems in this process (and their interrelationships) can be modelled in various degrees of detail according to the analytical focus. Figure 2.9 shows a general model of the self-regulation of human activity developed by G. Z. Bedny (Bedny and Meister, 1997, p. 77). The square boxes in the figure represent function blocks (goal, experience, negative evaluation of the result, *etc.*) which are considered to be coordinated systems of sub-functions that have a specific purpose in the process of activity (Bedny and Meister, 1997, p. 76). The

arrows represent feed-forward and feedback connections between these functional sub-systems. Function blocks represent those aspects of activity which can be considered functionally invariant but whose precise content is determined by the specifics of the given activity under study (Bedny and Karwowski, 2004b, p. 260). There are both conscious and unconscious (automated) levels of activity self-regulation. In the functional analysis of activity as a self-regulating system, self-regulation models of varying degrees of generality are used as lenses with which to "scan" activity.

2.5.3.3 The Three Major Analytical Perspectives of Activity Theory

According to Bedny (Bedny, 2004, Bedny and Karwowski, 2004b) SSAT differs from other post-Soviet developments in AT by presenting a unified theoretical framework, terminology, and methodology which encompasses all three major analytical perspectives developed within different strands of the activity approach:

- The objectively-logical, which studies tasks, tools, work processes, and results, and is concerned with inputs, products, and the object transformation process;

- The sociocultural, or cultural-historical, which studies culture, community, and historicity, and is concerned with situating and characterizing work activity, both historically and in relation to other activities (*cf.* §2.3 & 2.5.2);

- The individual-psychological, which is concerned with actions, operations, and self-regulation, and studies subject-object relationships.

Researchers in SSAT have criticized CHAT (§2.5.2, especially as expressed in the concept of the activity "system", Fig. 2.3; see also §3.5.2, next chapter) for neglecting the individual-psychological perspective on activity analysis. This is considered to produce a confused and imprecise understanding of the functional components of activity as a self-regulating system, rendering CHAT difficult to apply to practical design problems (Bedny and Harris, 2005, 2006b). In order to highlight these problems, an alternative triadic schema of activity illustrating some aspects of the conceptual framework of SSAT was proposed in (Bedny and Harris, 2005). This is shown in Figure 2.10. This schema of activity involving

two individual subjects[28] illustrates the primary types or aspects of activity according to SSAT:

- "object-oriented" or instrumental, activity, where subjects use culturally-developed artifacts (tools and signs) to transform or explore some aspect of the material world;

- "subject-oriented" (communicative) activity – also known as social interaction - where two or more subjects exchange information, develop mutual understandings, and engage in the many other types of personal interaction needed for organization, coordination and control (Wertsch, 1981b, pp. 17-23, Bødker, 1991, pp. 21-33, Bedny and Meister, 1997, pp. 1-49).
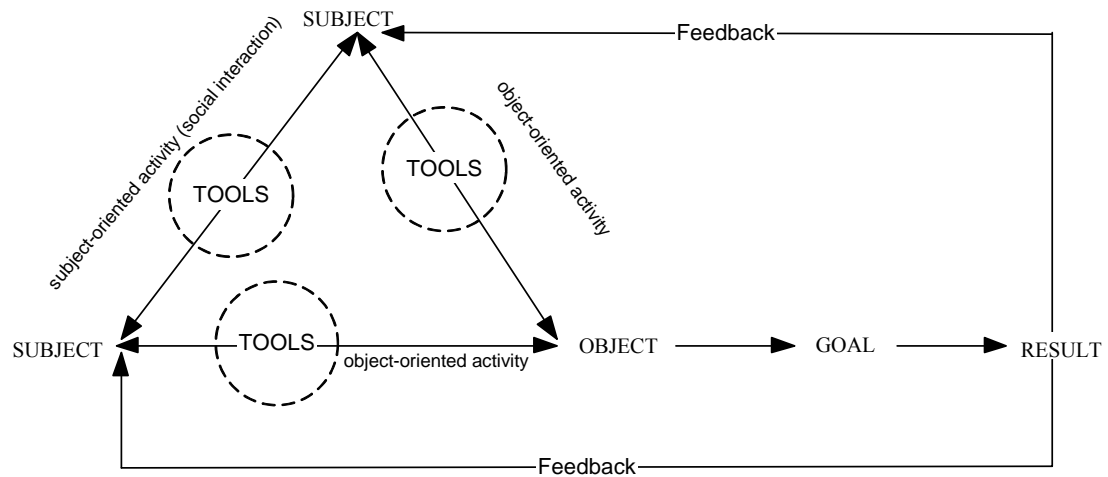
Figure 2.10: SSAT triadic schema of activity. Adapted from Bedny and Harris (2005, 2006b).

The broken circles in the figure indicate that subject-object or subject-subject interactions may involve the use of external mediating instruments. In both cases it is assumed that subjects always employ internal, psychological "tools" (concepts, symbols, *etc.*) acquired during ontogeny; following Vygotsky (§2.3), the possession of such internal tools is assumed as a precondition of subjectivity. SSAT thus views semiotic mediation and external, tool-mediated practical activity as being totally interdependent. Social interactions develop in a cultural environment containing historically developed physical artifacts; learning and using those artifacts involves learning and using the social norms, standards and worldviews they embody. During task performance, the object-oriented and subject-oriented aspects of activity are continuously transformed into one

another; social and societal relationships are manifested within subject-object interactions through the external speech, gestures, *etc.* involved in collaborative activity and the "inner dialogue" of verbal thinking. This understanding implies that in any analysis of object-oriented activity, inter-subjective relationships must always also be considered (Bedny and Karwowski, 2004a).

Figure 2.10 suggests that, in contrast to the CHAT activity system, SSAT re-introduces the individual-psychological perspective, principally by treating the object, goal, and result of activity as distinct components of activity (*cf.* the conflation of these elements in the central axis of Fig. 2.4). The object is a material or ideal artifact being explored or transformed; the goal is a (more or less precise) cognitive mental representation of the desired future state of this object; while the result is the actual outcome of activity manifested in the changed state of the object. As the actual result of activity may or may not coincide with the subjects' goal, attempts to reach a desired result are aligned through comparison of actual results and established goal, in a process of continual evaluation and adjustment utilizing proprioceptive and exteroceptive data and involving cognitive, motivational, and behavioural processes. An indication of the multiple feedback/feed-forward loops involved is given by the arrows connecting the result with the subject (*cf.* Figs. 2.8 and 2.9).

2.6 Discussion

Post-revolution, dialectical and historical materialism (§2.2) provided a "common theoretical foundation" (Graham, 1993, p.100) for developments within the Soviet human sciences.[29] However, the attempts by different disciplines (and individual scientists working within them) to explore and apply Marxist-Leninist concepts and principles to their work gave rise to a wide diversity of interpretations, in a still-unfinished complex developmental process which is made more difficult to retrospectively interpret both by the distorting influences of Soviet ideology and repression and both Soviet and Western propaganda. This chapter concludes by briefly identifying and discussing some discernible commonalities and differences within the (Soviet and post-Soviet) activity approach. The following chapter (3) considers the impact of the issues

discussed on the origins, development and current status of activity-theoretical information technology design and evaluation (ATIT).

2.6.1 Commonality and Difference in the Activity Approach

A central tenet of the activity approach is that the fundamental object of study for psychology is the activity of living beings in the world (Fig. 2.1). For human beings, the manufacture and use of tools in collective, socially-interactive activity provides the foundation for the development of consciousness and the higher mental functions. Material and ideal (*i.e.* word meanings, concepts, rules, *etc.*) human artifacts have an objective (*pace.* supra-individual) existence and are handed on from generation to generation; this allows the cultural-historical, rather than biological, mode of specifically human evolution (Leont'ev, 1981b, Tolman, 1994, Bærentsen, 2000). Thus, tools, skills, meanings and ideas are socio-cultural phenomena that encode particular types of operations and implicitly impose constraints and prescriptions on the activities they mediate; the cognitive and motor components of those tool-mediated activities being always inextricably interlinked (§2.4.2.1).

In his classic introduction to the concept of activity in Soviet psychology, J. V. Wertsch outlines six major theoretical features which all the various strands within the activity tradition can be said to hold in common (Wertsch, 1981a). These can be briefly summarized as:

1. Activity is analysed at various levels.
2. The notions of the goal, and the goal-directed nature of actions, are central. [30]
3. Activity is mediated by internal and external tools.
4. Developmental and genetic methods of explanation are emphasized.
5. Human activity and the means that mediate it arise through social interaction.
6. Internalisation, understood as the formation of internal, mental processes mediated by ideal objects on the basis of participation in external processes using material objects, is central to human development.

Three major analytical perspectives have been developed within AT: the cultural-historical, the objectively-logical, and the individual-psychological (§2.5.3.3).

The differing uses contemporary schools and approaches within AT make of these analytical perspectives, and the ways in which they interpret and apply the basic tenets of the activity approach outlined above, have an impact on the kinds of research problems that can be addressed. In the following chapter (3) it will be suggested that this has direct relevance to the concerns of the research reported here and, more generally, to the current status and future development of activity-theoretical HCI and ISD. Here, the discussion will focus on an issue that reveals something of the variation and differing emphases within the activity approach, that of defining basic units for the analysis of activity.

2.6.1.1 The Problem of Basic Units for the Analysis of Activity

Vygotsky was among the first to identify the challenge of developing basic units of analysis as one of the most important for the new Soviet psychology[31] (van der Veer, 2001). On the basis of his cultural-historical theory (§2.3) he suggested *word meaning* as being the most suitable unit for the analysis of semiotic mediation (Vygotsky, 1934/1986). The founders of activity theory rejected this unit as insufficiently holistic or materialistic. Leont'ev, while asserting that *activity* itself is the "molar …unit of the life of the physical, material subject" (Leont'ev, 1978, p. 50) used goal-oriented *action* as a basic unit of structural activity analysis (*e.g.* Leont'ev, 1981a, pp. 59-61). Anokhin and Bernshtein (§2.4.2) introduced the notion of *function blocks*; Zinchenko, Konopkin and others developed these ideas, using *functional micro- and macro-blocks* alongside action and *operation* as basic units for the functional analysis of cognitive, perceptual and motor activity at different levels of generality (see *e.g.* Zinchenko and Gordon, 1981, pp. 99-129). This systems-cybernetic approach was further developed in systemic-structural AT (§2.5.3) by Ponomarenko, Zarakovsky, and Bedny, who propose a unified framework of procedural and analytical units which synthesizes various approaches in Soviet psychology. This framework (shown in Fig. 2.6) comprises *activity, task, functional macro-blocks, member of algorithm* (a composite unit, see Chapter 7), *action, operation, and functional micro-blocks*.

Among the extra- and post-Soviet applications and developments of the activity approach (§2.5), a variety of units of analysis have been employed. Wertsch

(Wertsch, 1995) re-asserted the primacy of *action* as a basic analytical unit (§2.5.1). Santamaría has summarized this position:

> In the sociocultural approach, activity becomes a unit of analysis of institutional factors, while semiotically mediated action constitutes the unit of analysis on a strictly psychological level (interpsychological and intrapsychological). (Santamaría, 2001)

In formulating CHAT (§2.5.2), Engeström produced a new hybrid, macro-level unit of analysis, the *activity system* (§2.5.2.1, Fig. 2.4), which has recently been further expanded to include an even larger unit, *network of activity systems*.

It can be seen from this brief summary that a variety of closely interrelated (but frequently differently or imprecisely defined) analytical units have been developed within the activity tradition, which is itself a highly complex framework of interconnected ideas and approaches. This diversity and complexity has shaped attempts to apply the ideas of activity theory to the analysis, design and evaluation of information systems and human-computer interaction. The theoretical and methodological advances stimulated by these attempts, and some of the conceptual and practical difficulties they have encountered, are examined in Chapter 3.

2.7 Summary

Activity theory (AT) is a fundamental scientific approach initially developed within Soviet psychology which has continued to be applied and extended in the post-Soviet era. AT is specifically concerned with the study of human, socially-situated, motivated and tool-mediated activity, which is understood as a multi-dimensional, multi-level, dynamic and structured system in which cognitive, behavioural and motivational-affective elements are integrated and organized toward achieving conscious goals. One of the principal influences on the early development of AT was the cultural-historical psychology (CHP) of L. S. Vygotsky; however cultural-historical psychology differs significantly from activity theory. There have been at least two major strands in the historical development of activity theory itself: the work of A. N. Leont'ev and the "Kharkov School" which was strongly influenced by Vygotsky and has tended to focus on the cultural, historical, and developmental aspects of activity; and a

"systems-cybernetic" tradition associated with S. L. Rubinshtein, P. K. Anokhin, N. A. Bernshtein and others.

Activity theory was continuously developed throughout the Soviet era (1917-1991), and widely applied to practical problems in design, education, medicine and training. By the 1960s, it encompassed several distinct schools of thought which, although they shared a common philosophical orientation often took differing approaches, as illustrated by disagreements as to the basic units of activity-theoretical analysis. Political and ideological pressures, translation difficulties, the richness and diversity of the tradition, and its unfamiliar philosophical foundations have meant that much Soviet AT research is little-known outside the former Eastern Bloc countries. For historical and cultural reasons Western and post-Soviet developments of the activity approach have tended to emphasize the collective, cultural-historical aspects of the tradition while neglecting the systems-cybernetic approach and individual-psychological analytical perspectives. However, the modern systemic structural theory of activity (SSAT) is a design-oriented approach rooted in the Soviet tradition which claims to synthesise both strands of activity theory. It provides a range of clearly defined units of analysis and utilises all three of AT's major analytical perspectives.

Notes to Chapter 2

[1] These terms are used to indicate AT as a set of interlocking rules, principles, narratives, *etc.* that both describes and prescribes what is acceptable and unacceptable as the means of conceptual exploration in the scientific discipline of psychology. See also Note 2, Chapter 1.

[2] The Union of Soviet Socialist Republics (USSR) was established in 1922 and dissolved in 1991. The USSR was divided (from 1940 to 1991) into 15 constituent republics: Armenia, Azerbaijan, Belorussia, Estonia, Georgia, Kazakhstan, Kirghizia, Latvia, Lithuania, Moldavia, Russia, Tadzhikistan, Turkmenistan, Ukraine, and Uzbekistan.

[3] COMECON (The Council for Mutual Economic Assistance), was an economic organisation of communist states, based in Moscow and operational from 1949 – 1991. In the late 1980s its members were the Soviet Union, Bulgaria, Czechoslovakia, the German Democratic Republic (East Germany), Hungary, Romania, Poland, Cuba, the Mongolian People's Republic (Mongolia), and (North) Vietnam.

[4] The works of Loren Graham (*e.g.* Graham, 1993) provide a good introduction to the history of science in the USSR. Joravsky (1989) offers a comprehensive and critical account of the early years of Russian & Soviet psychology, while a definitive and fascinating analysis of the rise and fall of Soviet cybernetics can be found in (Gerovitch, 2002). Overviews of the history and content

of AT itself can be found in (Cole and Maltzman, 1969b), (Wertsch, 1981b), (Kozulin, 1984), (Haenen, 1996), and (Bedny and Meister, 1997, Bedny *et al.*, 2000). Among the most influential (in ATIT terms) narratives about AT history in recent years have been those developed by Engeström in (Engeström, 1987, Engeström, 1999d), which provide the template for many of the brief summaries of AT currently found in the HCI (*e.g.* Mwanza, 2001, Benyon *et al.*, 2004) and educational literature (*e.g.* Tusting and Barton, 2003).

[5] Seven years prior to the formation of the American Psychological Association (APA) in 1892.

[6] Graham (1993, p. 117) offers a list of "Soviet scientist of international rank…who exemplified that group of scholars who considered Marxism important to their work" which includes almost all of the major figures involved in the development of the activity approach.

[7] Dialectical materialism (also "Diamat") is a non-reductionist form of philosophical materialism, committed to physical, biological, and evolutionary viewpoints. Historical materialism is the application of dialectical materialism to human history, which is understood principally in terms of economic and technological developments. In their Soviet form, both trace their principal origins to the works of Marx and Engels, especially as interpreted through the writings of V. I. Lenin. One of the most clear and concise (if rather uncritical) expositions of the dialectical materialist underpinnings of Soviet psychology is that provided by Brian Simon in his introduction to *Psychology in the Soviet Union* (Simon, 1957b). See also entry for *Dialectical Materialism* in the glossary.

[8] The interdisciplinary scientific study of the life and development of children. Alt. spelling paedology (UK).

[9] *Deyatelnost* ("activity") is itself a translation of the German philosophical category *tätigkeit*, which is more accurately rendered in English as "the specifically human, inherently collective and societal, purposive and goal-directed, subjective and objective, internal and external, exploration and transformation of the human and natural environment" (*cf.* Leont'ev, 1978, esp. Chapters 2 & 3). For this reason some (*e.g.* Schurig, 1988) have argued that tätigkeit should remain un-translated, as has been the case with the psychological term *gestalt.* Difficulties with sufficiently rigorously defining the theoretical and methodological uses of "activity" as a psychological category have dogged the development of AT-HCI, and researchers have responded to these difficulties in a variety of ways; for example Bødker, in the English-language versions of her early AT-HCI work (*e.g.* 1989, 1991, see also Chapter 3), uses the term "human activity theory", strictly speaking a tautology. See also the entry for activity in the glossary, and the discussion on concepts and terminology in (Haenen, 1996, pp. 92-97).

[10] Toward the end of his career the accumulation of experimental evidence caused Leont'ev's position on internalisation to begin to shift away from the classic object-practical view.

[11] Often also rendered as Leontiev or Leontjew. This usage follows the spelling convention established by M. J. Hall, whose 1978 English translation of Leont'ev's *Activity, Consciousness and Personality* is among the most frequently cited AT texts in the Anglophone literature.

[12] The activity-theoretical principle of the unity of consciousness and behaviour established by Rubinshtein can be contrasted with the position held by influential contemporary Western philosopher John Searle, whose 'Principle of the Independence of Consciousness and Behaviour' has been significant in Western debates on AI and the brain and behaviour sciences (see, *e.g.* Searle, 1992). This comparison alone suggests that AT may be able to offer fresh perspectives on some current issues in cognitive neuroscience, perhaps helping to resolve some of the conceptual difficulties recently highlighted by Bennett & Hacker (2003).

[13] Anokhin's neurocybernetic concept of functional system should not be confused with the purely (activity-theoretical) psychological concept of *functional organ* (developed by Leont'ev, Luria, and others and applied to AT-HCI by Kaptelinin, 1996b) which is a higher-level construct. See glossary.

[14] For discussions of the significant philosophical and practical differences between Pavlov's approach and American Behaviorism see (Simon, 1957a) and (Joravsky, 1989).

[15] The date of the 23rd Congress of the Communist Party of the Soviet Union, which officially reinstated the principle of scientific objectivity. See (Cole and Maltzman, 1969a, pp. 4-12)

[16] S. A. Lebedev produced the USSR's first electronic stored-program computer, the MSM in 1950; in the 1960s about 250 models of a second generation machine, the BESM-6 were produced (Graham, 1993). However, although the Soviets continued to produce some independent designs over the next decade, they increasingly fell behind developments in the West, eventually shifting to IBM standards and abandoning attempts to develop an indigenous computer industry. There is as yet very little English-language scholarship on the history of computer science in the USSR; however, new sources are rapidly becoming available as the Soviet archives are opened up. One example is a project dedicated to digitizing the archive of Andrei Ershov, one of the early Soviet pioneers in the field of theoretical and systems programming, available online at http://ershov.ras.ru/english/index.html.

[17] The lack of a native HCI tradition in the USSR is illustrated by the fact that the first ever academic HCI course in Russia was delivered by the expatriate Victor Kaptelinin, in 1992 (Press, 1992).

[18] Although communication was possible, and often took place, it was highly constrained and never entirely free of personal or professional risk. Feigenbaum's (1961) account of the 1960 IFAC conference on AI, computing and cybernetics in Moscow gives a vivid picture of the continuing isolation of Soviet science seven years after the death of Stalin.

[19] This is one of many pieces of evidence which point to the incomplete and essentially (and perhaps ironically) ahistorical understanding of the Soviet activity approach which currently underpins many applications of AT to HCI and other design disciplines. A historical investigation of the ways in which Western scientists have appropriated activity theory is the subject of ongoing work by the author; (Harris, 2005a) presented some interim findings.

[20] Simon & Simon (1963, pp. 3-16) describe the relationships and responsibilities of the major institutions conducting psychological research in the Soviet Union during the 1950s and 60s. A comprehensive account of the organizational features of Soviet science as a whole can be found in Graham (1993, pp. 173-196).

[21] It is important to acknowledge that the account given here of factional rivalries within the activity approach, and their subsequent effect on the dissemination of AT in the West, is seriously under-developed. For example, apart from the well-known issues of the ideological distortion of Soviet science (elegantly explored in Gerovitch, 2002), the anti-Semitic theme (often evident in attacks upon "cosmopolitan" science) that recurs in Russian scientific history is also relevant here; both Rubinshtein and Bernshtein were Jews. The social and political history of the activity approach has great significance for understanding the current global status (and possible future directions) of AT, and in the author's opinion the field of ATIT can greatly benefit from the insights now being generated by science historians working with the newly-available Soviet archives. See also Note 19 above.

[22] Formed from the merging of ISCRAT (the International Society for Cultural Research and Activity Theory) and the Society for Sociocultural Studies (SSCS) in 2002. See http://www.iscar.org for more information.

[23] The term "object" is used here in the sense of "objective" or "outcome" rather than "material thing", although these meanings are often blurred in Engeström's work.

[24] Engeström has been both director of the Centre for Activity Theory and Developmental Work Research in Helsinki, Finland and Professor of Communication at University of California, San Diego, where he worked closely with the cultural psychologist Michael Cole in the Laboratory of Comparative Human Cognition.

[25] Several researchers interviewed during the research suggested that this state of affairs to some extent reflects and continues the historic disputes within the Soviet psychology community outlined at the beginning of Section 2.2.2. Further historical research will be required in order to clarify this issue.

[26] The Psychology of Set is a general theory of cognition founded by the Georgian D. N. Uznadze (1886-1950), who established original methods for research into unconscious forms of mental activity, delineating relationships between action-regulation and personality (Ketchuashvili, 1994). Due both to its findings being published initially only in Georgian and ideological pressures, the Psychology of Set was not fully incorporated into mainstream Soviet psychology until the 1960s (see editors' introduction to Natadze, 1969).

[27] Notably the use of measured time & motion formal description languages such as MTM-1 (see Karger and Bayha, 1987, Barnes, 1980).

[28] This schema can be usefully compared with the conceptualizations of the "collective subject" in collaborative activity developed by A. V. Petrovsky (1983, 1985) and D. A. Leont'ev (1992) and which are portrayed in diagrammatic form by Bardram in (Bardram, 1998, p. 33).

[29] That this common basis was both a blessing and curse is evident throughout the history of the activity approach. For example, the materialist-idealist debate which arguably still impedes progress in the Western human sciences (see discussions in *e.g.* Bennett and Hacker, 2003, Coulter, 1991, Dennett, 1993, Gibson, 1979) was considered decisively settled in Soviet psychology on the basis of Marxist-Leninist ideology. Although this had its advantages – *e.g.* in terms of fostering a (at least nominally) strictly materialist and monistic approach – it also meant that psychological theories were in constant danger of reduction to purely physiological modes of explanation, particularly during the forced ascendancy of neo-Pavlovian psychophysiology in the early 1950s. For further discussion of this issue see (Joravsky, 1989, Bakhurst, 1991, Kozulin, 1984, Graham, 1993) and the Editor's introduction to (Cole and Maltzman, 1969c).

[30] Some researchers (*e.g.* Engeström, 1987) have presented the concept of goal-orientation as being essentially the same as that of object-orientation; the term "object" being taken as implying the noun "objective". However, the ambiguities inherent in this approach have given rise to considerable confusion and debate in post-Soviet AT and ATIT. Here, we follow the example of Wertsch (1981) and others by stressing that orientation in (conscious) action performance is always provided by the *goal*, a more-less precise cognitive representation of the desired future result of the action. Clearly, conscious goals are linked to material or ideal objects which the subject seeks to explore or transform, and which are reflected in the acting subject's consciousness. However, when analysing activity little is gained – and much clarity sacrificed – by treating goal, object, and objective as synonyms. See §2.5.3.3 and the discussion in (Bedny and Harris, 2005).

[31] To illustrate: the reflex (and later reflex arc) was established by Pavlov as the basic analytical unit for the physiology of nervous systems.

3. ATIT: Activity-theoretical HCI & ISD

This chapter completes the introductory section of the thesis by situating the research project with regard to related work and current issues in the field of activity-theoretical human-computer interaction (AT-HCI), activity-theoretical ISD, and their related disciplines, henceforth collectively referred to by the acronym ATIT (activity-theoretical information technology design, development, and evaluation).[1] The principal objectives of the chapter are:

1. To establish the orientation of the research within the Scandinavian ATIT tradition and with regard to other contemporary developments in ATIT;

2. To introduce and discuss the activity-theoretical principles and methods used in the research;

3. To use a historical analysis of the origins and development of ATIT as a basis for critically evaluating its current status and highlight several challenges to its further development, some of which are addressed by this thesis.

The chapter begins with some background on the introduction of activity theory into HCI and ISD research. Section 3.2 provides an overview of ATIT methods; following sections discuss some of the main strands of development within activity-theoretical HCI and ISD.[2] The chapter concludes with a summary of some of the shared concepts and principles of ATIT (§3.5.1); Section 3.5.2 discusses current issues and challenges in ATIT, and their influence on, and relevance for, the design, conduct and outcomes of the research reported in this thesis.

3.1 Origins & Development of ATIT

Chapter 1 (§1.4.3.2) outlined factors contributing to the emergence of a second phase, or generation, of HCI in the mid-1980s as researchers sought ways of extending or replacing the cognitivist framework of HCI in order to accommodate new research methodologies and findings demonstrating the emergent, contingent, and environmentally-shaped nature of human-machine interaction. This movement brought an increased emphasis on the study of interactive systems in use, both in usability studies (Nielsen, 1989) and in

workplace settings (*e.g.* Gerson and Star, 1986, Heath and Luff, 1991); and in the use of ethnographic (*e.g.* Blomberg, 1993) and action research techniques (*e.g.* Bjerknes *et al.*, 1987, Avison and Wood-Harper, 1990) alongside more traditional HCI methods. An important aspect of (and primary contributor to) this "move to the contextual" was the investigation of activity theory (AT) as an alternative conceptual framework for the design and evaluation of computer artifacts by Scandinavian[3] computer scientists.

That the use of activity theory by HCI and IS researchers should emerge first in Scandinavia can be in part explained by noting the existence of a vigorous indigenous Marxist-Leninist/dialectical-materialist intellectual tradition in the region, this being one aspect of the many longstanding political, cultural and scientific ties between leftists in the democratic socialist Nordic countries and the former Soviet Union (Bjerknes and Bratteteig, 1995). Early attempts to make use of AT in computer science were partly inspired by the work of Scandinavian psychologists and social scientists using dialectical methods to address issues of technology and tool-mediation from a cultural-historical viewpoint, such as Hydén (1981) and Karpatschof (1984), an approach exemplified by K. B. Bærentsen's influential activity-theoretical analysis of the development of the hand-gun *Mennesker og Maskiner* ("Human Beings and Machines" Bærentsen, 1989) which investigates how operations with one generation of technology become incorporated into the design of the next.[4]

3.1.1 Participatory Design & the Tool Perspective

The origins of ATIT as research and design practice can be traced to two principal sources. The first lies in the series of politically-engaged, participatory action research (PAR) projects in workplace information technology design undertaken in Norway, Sweden and Denmark in the late 1970s and early 1980s (see *e.g.* Ehn, 1988, pp. 3-35, The Utopia Project Group, 1981, Bødker *et al.*, 1987).[5] Out of these projects emerged what became known as the "collective resources approach" (Ehn and Kyng, 1987, Ehn, 1988, pp. 278-280, Kraft and Bansler, 1994) to the participatory design (PD) of IT, and its "tool perspective" on computer systems as mediators of users' purposeful, skilled actions.[6] The practical and theoretical implications of adopting a tool perspective were

articulated by Pelle Ehn and his collaborators in a series of influential papers (*e.g.* Ehn and Kyng, 1984, Ehn, 1988, pp. 375-468) and the book *Work-Oriented Design of Computer Artifacts* (Ehn, 1988). Ehn's approach drew on a wide range of "other ways of seeing and doing" design (Ehn, 1988, p.184) including the systems thinking of Churchman and Checkland, the philosophy of Husserl, Heidegger, Merlau-Ponty, and Wittgenstein (*ibid.*, pp. 62-81 and 103-122),[7] and European and Scandinavian interpretations of Marxist dialectics (*ibid.*, pp. 82-102).

The development of the tool perspective within PD both contributed to, and was affected by, the critical analyses of the limitations of decontextualized human information-processing approaches in HCI and systems-theoretical approaches in IS discussed in §1.4.3.2. Researchers involved in PD actively sought out alternative and critical approaches in social psychology and industrial sociology, both locally (in the form of dialogues with the indigenous activity theoretical tradition in Scandinavian psychology noted above) and internationally, through contacts with the German work psychology being developed by Hacker and Volpert (*e.g.* Hacker *et al.*, 1982, Volpert, 1989) and the German critical psychology of Holzkamp (see Tolman, 1991) - both of which are directly derived from the Soviet psychology of activity. Later these efforts led to the establishment of links with Soviet psychologists such as Gal'perin and Davydov through the ISCRAT[8] and East-West HCI conference series.[9]

The first direct applications of activity-theoretical concepts to human-computer interaction research were made in the mid-1980s by the Danish computer scientist Susanne Bødker (Bødker, 1989, Bødker, 1991) and colleagues in the "Aarhus-Oslo school".[10] In the early 1980s Bødker had worked alongside anthropologists and educationalists at the US Xerox Palo Alto Research Centre (Xerox PARC), as a member of the multidisciplinary PARC Software Concepts Group, which made a number of significant contributions to the "move to the contextual" outlined in §1.4.3. On her return to Scandinavia Bødker became involved (with Ehn and others) in a number of major PD projects (*e.g.* Bødker *et al.*, 1987). It was in this context that she (with collaborators such as Bannon, Grudin, Kyng, Mathiassen, and Mogensen) first began to "explore the possibilities of *offering a new conception of user interfaces*" by "*trying out the*

Soviet psychology as presented by Leont'ev…" (Bødker, 1991, pp. 4 & 5, italics in the original). For Bødker, this investigation of AT as a radical alternative to the cognitivist paradigm for action-oriented research in HCI (Bødker, 1999a, p. 14) was at least partly spurred by the realisation that the philosophical eclecticism of Ehn's formulation of the tool perspective might lead to HCI theory-building on the basis of "conflicting assumptions" (see comments in Bødker, 1991, pp. 11-12).

3.1.2 CHAT & Developmental Work Research

A second important influence on the origins of ATIT - especially in its ISD aspects – has been Finnish education researcher Yrjö Engeström's cultural-historical, AT-based theory of "expansive learning" (§2.5.2), and the Developmental Work Research (DWR) approach to the participatory and reflective (re)design of organizations and work processes which developed around it. The early application of AT to ISD is closely associated with the work of Finnish researcher Kari Kuutti (Bannon and Kuutti, 1993, Kuutti, 1991, Kuutti and Bannon, 1991), for which Engeström's CHAT provided the principal theoretical foundation (see *e.g.* Kuutti and Engeström, 1987, Kuutti, 1989). Several of the activity-theoretical ISD methods developed in the 1990s – such as the ActAD of Korpela *et al* discussed in §3.2.2 below - are directly based on DWR. Engeström's CHAT has also strongly influenced the work of Bødker and her associates (see, *e.g.*, the summary in Bertelsen and Bødker, 2003). Bødker's insight that Engeström's synthesis of AT and cultural-historical psychology (§2.3, 2.5.1) could provide the basis for further conceptual re-framing of the collective resources approach (articulated in *e.g.* Bødker, 1996b) has been critical to her subsequent contributions to the development of PD and to the foundation of the field of computer-supported cooperative work (CSCW).

Important contributions to the founding of what was to become ATIT were also made by Bødker and Kuutti's mutual collaborators, the American Jonathan Grudin (Grudin, 1990) and Irishman Liam Bannon (Kuutti and Bannon, 1991). Particularly significant in this regard was the inclusion in the 1991 collection, *Designing Interaction: Psychology at the Human-Computer Interface* (edited by John Carroll) of a chapter by Bannon and Bødker, "Beyond the Interface:

Encountering Artifacts in Use" (1991) which coupled a "brief overview and critique" of the cognitivist approach in HCI with the presentation of "a more elaborated activity-theoretical framework" that aimed to "give a richer description of the HCI field" (*ibid*, p. 228). This article used a range of examples to explore what an activity-theoretical HCI might look like, complementing and summarizing the ideas set out in Bødker's doctoral thesis (published that year in book form as Bødker, 1991).

3.1.3 Further Development of ATIT

Throughout the 1990s research by Bødker and her colleagues, collaborators and students explored the application of general AT and CHAT to the participatory and user-centred design of computer artifacts (*e.g.* Bødker, 1996b, 1999b, Bødker and Grønbæk, 1991); HCI and user interface design (*e.g.* Bødker, 1993, Bardram and Bertelsen, 1995, Bødker, 1996a, Bærentsen, 2000); and information systems design in general (Bødker, 2000, Bertelsen, 1998). A strong thread in this development was the attention paid to the design and evaluation of computer-mediated collaborative work and learning processes (*e.g.* Bødker *et al.*, 1995, Bødker and Christiansen, 1997, Bouvin *et al.*, 1996), exemplified by Bardram's Doctoral thesis (Bardram, 1998) which presents a "theoretical foundation for the design of computer support for cooperative work" based on AT and CHAT.

The application of AT to HCI and ISD was taken up by other researchers during the 1990s, as indicated by the steadily increasing number of conference presentations and journal publications. In 1996, the emergence of ATIT as an established sub-discipline within HCI/ISD was signalled by the publication of the MIT Press paper collection *Context and Consciousness: Activity Theory and Human-Computer Interaction* (Nardi, 1996b) which contained important contributions by Kuutti (1996) on AT as a framework for HCI and ISD; by Bødker (Bødker, 1996a) on HCI video-analysis methods; and by Kaptelinin (Kaptelinin, 1996b, 1996a) on basic concepts in AT (functional organs, tool-mediation) and their application to HCI. In the same year, Engeström co-edited *Cognition and Communication at Work* (Engeström and Middleton, 1996),

followed in 1999 by *Perspectives on Activity Theory* (Engeström *et al.*, 1999). Both contained chapters dealing with ISD (*e.g.* Tikhomirov, 1999, Star, 1996).

In 2000 Bertelsen and Bødker edited a special edition of the *Scandinavian Journal of Information Systems* dedicated to ATIT (Bertelsen and Bødker, 2000). This included important papers by Bødker and Graves Petersen (2000) on design for learning-in-use; by Bertelsen (Bertelsen, 2000) on the notion of "design artifacts"; and by the Danish cognitive psychologist K. B. Bærentsen (2000) on the design of "intuitive user interfaces". The latter paper is notable for its incorporation of the concept of *affordances* drawn from Gibson's ecological psychology (Gibson, 1979) into the AT framework (see also Bærentsen and Trettvik, 2002), and includes proposals for a new UI design approach based on the integration of data from infant developmental research and human evolutionary studies into activity-theoretical understandings of technology use. This line of research is currently being developed by Nørager (2004) under the rubric of Ecological Cognitive Ergonomics (ECE). Bærentsen and his associates have also contributed important work on the role of "episodic knowledge" – that is, technology and work-process experience embedded in narratives of concrete use told between co-workers – in the learning and appropriation of complex automated systems (Bærentsen, 1996, 1999), and have emphasized the central importance of shared sensory experience (that is, engagement in collaborative practical activity) to knowledge generation and meaning-making.

2002 saw a special issue of the journal *Computer Supported Cooperative Work* on "Activity Theory and the Practice of Design" (Redmiles, 2002). Further acceptance of Scandinavian AT-HCI into the mainstream of international HCI was signalled in 2003 by the inclusion of a chapter on AT by Bertelsen and Bødker in a textbook (edited by John Carroll, one the leading figures of cognitivist HCI; see §1.4.3.1) surveying HCI models, theories and frameworks (Bertelsen and Bødker, 2003). The first International Workshop on ATIT was held in Copenhagen, Denmark, in September 2004, followed by the founding of a special section on ATIT within the International Society for Cultural and Activity Research (ISCAR) in July 2005.[11]

Elsewhere in Europe, a multi-disciplinary group of CSCW researchers working with augmented reality and tangible interfaces developed the BUILD-IT

groupware on the theoretical basis of a synthesis between AT and German Action Theory (*e.g.* Fjeld *et al.*, 2002). The French researcher M. Beaudouin-Lafon has proposed a new interaction model for UI design, "Instrumental Interaction" (Beaudouin-Lafon, 2000, Beaudouin-Lafon and Mackay, 2000) which takes Scandinavian AT-HCI as one starting point. A recent research development has been the emergence of applications of systemic-structural activity theory (§2.5.3) to the design and evaluation of HCI. [12] This is discussed in §3.3.2 below.

3.2 Overview of ATIT Analysis and Design Approaches

Table 3.1 gives an overview of analysis and design approaches in ATIT in terms of their principal focus, dominant analytical perspective (§2.5.3.3), objects and units of analysis (§2.5.3.1, Fig. 2.7, & §2.6.1.1), and principal theoretical foundation. Many of the approaches overlap considerably, and have been used in various combinations in different research projects. As the summary of ATIT principles in §3.5.1 points out, historical or developmental approaches are foundational across the whole field. Both the activity system, (and/or contradictions analysis), based on CHAT (§2.5.2.2) and activity analyses based on general AT (§2.4.1) are also very widely used. More specialised techniques such as focus-shift analysis and systemic-structural activity analysis are discussed more fully in following sections, which deal first with AT-HCI (§3.3) and then AT-ISD (§3.4).

3.3 Activity-Theoretical HCI (AT-HCI)

As §3.1 outlined, the main work in developing AT-HCI during the 1990s was carried out by a loose alliance of researchers working within, or closely connected with, the "Scandinavian School" of information technology design. The theoretical basis of this work has been in Danish psychologists' interpretations of the general activity theory of Leont'ev (§2.4.1), and the predominantly cultural-historical, post-Soviet interpretation of Leont'evian AT developed in Finland (CHAT, §2.5.2). The first part of this section sets out some of the principal ideas associated with the "Aarhus-Oslo" branch of the Scandinavian School in more detail, primarily focusing on the establishment of general AT-HCI concepts and principles in the work of Bødker and her

associates. The second part of this section examines new developments in AT-HCI based on the systemic-structural tradition in activity theory (§2.5.3), which draws directly on sources and ideas developed in Soviet engineering psychology, human factors/ergonomics, education, and training (§2.4.2, 2.4.3.1).

Table 3.1: ATIT analysis & design approaches.

Analysis and/or Design Method	Principal Focus of Method	Dominant Analytical Perspective	Object(s) of analysis	Basic units of Analysis & Principal Theoretical Basis	Examples of Application
Activity System, *or* Contradictions analysis	Conflicts and contradictions within and between activity systems	Cultural-historical	Activity systems, networks of activity systems	Activity system CHAT	(Bødker, 1996b, Engeström and Escalante, 1996, Helle, 2000)
Activity	Shared objects of work, means of work, jointly produced outcomes in CMA[1]	Cultural-historical, Objectively-logical	Activity	Elements of work activity CHAT, SSAT	(Korpela *et al.*, 2000, Bedny and Karwowski, 2004a)
Historical *or* Developmental	Development of CMA over time	Cultural-historical	Activity, Community of Practice	Activity General AT,[2] CHP, CHAT,	(Bødker, 1993, Bærentsen, 2000)
Parametric	The conditions, components and logical organization of activity during task performance	Objectively-logical	Activity, Work-process, Task	Task, typical component of activity General AT, SSAT	(Bedny *et al.*, 2001d)
Focus-Shift	Work objects; voluntary (focus-shift) and involuntary (breakdown); processes of automatization and deautomatization in CMA.	Individual-psychological, Objectively-logical	Activity during task performance	Action, operation General AT	(Bødker, 1996a, Bouvin *et al.*, 1996)
Morphological, Algorithmic	The logical structure of activity during task performance	Individual-psychological	Activity during task performance	Member of Algorithm, action, operation SSAT	(Bedny and Karwowski, 2003b)
Morphological, Time-Structure	The time-structure of activity during task performance	Individual-psychological	Activity during task performance	Member of Algorithm, action, operation SSAT	(Sengupta and Jeng, 2003)
Functional	The changing relationships between functional components during activity	Individual-psychological	Activity during task performance	Functional macro- and micro-blocks General AT, SSAT	(Harris, 2005d, Bedny *et al.*, 2005b)
Notes: (1) CMA: Computer-Mediated Activity; (2) General AT indicates applications of activity theory based mainly on work by Leont'ev (e.g. 1977, 1978) and his school (see §2.4.1).					

3.3.1 Scandinavian AT-HCI

As noted in §3.1.1, Scandinavian AT-HCI grew out of, and has been closely associated with, the participatory design movement (PD). As a consequence, many of the contributions of this school have been connected with the development of PD techniques such as collaborative prototyping (Bødker and Grønbæk, 1991) and the use of scenarios (Bødker and Christiansen, 1997, Bødker, 1999b) to build a "conceptual toolbox" (Bødker *et al.*, 1995) for the design of CSCW applications. There have been two main underlying (cultural-historical) activity-theoretical themes to these practical developments: the consistent use of historical and developmental modes of analysis, and the use of conflicts, contradictions and breakdowns as starting points for design (Bødker, 1993, 1996b).

The Aarhus-Oslo group has also been concerned with exploring and redefining some fundamental concepts of HCI, such as the nature of design and use, and their relationship (*e.g.* Bødker, 1998, Bertelsen, 1998) (Bærentsen, 1999, Bertelsen, 2000), particularly with regard to the emergence of new computer-coordinated work processes (Bardram, 1998) and computing platforms (Neilsen, 2002). In recent years some attempts have been made to connect AT-HCI with cognitivist concepts – such as affordances (*e.g.* Bærentsen and Trettvik, 2002) - and established HCI techniques such as task analysis (Harris, 2004, 2005d) and walkthroughs (*e.g.* Bertelsen, 2003, 2004a, Harris and Reddy, 2005).

3.3.1.1 Activity-Theoretical Perspectives on Computer Use

Table 3.2: Characteristics of the system, tool and media perspectives on computer artifacts in use in AT-HCI. Adapted from Bertelsen & Bødker (2003, p. 310). *Cf.* Fig. 2.2b, previous chapter.

	system	tool	medium
Why - activity	planning/control	material production	communication
What - actions	data entry +extraction	shaping material	creating and interpreting signs
How - operations	"low risk" data entry	transparency good access to material	transparency: undisturbed interpretation

In (Bødker, 1993) and subsequent work, three design metaphors, or perspectives, have been developed to characterise the main features and/or types of computer

artifact use (Table 3.2). The first of these is the *system* perspective, (traditionally associated with cognitivist HCI) a "birds-eye, control view" (Bødker, 1996a, p.153) which traces the information flow between essentially equally weighted components of an information-processing system. From the *tool* perspective (see also §3.1.1), the focus is on computer application use where a human subject ("the user") engages with materials *through* the application, that is, where the application acts as a mediating artifact. What Bødker considers important in this kind of mediation are the productive aspects of the interaction, and how the application feeds back information to the user on how the object is being shaped. The third *media* perspective is used to examine how the application in use supports communication between the acting subject and the human community within which their actions are taking place. Bødker suggests that understanding computer applications in use will generally require a characterisation of use activity from one, a combination, or all of these perspectives. In comparing this to the systemic-structural school's explanation of the three perspectives on activity analysis (outlined in §2.5.3.3), it can be seen that Bødker's system perspective relates to objectively-logical analysis and the tool perspective to individual-psychological analysis. The media perspective represents an attempt to focus on intersubjective (communicative) rather than object-oriented activity (*cf.* Fig. 2.10), using both individual-psychological and cultural-historical perspectives.

3.3.1.2 Foci of Use in HCI

Apart from her work on participatory techniques such as scenarios, *etc.*, a major methodological contribution of Bødker's work in terms of AT-HCI has been the development of the technique of focus-shift analysis (§3.3.1.3, below), which she and her associates have applied to the structured analysis of fieldwork data (Bødker, 1996a, Bouvin *et al.*, 1996). This technique is partly based on Bødker's identification of three principal foci of computer application use. The first of these foci is on the *physical aspects* of the artifact in use, that is on how the human user is supported to adapt to the "forms and shapes" (Bødker, 1996a) of the artifact. These physical aspect includes both general physical design features (*e.g.* mouse driven, touch screen, key or joystick operated) and interface details such as text size, use of colour, *etc.*

The second focus is on the *handling* aspect of applications, that is, how the design supports operations toward the application itself. Bødker suggests that handling operations are developed, through repetition, from what are initially actions learned step-by-step, either through use of the current application or in previous use situations. This is the process of *automatization*, or the transformation of actions into operations (§2.4.1.2, and Fig. 2.2a). It is the development of these handling operations that allows subjects to focus on the objects of activity *through* the interface, and it is the extent to which an application in use supports the formation of such handling operations that determines the "transparency" of its UI in use. Bardram & Bertelsen (1995), in further developing this approach, emphasize that transparency emerges not as a property of the UI itself, but as an emergent feature of the whole work situation (including its subjective, social, physical and communicative aspects), and that designing for transparency involves:

- Supporting development in use;

- Ensuring an initial familiarity with the artifacts and use situation;

- Setting conditions for the formation of new operations.

(a) The object is present only in the artifact and can only be accessed through the artifact	(b) The object exists as a physical object, but is only present in the use activity as the representation in the computer application ("what you see is what you get" is an important quality of such objects).	(c) The object is also physically present outside the artifact, and any interaction with the artifact has consequences to be inspected on the object.

Figure 3.1: Work objects as encountered in or through the computer artifact. Adapted from Bertelsen & Bødker (2003, p. 307).

The third focus in analysing use is on the *subject/object* directed aspects of applications. This describes the operational conditions the application presents for instrumental or communicative action *in* or *through* the artifact (see Fig 3.1

below), toward an object under transformation or with a member of the community within which CMA is being enacted. Bødker emphasizes that this aspect of computer application use will vary according to the subject or object of action, and so can only be defined in relation to *particular* subjects and objects in a specific analysis.

In Bødker's view, during use successfully designed applications must not only support subject-object directed operations, but must also be able to support the necessary *focus-shifts* between object- and subject-directed aspects of the work, and between the physical, handling, and subject/object directed aspects of the application in use. In further analysing the role of the computer as a mediating artifact in any actual work situation Bødker asserts that it is important to look not only at the actual objects of focus in this work but also of the various possible "locations" of the work-objects with regard to the user. Work-objects are seen to be present for the user either "inside" (Figure 3.1a) or "outside" the computer (Fig. 3.1c), or both simultaneously (Fig. 3.1b). Bødker and Bertelsen (Bertelsen and Bødker, 2003) suggest that each of these "locations" of the work-object has its own characteristics in terms of the three foci of use described above.

3.3.1.3 Focus-Shifts & Breakdowns
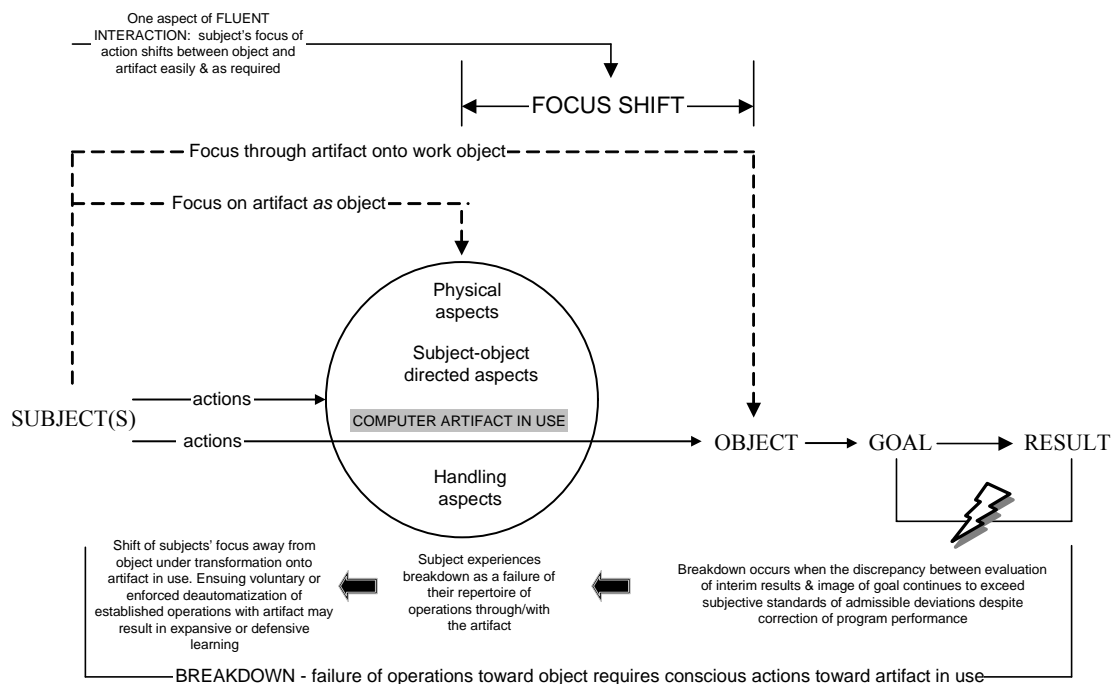
Figure 3.2: Focus shifts and breakdowns in computer-mediated activity. Drawn by the author on the basis of discussions in Bødker (1991, 1996, and 1999). Adapted to include consideration of activity as a self-regulating process, *cf.* Fig. 2.10, previous chapter.

Building on the ideas outlined in the previous section, it can be seen that in any computer-mediated activity, the user's attention is required to continuously shift between the work-object being explored or transformed (or the subject with whom they are communicating) and the various "instruments" mediating action (physical input/output devices and symbolic UI elements). These *focus-shifts* are necessitated as the (material or symbolic) tools require adjustment, adaptation, or exchange for other tools with different functionality. Focus-shifts may be supported or hindered by the design and functionality of the artifacts in use, the abilities and experience of the subject and the subject's relationship to the community of practice within which activity is taking place. As graphically depicted in Fig. 3.2, an interaction *breakdown* is a forced shift of the subject's attention that results in an interruption to, or the cessation of, transformative actions toward the work-object. In Bødker's words:

> *Breakdowns* related to the use process occur when work is interrupted by something; perhaps the tool behaves differently than was anticipated, thus causing the triggering of inappropriate operations or not triggering any at all. In these situations the tool as such, or part of, becomes the object of our actions. Breakdowns can occur for other reasons as well. What are important for this analysis are breakdowns somehow caused by the computer application.
>
> A *focus shift* is a change of focus or object of the actions or activity that is more deliberate than those caused by breakdowns. For example, a focus shift can occur when a user teaches a researcher about the technology; here a focus shift occurs not because of a breakdown caused by the artifact, but because the user is trying to articulate the "otherwise unarticulated". Now the operations she normally does become actions to her.

> (Bødker, 1991, p.150)

In Bødker's work interaction breakdowns have also been characterized in terms of forced focus-shifts occurring in situations where the computer artifact's instrumentality can no longer be handled through the level of (unconscious) operations, and is required to become the subject of conscious actions, through a process of *conceptualization*, the opposite of automatization. So:

> The term breakdown is used to indicate the shift of our practice and artifacts from being ready-at-hand to being present-at-hand, similar to what Leont'ev calls conceptualization. I use the term breakdown only to indicate such shifts that are caused by some unprecedented conflict between an operation and its material conditions.

(Bødker 1991 p. 53 Note 24)

Thus, breakdowns indicate contradictions within or between aspects of artifact design, individual characteristics (such as experience and motivation) of the subject, and sociocultural conditions (*e.g.* availability of training, support, *etc.*).

A consequence of actions *through* or *with* the computer artifact becoming actions *toward* the artifact is that the focus of the activity as a whole changes, from "getting the job done" to "figuring out how to use the application". Instrumental actions toward the work object are replaced by exploratory actions toward the work instrument. However, on this activity-theoretical view, where contradiction and conflict are seen as the main drivers of change and growth (see §2.5.2), breakdowns are not simply negative occurrences that interaction design should always seek to avoid. Rather, "…breakdowns are openings for learning, and in our unhampered daily activity, we can see some breakdowns causing a focus shift by which a use situation becomes the object of our learning activity" although "….learning can take place in deliberate learning actions as well, as when one actor teaches another actor about his or her work practice" (Bødker, 1996a, p. 149-150).

3.3.1.4 Focus-Shift Analysis

Focus-shift analysis is the most detailed (micro-) analytical technique to emerge from the work of Bødker and her collaborators, and to date is the only AT-based method *specifically* developed to support HCI research and design. Focus-shift analysis uses qualitative observational data - frequently in the form of video-recorded interaction sequences, but also observers' field notes, *etc.* - to build a detailed picture of how specific design attributes of computer applications and their use setting either support, hinder or force focus shifts during task performance. The aim is to reveal problems and issues connected with some or all aspects of the operation-forming conditions of the artifacts in use. Furthermore, it aims to reveal contradictions and mismatches between the physical, handling, and subject/object-directed aspects of the artifact and also problems with the support for transitions between a focus on one or another of the aspects. For this approach, an optimal design will be one which produces a

situation where the physical, handling and subject-object directed aspects of the tools mediating the work are appropriately balanced and mutually supporting.

Focus-shift analysis – which is always utilized within a larger framework of detailed cultural-historical-developmental accounts of the interaction and its context - begins with the detailed observation and logging of applications in use in work activities, usually using checklists as prompts for data-recording. Focus-shift analysis based on video-data follows the general guidelines for video analysis set out in Trigg, Bødker, & Grønbaek, (1991), Suchman & Trigg (1991); initial selection of data for detailed analysis is based on the identification of interaction breakdowns (involuntary focus shifts) as indicators of potentially design-relevant episodes in the data. Focus-shift analysis involves a large amount of multivariate data, and the organization and the presentation of the data presents numerous practical challenges.
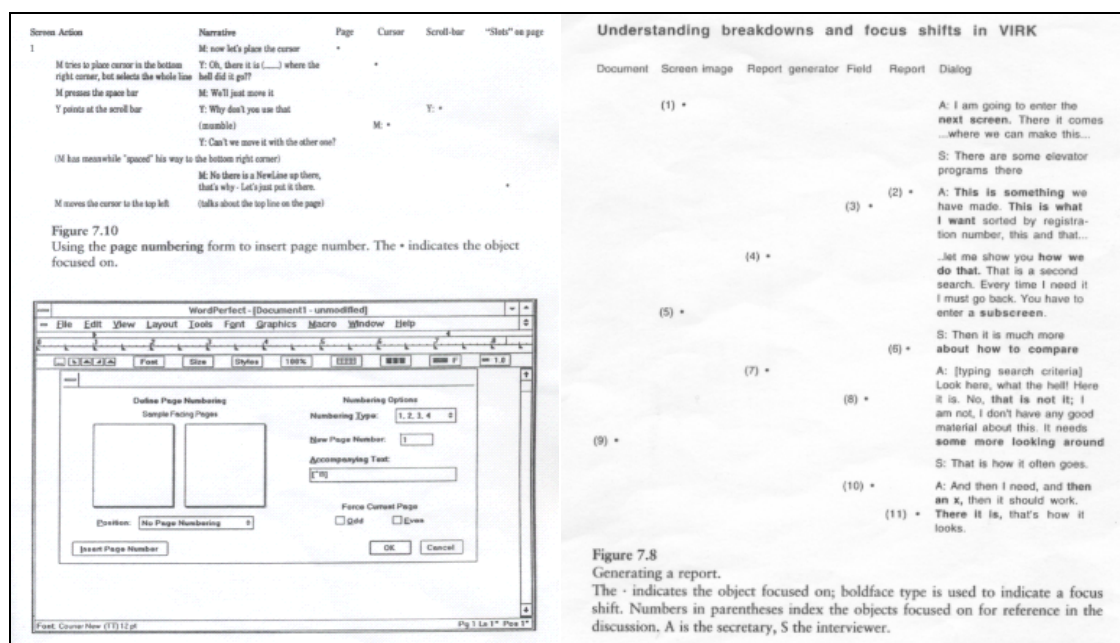
Figure 3.3: Example of focus-shift analysis from the AT project. From (Bødker, 1996a).

Only a handful of detailed examples of focus-shift analysis have appeared in the literature, (Bødker, 1996a, Bouvin *et al.*, 1996) being the best-known to date. Consequently, there is as yet no standard set of procedures or system of notation. Figures 3.3 & 3.4 show the graphical notations used in (Bødker, 1996a) and (Bouvin *et al.*, 1996) and illustrate their general approach to presenting findings.

Scenario	Note	Text button	View button	Xedit window	Xedit toolbar	Xedit (bottom)	Instr.	Transcript log	Observation log
1									Reads scenario, in which he has to edit an existing text note.
	2								Uriel has the pen hovering over the text note
		3						Uriel: Then I activate 'Text' and ...	Uriel moves pen to toolbar and hesitates. Presses 'Text' button but does not activate the 'create text' mode.
							4	NOB: What do you want to do?	
		5						Uriel: I want to extend this text ...	Uriel refers to the active text note
			6					Uriel: ... but that means that I have to create some text myself.	Uriel moves pen away from tablet and looks at the Create buttons
							7	CN: Yes, but no. Because when you choose 'Create' something, you make a new annotation.	
				8				Uriel: Well, then I will have to view it ...	Uriel presses the 'View' button.
					9			Uriel: ... and see if I am able to ahmmm	Xedit starts and Uriel watches it for a while.
						10		Uriel: ... could you say load ... no.	'Load' is a button on the toolbar.
							11	CN: The text editor is easy	

Figure 3.4: Example of focus-shift analysis from the EuroCODE CSCW project (fragment). From (Bouvin *et al.*, 1996).

3.3.1.5 Collaboration & Coordination in Computer-Mediated Activity

In his 1998 doctoral thesis (Bardram, 1998) and related papers (*e.g.* Bardram, 1997) Bødker's student and collaborator Jakob Bardram outlined an activity-theoretical approach to understanding collaborative computer-mediated work activity. Although his approach is mainly based on the general models of the hierarchical and dynamic structure of human activity developed by Leont'ev (§2.4.1.1, Fig. 2.2), Bardram's work also incorporates important insights from both cultural-historical (§2.4.1, 2.5.2) and systems-cybernetic (§2.4.2, 2.5.3) approaches to activity theory.

Co-construction

Reflection on the object of work ↓ ↑ Implementation: stabilising the shared object (goal) of work

Co-operation

Reflection on the means of work ↓ ↑ Routinization: stabilising the shared means of work
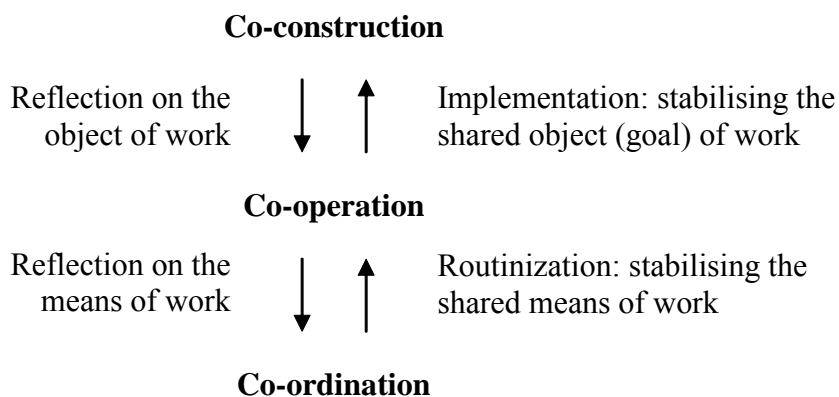
Co-ordination

Figure 3.5: Levels and transformational dynamics of collective activity. Redrawn from (Bardram, 1998). *Cf.* Fig. 2.2, Chapter 2.

Bardram identifies three major types, or levels of collaborative work activity (shown in Fig. 3.5):

- Co-ordination, where individuals mainly concentrate on their own actions, which are carried out according to "scripts" (Schank and Abelson, 1977) derived from the plans, rules and norms which make up the current work process. In coordinated work each person contributes to the collective aspects of the work activity passively, by playing their part in the division of labour. Bardram (*ibid.*, pp. 3-35) suggests that this kind of coordinated activity roughly corresponds to the operational level of Leont'ev's activity hierarchy.

- Co-operation: collective activity in which - in contrast to co-ordination - participating subjects more often focus on a common (complex) work object and more consciously share a common goal (a visualization of the desired future state of those objects). This kind of activity is regulated mainly through communication *i.e.* semiotic actions and operations using sign systems. It relies on each participant forming a relatively clear image or conception of the goal which overlaps sufficiently with those of other participants to allow co-operation to proceed. There is negotiation between actors, but the goal and objects of work must remain relatively stable for the process to be sustainable.

- Co-construction: this is essentially creative and innovative collective activity in which few or no elements are fixed, and which requires participants to engage in continuous communication in order to collectively develop and clarify their common goals.

As noted, these levels can be envisaged as roughly corresponding to the levels of operation, action, and activity shown in Fig.2.2 & Table 3.2. A major characteristic differentiating levels of collective activity is the degree of freedom and creativity involved in the work; this in turn is reflected in their dominant mode of activity coordination (see Table 3.3).

While all levels can be thought of as being continuously coordinated using complex combinations of scripted, instrumental and communicative means, communication (both verbal and non-verbal) becomes increasingly important as

the pre-determined or routine aspects of the work diminish. The arrows in Fig. 3.5 indicate that collective work-processes involve continuous and dynamic transformation between one level and another, in ways analogous to the conceptualization and automatization that occurs in an individual's activity (§2.4.1.2, 3.3.1.3). For example, as co-creative work becomes stabilised and routinized, instrumental, and then eventually scripted means of coordination increasingly come to predominate. Conversely, if contradictions arise and breakdowns occur within routine collective work-processes, this can trigger a phase of development involving increased reflection and creativity requiring increased participation in dialogue and discussion.

Table 3.3: Three modes of activity coordination. Adapted from (Bardram, 1998)

Coordination Type	Description	Prerequisite
Communicative	Coordination through semiotic actions and/or operations using sign systems (incl. indexical, symbolic, iconic and conceptual communication.	Shared cultural-historical sign-systems.
Instrumental	Coordination according to the "readable" reflections from other subjects' activity, *i.e.* "according to what other actors do, rather than what they deliberately signal" (Bardram, 1998, p. 50).	Externalization of operations and/or results.
Scripted	Coordination according to a script of action, reflecting who is doing what, when, why, *etc.* Typically embedded in norms, procedures, protocols, rules, division of work, *etc.*	A common script.

3.3.2 Systemic-Structural AT-HCI

Following the collapse of Communism in 1991, expatriate Russians such as V. Kaptelinin (*e.g.* Kaptelinin *et al.*, 1995, Kaptelinin, 1996a, 1996b) and B. Velichkovsky (*e.g.* Raeithel and Velichkovsky, 1996) have played a role in strengthening the links between Scandinavian ATIT and the concepts and traditions of general activity theory (Bertelsen and Bødker, 2003). As noted in §2.4.4, for various historical reasons little research directly concerned with HCI or ISD was carried in the former Soviet Union. However, there was a strong tradition of AT-based work in engineering psychology, human factors/ergonomics, education, and training, although this work was, and to some extent remains, largely unknown in the West (see §2.5). An important recent development been the introduction into ATIT of ideas and techniques from this

tradition, mainly based on the systems-structural strand (§2.4.2) within theoretical and applied Soviet AT. This movement is associated with former Eastern Bloc researchers now living in the US, among the most well-known being the group associated with the Ukrainian work psychologist G. Z. Bedny.

At the time of writing (Spring 2006) Bedny's *The Russian Theory of Activity: Current Applications to Design and Learning* (1997, part-edited for a Western audience by the American human factors expert David Meister) is the only widely available English-language textbook on AT written by an (ex-) Soviet scientist. It mainly deals with Systemic-Structural Activity Analysis and Design (SSAAD), a body of interrelated and complementary principles, methods, and techniques based on systemic-structural activity theory(SSAT, see §2.5.3). SSAAD has been applied to the study and design of HCI by Bedny and Karwowski (Bedny *et al.*, 2005a, Bedny and Karwowski, 2003b, Bedny *et al.*, 2001b), Sengupta (Sengupta and Jeng, 2003, Sengupta, 2004) and others. In common with other AT-HCI approaches, analysis begins by investigating general characteristics of the activity of interest: the means of work, tools, and objects; possible strategies of work activity; constraints on performance; social norms and rules; possible stages of object transformation; and changes in the structure of activity during skills acquisition. This general, qualitative investigation is carried out from the cultural-historical and objectively-logical perspectives on activity analysis (see §2.5.3.3).

Having established a general context, the analytical focus then shifts to activity during the solution of some specific problem - a task - defined as a fragment of activity organized around a supervening goal (§2.5.3.1). The notion of activity during task performance as a fundamental object of study underpins systemic-structural analysis, in which HCI is considered as a specific type of work process involving sequences of goal-directed tasks (Bedny and Harris, 2005). Tasks are seen as having various attributes (such as complexity, subjective assessments of difficulty, and significance) and as always being carried out under specific circumstances - task conditions - which determine the constraints on performance. In SSAAD, tasks and sub-tasks are primarily differentiated on the basis of their organizing goals, with the formation or acceptance of a distinctive task-goal is taken as marking the inception of a task or sub-task, and achievement

or abandonment of the goal as marking task completion. Once tasks have been identified it is then possible to classify them according to various criteria; Bedny, Chebykin & Karwowski (2005a) have proposed methods of task classification based on the work of Landa (Landa, 1983). Both morphological (structural) and functional techniques of analysis are then carried out on tasks at various levels of decomposition.

3.3.2.1 Morphological Analysis of HCI

The primary unit of morphological (structural) analysis is the *action*, defined in SSAT as a relatively complete, temporally delimited, element that fulfils an intermediate, conscious sub-goal of activity (Bedny and Meister, 1997, p. 13). Individual actions are first isolated and then classified (either in terms of their object, tools, goals and subject, or of their dominant psychological process) then formal descriptions of the logical structure of activity are produced using symbolic representations known as human algorithms. Subsequent stages of morphological analysis involve detailed time-structure analyses and, when required, the quantitative evaluation of task complexity (see Bedny and Meister, 1997, pp. 262-293).

Algorithmic Analysis

Activity analysis using human algorithms involves:

- The subdivision of observed activity during task performance into qualitatively distinct units, called *members* of an algorithm;
- Determination of the logic of the organization and sequence of those units in the structure of activity.

The construction of human algorithms aims to support the detailed examination of the performed actions and logical relationships in a given task or sub-task from an individual-psychological perspective. When analysing collaborative activity, algorithms can be constructed from the point of view of each involved user, then compared, contrasted, or combined. There are two main types of members of an algorithm (Bedny and Meister, 1997, pp. 189-190, 204-210). *Operators* are composite units, formed from 3-5 discrete goal-oriented actions organized by a supervening goal. They denote clusters of efferent (O epsilon) and afferent (O alpha) mental and motor actions that transform objects, energy,

and information. Members of an algorithm called *logical conditions* (*l*) determine the logic of selection and realization of different members of an algorithm, and indicate the decision-making processes involved in task performance. Logical conditions may be complex (L) or simple (*l*). Operators and logical conditions are labelled in series with subscript numbers to facilitate reading of the algorithm. The algorithm is read from top to bottom; arrows with superscript numbers designate the logic of non-sequential (forward or backward) transitions from one algorithm member to another.

Algorithm	Description	Actions obtained from action classification table	Time (ms)
O_1^α	Look at goal area and initial state of object area.	Simultaneous perceptual actions (3 actions)	1030
$O_2^{\alpha th}$	Find out differences between goal area and object area.	Thinking actions based on visual information (4 actions)	1650
$O_3^{\alpha th}$	Find out differences between goal area and object area and simultaneously perform O_4^ε.	Thinking actions based on visual information (2 actions)	740
O_4^ε	Move cursor closely to object area.	Simple motor action.	
l_1	Decide to click object (element O_b) and simultaneously perform O_5^ε.	Decision making action based on information from memory.	840
O_5^ε	Simultaneously with l_1, click object element O_b.	Simple motor action.	

Figure 3.6: Fragment from the algorithmic description of an HCI task. From (Bedny *et al.*, 2005b).

Figure 3.6 shows an example of algorithmic analysis taken from (Bedny *et al.*, 2005b), which includes descriptions of the operators and logical conditions, their temporal duration, and an indication of the number and type of actions involved in their performance. Chapter 7 demonstrates the application of algorithmic analysis to the field study data.

Time-structure Analysis

In time-structure analysis the temporal structure of activity in terms of performed tasks, actions and motor operations is described at various levels of detail, often through the use of graphical representations such as timeline charts (Bedny and Meister, 1997, pp. 246-262). Time measurements derived from observational or experimental data are used to specify the duration of individual elements of activity, with particular attention being paid to the structure of sequential and simultaneous performance of mental and motor actions. Figure 3.78 shows a fragment from the time-structure of an HCI task using a word-processing application developed in a lab-based study by Sengupta & Jeng (2003).
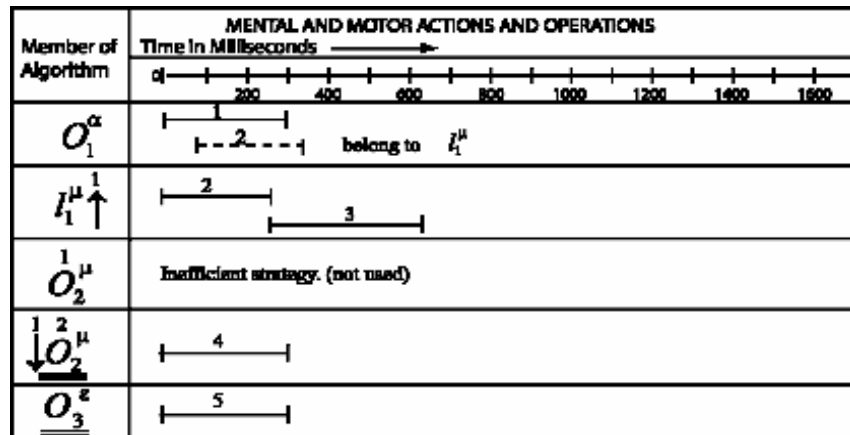
Figure 3.7. Fragment from the time-structure analysis of computer graphics task. From Sengupta & Jeng (2003).

Methods of algorithmic and time-structure analysis can also be further supplemented through the use of existing standardized classifications of motor actions, such as those of the MTM-1 system developed within American HFE (see *e.g.* Bedny & Meister, 1997 pp. 252-262).While an extended discussion of advanced techniques of algorithmic and time-structure analysis is beyond the scope of this thesis, further information can be found in Bedny *et al.,* (2000); Bedny, Karwowski, & Kwon, (2001); Bedny & Karwowski, (2003b); Sengupta & Jeng, (2003); and Sengupta, 2004.

3.3.2.2 Functional Analysis of HCI

Functional analysis refers to the technique of describing activity during task performance in terms of a goal-directed, self-regulating system which is conceptualized as consisting of discrete functional mechanisms linked through complex feed-forward and feedback connections (see also §2.5.3.2). The primary units used for such analyses are *function blocks* (Fig.2.7) such as goal, motive, subjectively relevant task conditions, *etc.* (Bedny, 2004, p. 250-251). In functional analysis, models of activity self-regulation (derived from laboratory studies, see *e.g.* Zinchenko and Gordon, 1981) depicting relevant function blocks and their interconnections are used as "lenses" with which to scan activity, in order to trace how the structure of activity is shaped not only by external conditions but also the subjective ways in which individuals interpret and perform tasks. Both qualitative (video, screen captures, dialogue transcripts, observer notes, *etc.*) and quantitative (keystroke logs, chronometric measures) observational data are used as the basis for functional analysis. This multivariate

data is then qualitatively analysed in a type of expert inspection process, where the analyst attempts to use relevant self-regulation models as an aid to identifying orienting, executive and evaluative stages of action, and for isolating the transitions between those stages. These stages and transitions in observed activity are then analysed in terms of the major components of work activity (§2.5.3 & Fig. 2.7) so as to determine the part played by *e.g.* tool design in supporting or hindering progress toward the task-goal. Of particular interest in connection with HCI studies is the analysis of orienting activity and the impact of various aspects of computer artifact design on users' goal-formation processes.

Functional analysis supports study of the interconnections between users' experience, motivation, and subjective interpretation of the objective complexity of the task in terms of perceived ease or difficulty, the way these complex relationships develop over time during an interaction or task sequence, and the part played by the various artifacts in use in shaping that development. To date few explicit examples of the functional analysis of computer-mediated activity have been published, although to some extent some degree of functional analysis is implicit in all studies of user motivation and goal-formation within ATIT, such as the analysis of eye-movement registration data in Raeithel and Velichkovsky (1996). Harris (2005d) and Bedny, Karwowski and Sengupta (2005b) provide examples of functional analysis of HCI data using SSAAD, the former in a field study, the latter under laboratory conditions. Chapter 8 presents a functional analysis of the field study data.

3.4 Activity-Theoretical ISD

> Activities, as opposed to tasks, are inherently context-sensitive. A key principle of activity-theoretical ISD has been to use the notion of activity, or activity systems, as a basis for establishing a "minimal meaningful context" for individual actions (Kuutti, 1996).

The application of AT to ISD has also in the main centred on the Scandinavian School, and has developed in parallel and intertwined with the efforts in AT-HCI outlined above, in many cases within the same groups.[13] As the quotation from Kuutti points out, the principal foci of AT-ISD has been on establishing methods for capturing useful information about the context in which information systems are to be deployed, and on creating means by which this information may be used to inform system design and development.
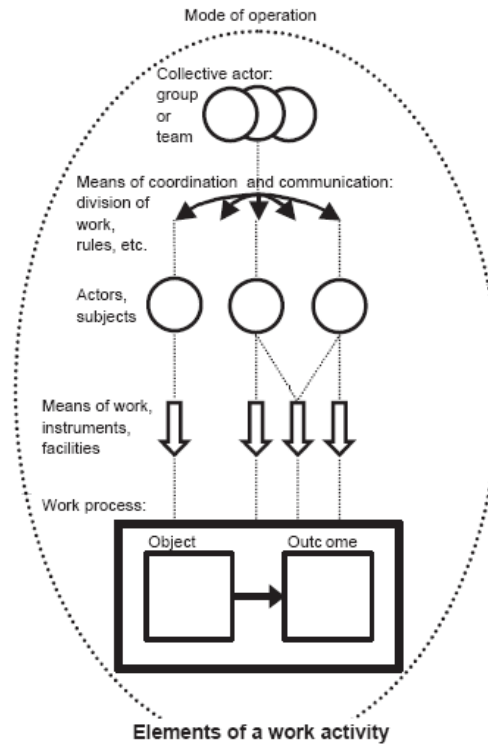
Figure 3.8: ActAD's depiction of collective work activity as a systemic entity. From Korpela, Soriyan, & Olufokunbi, 2000.

As noted in §3.1.2, the dominant influence on developments in AT-ISD has been Engeström's CHAT. This is clearly evident in the Activity Analysis and Development (ActAD) method created by the Finn Mikko Korpela and his collaborators (Korpela, 1999, Korpela *et al.*, 2001, Korpela *et al.*, 2000, Korpela *et al.*, 1998), which is an activity system or activity analysis approach (see Table 3.1) based on DWR (§2.5.2.4).[14] ActAD offers a four-stage framework for "studying and developing work activities, particularly in relation to information systems development" (Korpela, 2005) utilizing a series of requirements elicitation techniques. The data produced is described in terms of various aspects of collective work activity seen as a systemic entity, graphically depicted using modified versions of Engeström's activity system and activity network diagrams. The primary focus is on "the central activity" (Mursu, 2004), which is identified through the examination of shared work objects and jointly produced outcomes, then characterized in terms of historical development, current weaknesses, and future potentials. An example of the graphical models produced during the ActAD process is shown in Figure 3.8.

The Activity Checklist developed by Kaptelinin, Nardi and Macaulay (Kaptelinin *et al.*, 1999) is a list of questions based on general activity-theoretical principles which are designed to guide the design and evaluation of user interfaces, individual computer applications, and whole information systems. It is one of the most fully-developed examples of the query-based approach that has been central to much work in ATIT. In their preamble, the authors describe the Checklist as:

> …a guide to the specific areas to which a researcher or practitioner should be paying attention when trying to understand the context in which a tool will be or is used. The Checklist lays out a kind of "contextual design space" by representing the key areas of context specified by activity theory. (Kaptelinin *et al.*, 1999, p. 28).

The Checklist represents an attempt to bridge between activity-theoretical description and practical design. It also aims to provide a tool which seamlessly links the HCI and IS domains on the basis of AT (see Note 2, this chapter).

The majority of other AT-based ISD methods combine elements of ActAD and the Activity Checklist, inasmuch as they involve knowledge elicitation using (direct or participant) observation, interviews, and checklists of questions, and the subsequent graphical representation of the context of the IS development. Turner and Turner (2002) present an IS evaluation method based on Engeström's contradictions analysis (§2.5.2.2, Table 3.1). Both Jonassen & Rohrer-Murphy (1999) and Martins & Daltrini (1999) provide checklist-based approach to requirements elicitation. The Activity-Oriented Design Method (AODM) of Mwanza (Mwanza, 2002b) is a 6-stage macro-analytical ISD method focused on the initial stages of IS design from a global and mainly cultural-historical perspective (Quek and Shah, 2004). The Activity Theoretical Iterative Evaluation Method (ATIEM) developed by Quek & Shah (Quek and Shah, 2005) provides a series of "templates" which allow answers to the guiding questions provided to be developed into graphical and tabular representations for knowledge elicitation within an organizational setting and the subsequent construction of evaluation criteria.

3.5 Discussion

3.5.1 Shared Concepts & Principles in ATIT

Over the period 1984-2004 the developments outlined above have given rise to a number of general concepts and principles which, in a number of (sometimes widely varying) interpretations, are held in common by most researchers working on ATIT, *i.e.* the application of activity theory to information (and communication) technology design. These ideas and attitudes – which are directly linked to some of the major theoretical features of the activity tradition outlined in the previous chapter and summarized in §2.6.1 - can be said to represent the foundations of that shared body of knowledge and experience which currently constitutes ATIT as a distinctive area of research and application. They can be briefly summarized as follows:

3.5.1.1 Computer Applications and Hardware are Cultural Artifacts

AT posits that purposive and motivated work actions are always mediated by material and ideal artifacts – tools and signs – which emerge from, and shape, collective human activity and embody (*objectify* or *crystallize*) historically-developed and developing modes of operation, norms, rules, and methods of work (§2.3.1, 2.5.2.3). Tools and signs mediate action as humans create, explore, and transform material or ideal (non-material) objects in the world; tools and signs are themselves produced, reproduced, and evolved through those actions. The preservation and transmission of historical modes of operation through their embodiment in artifacts is the essence of cultural-historical (as distinct from biological) evolution (Bærentsen, 2000); technological artifacts such as computer programs and hardware are as much a part of this process as hammers or works of art.

In common with all human artifacts, computer artifacts exhibit a dual nature in activity. In *use*, computer artifacts are complex tools or means of work which mediate human activity; when being adjusted or explored, and in *design* or *evaluation*, they form the *object* of human activity. A major distinguishing feature of computer artifacts is their remarkable flexibility and adaptability in comparison to other tools. As mediators, they can function as both primary and

secondary artifacts (§2.5.2.3), and as tools for both communicative and instrumental actions (Fig. 2.10).

From the foregoing it can be seen that human-computer interaction can never be usefully considered – as in the cognitivist framework which formed the basis of early HCI, see §1.4.3.1 - as a communicative transaction equivalent to that between human actors, or one where computer systems and human actions can be represented by the same models and languages. Any HCI or IS method or theory based on *human* activity theory must approach the relationship between user and computer application as fundamentally asymmetrical: computer artifacts are always the *mediators, objects,* or *products* of human action; in computer-mediated activity they form only a *part* of the conditions and means of task performance. However, unlike traditional artifacts, the relatively short developmental history of any given computer artifact may not have allowed sufficient time for their design to be modified by the experience of users, especially where the culture and practices of those users differs significantly from that of the artifact's designers.

3.5.1.2 Computer Artifact Use is Situated Action

ATIT is committed to the attempt to take full account of the reality that the (actual or proposed) use of computer artifacts always takes place in specific, complex, and historically developing sociocultural and technical *contexts* (Harris, 2005d, Bødker, 1999a, pp.17, 21), and as such always involves both pre-planned and situated, emergent actions (Suchman, 1987, Bedny *et al.*, 2004). Furthermore, the situated use of computer artifacts is essentially *social* and *motivated*, and always involves the (co)production and reproduction of shared social meanings (§2.4.1.3. and see Bærentsen and Trettvik, 2002, Bedny and Karwowski, 2004c) and both individual and collective learning and development. Use always takes place within complex webs of activities (Bødker, 1999a, p. 22) or networks of activity systems (Engeström, 1999b) involving many other kinds of mediation and mediating artifacts. HCI cannot ever be fully understood apart from its specific, concrete, context of use; and the design of HCI necessarily *always* implies some (re)design of the whole use situation.

From the point of view of the user, under normal operating conditions the user interface *is* the computer application or system, that is, it is the UI that provides the actual conditions for operations in any specific use situation (Bødker, 1991). Computer applications provide support for both the *intentional* (conscious) and *operational* (automatic, unconscious) aspects of instrumental and communicative actions (§2.4.1.2). However, underlying system functionality (and the *physical* and *handling* aspects of the artifact-in-use, §3.3.1.2) is generally only revealed to, or considered by, the user in reflection on the results of the use process (that is, when the artifact becomes an object rather than tool). Such reflection may be necessitated, for example, by the requirement to consciously focus on the application itself (rather than the work-object) as a result of breakdown (Bødker, 1991). Thus, interface transparency that is, the situation where the artifact unobtrusively mediates actions toward the work-object must be understood as an emergent feature of the whole user-artifact-setting ensemble (Bardram and Bertelsen, 1995).

3.5.1.3 Design, Use and Evaluation are a Continuum

In ATIT, the design and use of computer artifacts is understood as an essentially co-constructive, multi-practical activity (Bødker, 1999a p. 17). Avoiding the assumption that technology users only perform those actions with an artifact that its initial designers intended, design and use are seen not as discrete phases of a system lifecycle but rather as forming a developmental continuum (*cf.* Suchman, 1994). On this continuum, design and use are interlocking aspects or phases of a complex cycle of cultural transmission and development which involves the (both conscious and inadvertent, and by both designers and users) *objectification* of beliefs, worldviews, insight, skills, knowledge, practices and operations into technological artifacts, and the creative *appropriation* of those artifacts into historically developing practices in ways which alter both the practices and the artifacts, resulting in their further development (Leont'ev, 1981b 421-422, Bærentsen, 2000 p. 44, Törpel *et al.*, 2003). Through use and reflection, users discover the constraints and possibilities of a computer artifact, and both adapt it and adapt *to* it. These adaptations become incorporated in later versions of artifact and work process design. Research in context-aware HCI and CSCW has studied aspects of this appropriation process in terms of tailoring (Trigg and

Bødker, 1994, Robertson, 1998), articulation work (Schmidt and Bannon, 1993), and end-user programming (Nardi, 1993). This understanding implies that to be effective, design must attempt to get as close to the actual processes of use as possible (hence, participatory or user-centred design is ideal when possible); and that it is human work practices, rather than abstracted or idealized information-processing tasks, that should be designed for (*cf.* the discussions of large-scale information systems failures in §1.4.3.2).

3.5.1.4 Use is Learning and Development

ATIT emphasizes the part played in the design and use of computer artifacts by socioculturally situated, dynamic, creative and recursive *learning* processes taking place in the context of object- and subject-oriented (communicative) activity in developing communities of technology-based practice (Lave and Wenger, 1991, Wenger, 1998, Harris and Shelswell, 2005). In general AT terms computer artifacts are seen to support the development of new *functional organs* (ensembles of ideal and material tools and processes, §2.4.2.2) which enable a new range of actions in the world; most particularly, they extend or augment the human ability to create and transform visualizations of external objects before acting toward them in reality (Kaptelinin, 1996b). The *learning-in-use* (Bødker and Graves Petersen, 2000) of information and communication technologies is seen as having both conscious and unconscious aspects, and as involving processes of *internalisation* and *externalization* (§2.3.2) and *automatization* (transformation of actions to operations through repetition) and *conceptualization* (bringing into conscious attention formerly unconscious operations when they prove inappropriate or inadequate, so that they may be modified). The moment-to-moment learning-in-use process is understood as a sequence of changes in activity performance critically affected by goal-formation and motivation (Haenen, 1996, Bedny and Meister, 1997 pp. 369-373). Errors, shifts of focus, and *breakdowns* during human-computer interaction play an important role in learning processes (Bødker, 1996a) and consequently provide important starting points for analysis and design (*e.g.* in collaborative prototyping, see Bødker and Grønbæk, 1991). Furthermore, when computer artifacts and the practices they mediate are understood as being historically-formed, and their actual use in specific settings is seen as dynamic and developing learning process, then it is

evident that their analysis and design will always require the use of historical and developmental approaches, with an emphasis on the development of expertise (skill) during interaction (Bertelsen and Bødker, 2003, p. 294).

3.5.2 Issues & Challenges for ATIT

3.5.2.1 Critiques

In the early stages of the development of ATIT (§3.1) many researchers associated with the Scandinavian School (*e.g.* Kuutti, 1987, Kuutti, 1991, 1996, Nardi, 1996a, Bannon and Bødker, 1991) were optimistic as to the potential of activity theory to provide an effective alternative to cognitive science as a conceptual framework for research and practice in HCI and ISD. In particular, the 1996 Nardi collection (Nardi, 1996b) was seen by its contributors as an opportunity to present a number of analysis and design methods which would provide practical, context-aware alternatives to cognitive science-based approaches such as GOMS and cognitive task analysis (Bertelsen, 1994), while also demonstrating that AT provides a more fully developed, and viable, conceptual framework for research than other alternatives such as distributed cognition (Nardi, 1996c). However, by the early 2000s there was evidence of an emerging consensus within the Scandinavian ATIT community that, after a decade of work, progress toward the establishment of practical design and analysis methods has been disappointingly slow in comparison to these initial expectations.[15] In (Bertelsen and Bødker, 2003, pp. 320-321) the authors claim:

> Activity theory has served well to inform analyses of computer artifacts in use, in particular in work. A wide array of methods and tools support this perspective, from historical analyses and ethnographical studies to schemes for focus shift analyses. Similarly, activity theory is getting a foothold for understanding design activities, structurally and processually.

But then continue:

> The change-oriented perspective on computer applications in use implies direct demands on how we do design, so as to accommodate for further change.

> It seems to be one of the really big challenges for an activity theory informed design, how far one may actually be able to go? How close to technology? How design-oriented? …very few examples, thus far, have addressed the issues of IT in use and design.

A comparative survey of AT-ISD methods carried out in 2004 (Quek and Shah, 2004) concluded that "most of the methods are selective in their use of AT, and are not sufficiently validated… there is a lack of comprehensive treatment…" Both advocates and critics of ATIT (*e.g.* Nardi, 1996a, Halverson, 2002) have stated that ATIT lacks any *specific* methods for informing analysis and design. A recent critique by Crystal & Ellington (2004, p. 5) alleges that the root cause of this problem lies with AT itself:

> Activity theory in its current form is only the beginning of a coherent foundation for task analysis and HCI. Key concepts—such as activity, action and operator—are situation-dependent. The lack of consistent definitions makes it difficult to compare and generalize empirical results. Activity theory has yet to provide a disciplined set of methods to guide design, as information-processing theory has. Until such methods are available, activity theory may serve to provoke creative design thinking in particular cases, but will be difficult to apply systematically.

Recent work by Bertelsen (*e.g.* Bertelsen, 2004b, 2005, Bertelsen and Harris, 2005) has also suggested that (Scandinavian) ATIT faces a fundamental "crisis from within", provoked by the contradiction between its assertion that, on the one hand, allowing for unanticipated use and development in use forms a basic condition of information technology design, while, on the other, accepting that design must necessarily predict, support, and constrain users' activity.

One overall conclusion that might be drawn from these critiques is that the focus on socio-historical-cultural context advocated by the Scandinavian AT-HCI tradition which is its major contribution toward expanding the scope of HCI research, has resulted in a largely macro-analytical, descriptive approach which has proved difficult to develop into more detailed and practical design and analysis methods.

3.5.2.2 Responses

Advocates of the systemic-structural approach in AT (§2.5.3) have suggested that critiques such as Crystal and Ellington's actually highlight problems with CHAT rather than AT as a whole. Bedny (2004), Harris (2005d) and others point out that the strong influence of CHAT on ATIT has led to an over-privileging of collective, cultural-historical perspectives on activity analysis, amplifying the under-emphasis on the agentive self in Leont'ev's work noted by Vygotskian critics such as Stetsenko (Stetsenko and Arievitch, 2004, p.490), leading ATIT

researchers to pay insufficient attention to the individual-psychological aspects of activity. Bedny and Karwowski (2004a) and Bedny and Harris (2005) point out that the while the CHAT/DWR approach can produce useful general descriptions of work settings, it is much less well-suited to the detailed analysis and design of work processes, for the following reasons:

- CHAT lacks sufficiently precisely defined units of analysis, and in particular provides insufficient support for delimiting the scope of analysis (where does an activity system begin or end? How big is a network of activity systems?)

- CHAT does not provide means for sufficiently or precisely differentiating between operations, individual actions and collective activity, making detailed morphological analysis of HCI difficult;

- CHAT in general, and the activity system schema (Fig. 2.4) in particular, uses standard activity-theoretical terms in ways that are insufficiently clearly defined, *e.g.* the use of the term *object* to encompass fundamental, and distinct AT concepts such as goal, object, outcome, and result (compare Figs. 2.4 & 2.10 and see also Note 30, Chapter 2).

3.5.2.3 Interim Conclusions

While the literature review and other background research reported here lend some support to the responses outlined above, it is also clear that the root causes of the slow progress toward a practical, applied ATIT cannot be entirely ascribed to the influence of CHAT. Rather, the problems outlined in §3.5.2.1 appear to have deeper roots in the histories of ATIT, AT, and HCI. Chapter 2 (§2.4-5) traced the emergence of several different schools in AT during the Soviet era, noting that for a variety of reasons some strands within the activity approach have had more influence than others on extra- and post-Soviet developments in AT. This chapter has described the origins of activity-theoretical HCI and ISD in a Scandinavian participatory design tradition rooted in the sociotechnical systems approach (§3.1.1 & 1.4.2.3). It has shown that ATIT's conceptual framework, although subsequently strongly influenced by Finnish CHAT (a synthesis of cultural-historical psychology with selected aspects of Leont'ev's general theory of activity), was initially mainly derived from Danish psychologists'

interpretations of AT which, *ab initio*, strongly emphasized the cultural-historical aspects of activity theory.[16]

As this chapter has shown, both scientific and ideological considerations led the emerging Scandinavian School of ATIT to cast their views somewhat in opposition to cognitive science (see also comments in Bertelsen, 2004b, 2005). The "move to the contextual" - a move away from conceptions of HCI in which human beings were often treated as individual, isolated and essentially static information-processing entities - can also be seen as a consequence of the earlier splitting-off of (cognitivist and reductive) HCI as a separate discipline from the broader field of Human Factors/Ergonomics (as outlined in the second part of Chapter 1). While it is evident that those aspects of HFE research which were most influential on the development of cognitivist HCI of the 1970's and early 80's were indeed highly decontextualized, taken as a whole Western HFE has arguably made steady progress toward increasingly involving sophisticated considerations of the social and situated aspects of work practice into design practice (a recent example of this trend is the work by Endsley and Garland (2000) on situation awareness).

In the light of the foregoing considerations it can be seen that in responding to Bannon's call for a move "from human factors to human actors" (Bannon, 1991), the emerging field of ATIT drew on predominantly social, cultural, and historical interpretations of AT already established within Scandinavian psychology. The origins of ATIT in the radical, oppositional PD movement within HCI might have contributed toward the avoidance or rejection[17] of those (systems-structural-cybernetic) strands within AT which, despite being framed within an entirely different ontology and epistemology, have clear affinities to Western cognitivism. This tendency within ATIT was later strengthened – rather than initiated by - the influence of CHAT. Thus, despite its ambitions to develop as an *applied* discipline, ATIT's conceptual roots have mainly been in those aspects of the activity approach concerned with very general psychological concepts and principles, and with theories of culture and history, rather than in those traditions of applied AT in Soviet engineering psychology and HFE (briefly outlined in §2.4.3.1) which arguably have greater potential for providing concrete methods.

3.5.2.4 Implications

A general challenge for current research in ATIT - including the work reported here - is to develop more detailed and explanatory forms of analysis. One aspect of meeting this challenge involves finding ways to clearly and consistently differentiate types, stages and levels of activity. Chapter 2 described how, during the development of AT, a number of differences emerged between different schools' interpretation of key concepts such as internalisation (§2.5.3.3). There was some divergence in terminology and methods, and in the ways in which schools utilized some or all of the theory's major analytical perspectives (§2.3.2), manifested for example in differing views on what should be the basic standard units of activity analysis (§2.6.1.1). The overview given in this chapter suggests that the development of Scandinavian ATIT has reflected, preserved, and possibly amplified some of these historic problems. Section 2.5.3 noted the emergence of a systemic-structural approach which specifically set out to develop a unified and coherent terminology and methodology within AT. One implication of the arguments set out in this section is that the combination of ideas and methods from the SSAT approach in AT with Scandinavian ATIT might prove fruitful in supporting the further development of practical activity-theoretical HCI/ISD analysis and design techniques. Some initial experiments in this direction are reported in Chapters 7 & 8.

3.6 Summary

Activity-theoretical information technology design, development and evaluation (ATIT) originated in the Scandinavian participatory design movement (PD) and Finnish CHAT and developmental work research. Table 3.1 presented a summary overview of ATIT analysis & design approaches. Section 3.3.1 discussed Scandinavian AT-HCI, tracing the elaboration of a theoretical and methodological framework which includes various analytical and design perspectives on computer use, PD techniques such as scenarios and collaborative prototyping, and methods of historical and developmental analysis utilizing checklists and techniques such as focus-shift analysis. Section 3.3.2 discussed the introduction into AT-HCI of methods based on systemic-structural activity analysis and design (SSAAD), outlining techniques of morphological and functional analysis. A brief overview of some of the major approaches in AT-

ISD was given in §3.4. Section 3.5 set out a number of concepts and principles shared by most researchers using AT in HCI and ISD, such as the idea that computer applications and hardware are cultural artifacts; computer artifact use is always situated action, involving both pre-planned and emergent elements; that the design, use and evaluation of computer artifacts should be considered as a continuum, rather than disparate activities; and that computer artifact use always involves learning and development. §3.5.2 discussed some of the current issues and challenges for AT-HCI & AT-ISD, which have been criticised from both within and without as having failed to live up to their initial promise, particularly with regard to developing specific and detailed design and analysis methods and clearly defining terms and concepts. Some commentators have identified the over-dependence of ATIT on the general, cultural-historical perspective on activity analysis current within the Scandinavian School as one source of these problems. This implies that ATIT should begin to draw on and adapt a wider range of resources and methods, especially those developed within applied AT.

Notes to Chapter 3

[1] O. W. Bertelsen coined the acronym ATIT for the First International Workshop in Activity-Theoretical Information Design (ATIT04), which was held in Copenhagen, Denmark in September 2004 (proceedings published as Bertelsen *et al.*, 2004). This portmanteau term denotes the use of "activity theory based practical methods for IT design… (software, IS, HCI, CSCW, PD…)" (Bertelsen, 2004, personal communication). See also Note 2 below.

[2] It is often difficult to make clear distinctions between work in HCI and Information Systems design and development (IS/ISD). The origins of HCI (§1.4.2.2) lie in research into the user interface and input/output technologies, whereas ISD has mainly been concerned with the implementation and evaluation of whole systems, of which the HCI elements form one aspect. However, as both fields have developed there has been an increasing overlap, as the concerns of HCI have expanded (particularly following the "move to the contextual" within HCI described in §1.4.3), and ISD has become increasingly human-centred (see also §1.4.3.2 and Note 14, Chapter 1). In this thesis I follow (Kuutti, 1996) in using the term activity-theoretical information systems design (AT-ISD) to refer to research mainly concerned with methods for developing large-scale information systems within specific organizations, such as those reviewed in (Quek and Shah, 2004). The term activity-theoretical human-computer interaction (AT-HCI) is used to refer to fundamental AT-based research in HCI (the scope of which discipline is discussed in §1.4), such as that undertaken by Bødker (*e.g.*, 1989), Kaptelinin (1996a, 1996b), Bærentsen (2000) and others. The term ATIT (Note 1 above) offers a useful means of referring to both lines of research simultaneously, and of recognising their complex interconnectedness.

[3] The Scandinavian, (also known as Nordic) countries are Denmark, Finland, Iceland, Norway and Sweden, along with the territories of Greenland and the Aaland and Faroe Islands.

[4] Here mention should be made of the 1984 publication (in Danish) of a special edition on "man and machine" (menneske og maskine) of the journal *Psyke & Logos* (volume 5 no. 2, ISSN 01071211). This volume, which presented articles by B. Karpatschof, S. Folke Larsen, J. Rasmussen, E. Hollnagel and others – a number explicitly drawing on AT - was an important

influence on Danish researchers (*e.g.* Bødker, Mogensen) involved in the PD movement at this time (Bødker, personal communication, 2005).

[5] Scandinavian computer science pioneered improvements in the accessibility and usability of computer-based systems and has become internationally known for its emphasis on socio-technical (§1.4.2.3) and critical approaches to IS development. The best-known early example of this human-centred approach is the development (by Ole-Johan Dahl and Kristen Nygaard at the Norwegian Computing Centre, Oslo) of the programming languages SIMULA I (1962-65) and SIMULA 67 (1967) which introduced most of the key concepts of object-oriented programming, using a conceptual framework explicitly designed to relate to the real world in human terms. Nygaard, as Scandinavia's foremost politically and socially engaged scientist, was an important influence on the development of Scandinavian computer science in general, and on the participatory design movement in particular, many of whose founders (Ehn, Kyng, *etc.*) trained under him. In 1989 Jürgen Bansler (1989) identified three basic approaches within Scandinavian systems design: the systems-theoretical, the socio-technical, and the critical. It is the latter two which have since become most strongly identified with a distinctive "Scandinavian School" of IS and HCI, the cybernetics/systems approach of the first differing little from its application in other countries. See also §1.4.2.3.

[6] For an overview of the collective resources approach see (Törpel, 2005b).

[7] The introduction of concepts drawn from Husserl, Heidegger, and Wittgenstein into computer science is generally associated with the landmark text *Understanding Computers and Cognition* by Winograd and Flores (1986), preprints of which were circulating among the Scandinavian computer science community as early as 1984 (Bødker, personal communication).

[8] ISCRAT (The International Society for Cultural Research and Activity Theory) was a forerunner of ISCAR (Note 22, Chapter 2).

[9] The First International Workshop on Human-Computer Interaction was held in Moscow in October 1991. This was followed by a series of annual East-West Conferences on Human-Computer Interaction (EWHCI) in Moscow and St. Petersburg over the period 1992-96. Selected papers from EWHCI '93, '94 and '95 were published by Springer-Verlag in their Lecture Notes in Computer Science series. In 1993, a Russian branch of the ACM SIGCHI (special interest group in HCI) was launched with J. Gornostaev as its first Chair. In 1996 the organized HCI movement in Russia collapsed, due to worsening socioeconomic conditions and the large-scale exodus of Russian academics discussed in §2.4.4. In 2004 a new SIG in HCI (RusCHI) was formed, again under the auspices of the ACM (see "An interview with RusCHI's Ivan Burmistrov", SIGCHI *Bulletin*, September 15, 2004).

[10] Here I follow Bødker's self-identification with that school in (Bødker, 1991, p. 1) and an account given by her in personal interviews with the author during August 2005. Other early associates of this group included researchers such as Lars Mathiassen, John Kammersgaard, and Bro Bjerknes.

[11] See http://www.iscar.org/section/atit/.

[12] A movement to which the author has contributed. See §3.3.2 and Chapters 7 & 8 of this thesis and (Harris, 2004, 2005d, 2005c).

[13] For the definition of AT-ISD used here, see Note 2 above. Some research in AT-ISD has also been undertaken in Australia (*e.g.* Hasan *et al.*, 2000) and the United Kingdom (*e.g.* Turner and Turner, 2002). This work has been along similar lines to the Scandinavian approach outlined here.

[14] A derivation mentioned in the introduction to Korpela, Soriyan, & Olufokunbi (2000) and subsequently confirmed in an interview with Mikko Korpela carried out in September 2004.

[15] The arguments in this section are informed by research in the literature and a series of interviews and discussions with some of the principal researchers in ATIT (K. B. Bærentsen, J. Bardram, G. Z. Bedny, O. W. Bertelsen, S. Bødker, C. Brodersen, M. Korpela, A. Mursu, R. Nørager, T. Sengupta, B. Törpel, and J. Trettvik) carried out by the author over the period 2002-5. One aim of ATIT04 (Bertelsen *et al.*, 2004) was to establish the then-current status of practical ATIT design and analysis techniques. It was found that such techniques as existed were still

largely under-developed, with few having been evaluated or validated through case studies or completed designs.

[16] A cultural-historical interpretation based almost exclusively on the work of Vygotsky and Leont'ev was becoming the dominant approach in Danish AT by the mid 1970s (K. B. Bærentsen, personal communication). This trend, which continues to the present day, is exemplified by the accounts of AT offered in (Engelsted *et al.*, 1993).

[17] For example, one of the few research publications within Scandinavian ATIT to explicitly draw on systems-cybernetic concepts (namely, Anokhin's work on the anticipatory reflex), Bardram's 1997 paper *Plans as Situated Action: An Activity Theory Approach to Workflow Systems,* appears to have had little impact on the development of ATIT at the time (Bardram, personal interview).

4. The Field Studies: Setting & Methods

Chapters 1-3 set out the motivation for, and general practical and theoretical background of, the research project. Chapters 4-8 focus on the empirical aspects of the work. This chapter provides an introduction to the field studies, describing the research setting, the general research approach, and the methods used for data capture.

4.1 Two Phases of Fieldwork

Two phases of field study were carried out during the research project. Both involved the systematic observation, recording and AT-based analysis of collaborative computer-mediated activities undertaken at an adult basic education Open Learning Centre (the OLC, §1.1.2). The first, major phase of fieldwork was a longitudinal study carried out from September 2000 to May 2001. This involved participatory action research (PAR, see §4.3.1 below) into the development and delivery of an experimental digital multimedia ABE course, *Computer Creative*. Data-gathering was mainly accomplished using ethnographic fieldwork techniques, described in §4.4 below. The longitudinal study is discussed in Chapters 5, 6, and 7.

Toward the end of Phase 1 a number of video recordings were made. Post-study analyses of this data (described in Chapter 7) indicated that more extensive use of video-recording might usefully supplement the ethnographic approach employed so far in the project, particularly in terms of supporting detailed micro-analyses of observed interactions. Accordingly, a second "follow-up" phase of fieldwork involving the video-recording of a three-hour desk-top publishing (DTP) session was undertaken in May 2002. Phase 2 is described and discussed in Chapter 8.

4.2 The Research Setting

Both phases of fieldwork were carried at the Open Learning Centre described in §1.1.2. The OLC is the administrative and teaching headquarters of the Coleg Morgannwg School of Basic Skills, the principal provider of adult basic education (ABE) in the Rhondda Cynon Taff (RCT) region of south Wales, UK.

This section outlines some of the main physical, organizational and sociocultural characteristics of the OLC and the region in which it is located.

4.2.1 The Region

RCT, which encompasses three of the major valleys (Rhondda, Cynon and Taff) of the South Wales coalfield, was mainly settled and developed during Britain's Industrial Revolutions (*c.* 1750-1914). Historically, the region is also associated with evangelical, non-conformist Christianity (The British Broadcasting Corporation, 2004) and radical working-class collectivist politics (Williams, 1998, Tanner *et al.*, 2001). During the 18th and 19th Centuries the regional economy was principally based on coal and steel production. The steady decline of these industries resulted in the almost total collapse of the regional economy by the mid-1970s (Davies, 1994). In the last four decades of the 20th Century RCT became one of the most socio-economically disadvantaged regions of the UK, with high unemployment, poor health, and very low levels of educational attainment. By 2000 RCT was ranked among the poorest areas – in terms of *per capita* income - in the European Union[1], and as a consequence was awarded European Social Fund Objective 1 status (Salvador, 2004). [2]

Through the 1980s and 90s, several national and European-funded regeneration initiatives attracted some inward investment to the region and fostered the growth of small and medium enterprise in precision manufacturing, high technology, and new media. A gradual upturn in the regional economy was accompanied by a need for new skills among the local workforce, re-emphasising the significance of training and education for the region's recovery. In 2001 it was estimated that almost 40% of the adult population in the region had significant basic literacy and numeracy needs (The Basic Skills Agency, 2001). On the basis of research linking basic skills and employability (*e.g.* Moser, 1999), adult basic education has been consistently identified as a key aspect of economic and social regeneration strategies in RCT (Welsh Assembly Government, 2002). [3]

4.2.2 The Organization

Coleg Morgannwg is the main provider of both academic and vocational further (post-16, non-university) education in RCT, and is one of the largest such

institutions in Wales. It has one major campus, and many smaller outreach centres in schools *etc.*, in each of the three valleys which make up the region.[4] Its central administrative and ICT services are located on the Rhydyfelin campus in the Taff Valley, about 1.5 miles from the town of Pontypridd. The organization is centrally governed by an executive board under a Principal, and is subdivided into academic schools and administrative departments, each with their own Head of School.[5]

4.2.2.1 The School of Basic Skills

The School of Basic Skills is the department of Coleg Morgannwg responsible for the College's network of adult basic education (ABE) outreach centres in the RCT area. The School delivers accredited instruction in the basic skills of literacy (reading, writing, and communication) and numeracy (basic use of number). Since 1997 it has also offered training in the use of ICT, initially as stand-alone provision, later integrated with literacy and numeracy teaching to greater or lesser degrees (see §1.1.2 & Fig. 1.1).[6]

The School has a yearly budget of around £1m GBP,[7] and is one of the largest departments within the college. It employs around 20 full-time (37+ hours per week) staff (managers, tutors and administrators) and 30 part-time (4-18 hours per week) tutors. Its activities are also supported by around 40 volunteer teaching assistants, each working 2-4 hours per week. During the period of the research project, around 3000 learners were enrolled *per annum*. Students are drawn from the post-compulsory schooling sector (*i.e.* aged 16+) of the local population. Entry criteria for all courses are that applicants should have no, or few, academic qualifications at GCSE level or above,[8] and must be assessed as having identifiable basic skills deficits. Around 10% of learners also have learning or physical disabilities, and are offered extra support appropriate to their needs.

Ethos of the School of Basic Skills

Under the guidance of successive Heads, the School has become nationally recognized for innovative and effective practice in ABE. The School's personnel – who are predominantly female, aged from 28-55 - form an experienced, well-integrated, and dedicated team. In general, adult basic educators are professionally and legally committed to the promotion of equal opportunities and

democratic values; many of the School's tutors are also personally motivated by the belief that supporting adult learners to improve their basic reading, writing, and number skills may also help those individuals to alter their view of their own potential. The hope is that learners' confidence will benefit from their improved skills, allowing them to pursue a wider range of educational and employment opportunities in ways that benefit themselves, their local communities, and society as a whole (Harris and Shelswell, 2005). The term *empowerment* is often used among adult educators as shorthand for this "envisioned synthesis of individual and collective change" (Page and Czuba, 1999). In its commitment to empowerment, the School can be seen as exemplifying the tradition of socially-aware adult education practice in the UK established by Christian Socialists and Trades Unionists in the first half of the Twentieth Century (Kelly, 1970), a tradition which has particularly strong roots in south Wales.

4.2.3 The Open Learning Centre

The OLC comprises two three-storey buildings (former retail units) on opposite sides of Mill Street, central Pontypridd. Pontypridd is one of the principal market towns of the region, and this location is well served by public transport, with both bus and rail links nearby. The buildings house nine teaching rooms, known as workshops; six offices, including that of the Head of School; two interview rooms; and three staff workrooms. The type and age of the buildings mean that facilities for the disabled are limited; neither building has a lift. There is no provision for either staff or students to eat at either location; teaching staff have access to basic tea- and coffee-making facilities. The buildings are open from 0800–2100 hours Monday-Saturday inclusive. The OLC is in use throughout most of the year, with two-week breaks at Easter and Christmas. The buildings are semi-secure; students gain entry by using a video intercom linked to the reception desks and administration offices.

4.2.3.1 OLC Workshop 3

Observations during both phases of field study were carried out in OLC Workshop 3 (Figures 4.1 & 4.2). This is a medium-sized room (approx 40 m^2) on the second floor of the smaller of the two buildings.[9] While much of the available floor space in Workshop 3 is occupied by furniture and equipment, there is an

unobstructed line of sight between all points in the room, as can be seen from the photographic views in Fig. 4.2. The nearest toilet facilities are located on the floor immediately below. Access to the workshop is via the building's steep central staircase. This presented a physical challenge to several participants in the field studies, who were consequently often reluctant to leave the workshop during refreshment breaks.

4.2.3.2 Computer Hardware & Equipment

This section describes computer hardware and other tools available to participants during both phases of field study; the software in use is described in Chapter 6.
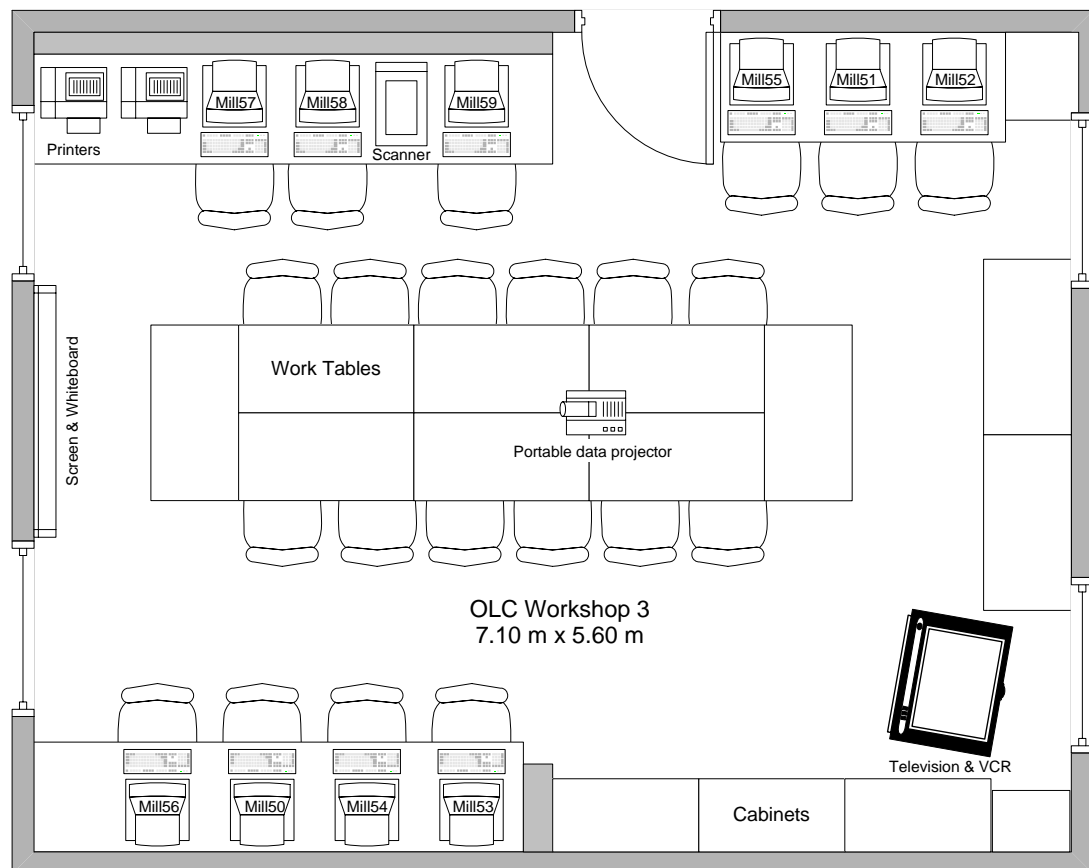
Figure 4.1: Layout & equipment, OLC Workshop 3. Drawing to scale; 1cm = 0.38 m.

Computers & Networking

During both phases of study Workshop 3 was equipped with 10 desktop multimedia personal computers (PCs). Four laptop computers were also available for use on request. All machines were Intel-based systems running the Microsoft

Windows 98 OS. The desktop PCs were equipped with either Pentium II (4 machines) or III processors (6 machines), clock speed 450-650 MHz, RAM either 32 or 64 MB, 16 MB graphics cards, onboard sound, and hard disk storage capacities of between 2 and 6 GB. All machines were fitted with both 3.5 floppy and compact disk drives; during the longitudinal study all Pentium III desktop machines were upgraded to include additional write/rewrite CD drives. Display output on all desktop PCs was via 15-inch CRT monitors.

Figure 4.2: Views of OLC Workshop 3 showing layout & equipment. Reading l-r from top and referring to Fig. 4.1 (a) shows entrance door, PCs & scanner; (b) PCs 55,51, &52; (c) view to back of room; (d) television, VCR, & video camera; (e) PCs 53 & 54, cabinets & work tables; (f) PCs 53,54,50, & 56; (g) data projector & screen; (h) PCs 57, 58, 59, 55,51, &52; (i) using a laptop on a work table. All photographs taken during the longitudinal study.

The desktop PCs were interconnected via an Ethernet local area network (LAN). [10] In Fig. 4.1 each machine is shown labelled with its network ID; these labels are used in the text when referring to specific machines. There were no local file servers; file-sharing was accomplished through copy/transfer around the network to named directories with appropriate access settings. From each individual PC,

remote directories (*i.e.*, those on other machines in the network) were accessed via the Windows Network Neighbourhood tool, a file-management utility. From any PC, viewing or modifying files stored elsewhere than the local drive involved accessing the appropriate remote machine (recognised by its network ID), and then browsing the remote directory structure to find the shared directory, indicated by a modified folder icon. Access to the Internet, and the College Intranet, was provided through a dedicated optical cable connected to a server on the main College campus, some 1.5 miles distant from the OLC.

Computer Peripherals & Other Equipment

Peripherals available in Workshop 3 included 2 inkjet colour printers and a flatbed scanner. Digital stills cameras, analogue and digital camcorders, and a portable data projector to be used in conjunction with the laptop computers were also available; when not in use these items and the laptops were stored in a secure cupboard on the first floor of the building. Also in the room were 8 large worktables and 6 storage cupboards containing supplies of a variety of pens, paper, and modelling materials. During the longitudinal field study participant learners also brought in their own materials: photographs and paintings to be scanned; newspaper and magazine articles; and miscellaneous artifacts including dolls, pieces of fabric and mechanical toys.

4.3 Designing the Research Practice

In designing the empirical research practice the researcher's initial priority was to achieve an approach appropriate to, and acceptable within, the fieldwork setting. The complex and developing nature of the situations under study suggested that to be effective in achieving the overall aims and objectives of the research project, the practice must be flexible enough to develop in response to unfolding events and should employ a wide variety of observation, interview, and materials collection methods. The nature of the research setting was judged to preclude pre- and post-, or control-group type experiments as such activities could be expected to cause unacceptable disruption to the OLC's learner-centred teaching and learning approach. The use of experimental or statistical approaches was also judged largely inappropriate, as the expected small numbers of study participants (in the event, 25 in Phase 1, 8 in Phase 2) implied that statistical

analyses would be unlikely to significantly contribute to the usefulness or validity of the findings.[11] As the overall aim of the research project was to produce design guidelines and recommendations, it was assumed that future work based on the guidelines would develop models or prototypes more amenable to experimental testing and/or statistical analysis.[12]

Prior to the inception of the research reported here the University of Glamorgan's Hypermedia Research Unit had carried out a long-term, multi-disciplinary project investigating the practice of prototyping in software design (see Tudhope *et al.*, 2000, Tudhope *et al.*, 2001). In this project, ethnography, or descriptive anthropology - "the art and science of describing a group or culture" (Fetterman, 1998, p. 1) – provided the basis for the research approach, which involved observation, semi-structured interviews, and video-recording. The researcher drew on colleagues' accounts of this experience when designing the first phase of empirical fieldwork described here. Another important influence was his developing understanding of the tradition of ethnographically-informed action research in Scandinavian ATIT (§3.3.1).

4.3.1 Ethnography and PAR

The task of ethnography is to undertake structured and systematic study of the group, culture or activity under investigation while striving to retain an "open mind" and an awareness of (and thus some measure of control over) the various biases limiting and focusing the research (Fetterman, 1998, p. 1). In Phase 1 the planned role of the researcher in helping to design and deliver the course appeared to render any non-participatory observation impracticable. As the study was to take place in the close confines of Workshop 3 (Fig. 4.1), sometimes with as few as 10 people present, and over a considerable stretch of time, there seemed little prospect of any observer remaining uninvolved with unfolding events, particularly as the classroom situations were being expressly designed to promote collaborative learning through social interaction and joint practical activity.[13] Accordingly, it seemed logical and appropriate that the research approach for Phase 1 should employ ethnographic data-gathering techniques within a participatory action research (PAR) framework.

PAR[14] is a broad approach to improving social practice by changing it and learning from the consequences of change (Kemmis and McTaggart, 1988, McTaggart, 1989, Stringer, 1996). PAR approaches to information technology design using ethnographic fieldwork techniques have been used frequently in second-generation HCI and IS, *e.g.* (Suchman, 1987, Blomberg, 1993, Jordan and Henderson, 1995, Bødker, 1996a, Crabtree, 1998, Nardi and O'Day, 1999, Macaulay, 2000, Tudhope *et al.*, 2001, Tudhope *et al.*, 2000, Barab *et al.*, 2001b). Action research approaches are well established in educational and organizational research, and are strongly associated with research in the critical tradition. The participatory design (PD, §3.1.1) movement is essentially based on technology-oriented PAR projects, including many explicitly utilizing activity theory (Raeithel, 1996, Holland and Reeves, 1996, Korpela *et al.*, 1998, Hedegaard and Lompscher, 1999, Helle, 2000).

Adopting a PAR approach implies that the researcher must be prepared to be fully and actively involved in guiding and shaping events taking place during each meeting with the study participants, while also striving to consciously observe and record what was happening. This presents practical, ethical and personal challenges. For example, in cases where participant learners encountered interaction breakdown (see §3.3.1.3), the researcher decided to intervene to aid recovery whenever requested to do so. Although breakdown incidents clearly offered rich sources of potentially useful data, the risk of negative impacts on the learner's motivation, skills development or relationship were judged unacceptable. The impact such decisions eventually had on the design and conduct of the research is discussed further below. In retrospect, although the PAR approach proved to be well-suited to the requirements of the research setting and the temperament of the researcher, it had severe limitations with regard to achieving the research objectives. The fact that the second phase of field study used markedly different methods (see §4.1, 5.6.2.2, & Chapter 8) is a measure of the researchers' recognition of those limitations.

4.3.2 Theory, Practice, and Reflexivity

> Theory is a guide to practice: no study, ethnographic or otherwise, can be conducted without an underlying theory or model. Whether it is an explicit anthropological theory or an implicit personal model about how

things work, the researcher's theoretical approach helps define the problem and how to tackle it. (Fetterman, 1998, p.5)

There is a widely held view – succinctly expressed here by Fetterman and found throughout the field ethnography literature, *e.g.* (Wolcott, 1995, pp. 182-190, Handwerker, 2001, esp. p. 68, Emerson *et al.*, 1995, pp. 111-2, Hammersley and Atkinson, 1995, 232-8, Spradley, 1980, p.106) - that the gathering, sorting, and organization of fieldwork data can be made more effective through the use of an organizing conceptual framework, model, or theory.[15] In the complex situations confronted in ethnographic fieldwork, theory can also help researchers retain their focus on the research problems and reflect on the research process. As the quotation above implies, it is reasonable to assume that researchers' preconceptions about the topic under investigation go with them into the field or laboratory; articulating, examining, and developing those assumptions through a dialogue between theory and empirical data can be useful in developing knowledge in the research area.[16]

As discussed in Chapter 1, an early decision was taken by the researcher to adopt activity theory as an organizing conceptual framework. Attention was also paid to other theoretical framings in the social sciences, noting the emphasis on working with multiple data sources made by Grounded Theory (Glaser and Strauss, 1967, Glaser, 1978, Strauss and Corbin, 1990); and the need for "indefinite triangulation" advocated by cognitive ethnography (Cicourel, 1964). Attempts were also made by the researcher to incorporate into his research practice the sensitization to issues of reflexivity and accountability promoted by ethnomethodological approaches to ethnography (Pollner and Emerson, 2001, Davies, 1999).[17] Reflexivity is the process through which researchers attempt to assess, and reflect upon, the impact of their assumptions and cultural values upon the conduct and outcomes of the research (Davies, 1999). Accountability, in this context, means making researchers' agendas observable and reportable by and to research participants. Striving after reflexivity and accountability implies not only making available explicit knowledge about the research practice and situation but also continually questioning what both participants and researcher "take for granted" in their practices (Pollner and Emerson, 2001). In the longitudinal study, reflexivity and accountability were pursued through the researcher's many dialogues about the methods and purposes of the research with

participants and other interested parties; his discussion of the ongoing research process with collaborators, peers and mentors; and his engagement in the process of continually reviewing research practice through the composition, correction and re-reading of the field notes.

4.3.3 Activity Theory in the Field

The use of activity theory as a conceptual framework for the research imposed a number of general requirements on the fieldwork design. In Chapter 3 it was noted that Bødker *et al* convincingly argued the case for studying computer artifacts in use, establishing that (a) to design a computer application or interface is, *per se*, to design conditions for the whole use activity involving that artifact; and (b) that the *practice* of users should be the starting point for design (Bødker, 1991, pp.2, 48-49, 148, reiterated in Bødker, 1999a pp. 5-7). On this basis the Aarhus-Oslo School has emphasized the historical and developmental analysis of HCI; the use of ethnographic data-gathering techniques; video-recording (*e.g.* Trigg *et al.*, 1991, Bødker, 1996a); and the employment of action-oriented, participatory approaches to field research facilitated by interactive "design artifacts" (Bertelsen, 1998) such as scenarios (Bødker and Christiansen, 1997, Bødker, 1999b), checklists (Bertelsen, 1996), and prototypes (Bødker and Grønbæk, 1991).

As noted in §3.2, similar approaches have been adopted throughout ATIT. Honold (2000) in a review of design-oriented work in the field, summarized eight factors to be taken into consideration in any investigation of computer artifacts in use based on activity theory: (1) objectives of the users; (2) characteristics of the users; (3) environment; (4) infrastructure; (5) division of labour; (6) organization of work; (7) users' mental models based on previous experience; and (8) tools. This checklist was used to inform the research design, and was further supplemented by considering the major elements of work activity identified by SSAT (Fig. 2.6): task and goal-conditions; subject and object of activity; tools; methods or procedures; and products or results of activity. The discussion in Chapters 2 & 3 also established that, from the point of view of general activity theory (§2.2.1.2 & Fig. 2.4) the structure of observed computer-mediated activities must always be analysed on three major levels:

activities (motives), actions (goals) and operations (conditions) and from three interlocking general perspectives - the cultural-historical, the objective, and the individual-psychological (at least according to SSAT; see §2.2.2.3). Established work in ATIT suggests that computer artifact use must also be considered from system, tool, and media perspectives (§3.3.1.1).

Taken together, the practical implication of these requirements for empirical field work is the need to employ a variety of data-gathering techniques. Analyses concerned with the objectives of users, their previous experience and existing skills, tools used, and the organization of work, that is with tasks and actions whose goals may be explicitly stated or clearly signalled by participants and which involve "mental models based on previous experience",[18] can, at least for the main part, be based on interview and observation data. Consideration of the operational aspects of work can be derived from the objective analysis of observable task conditions and the tools in use. However, inquiries into motivation, which AT considers as layered, complex, and only partly conscious, clearly require the use of more indirect methods, indicating the need to supplement ethnographic enquiries with historical, cultural, and organizational analyses. The overriding concern of AT with issues of change and development also suggests that enquiries should preferably be carried out over periods sufficiently long to afford observation and analysis of subjects' learning processes.

The translation of these general requirements for the research approach into concrete data-gathering methods is discussed further below. However, it is already clear from this outline that attempting to apply the multi-level, multi-dimensional approach demanded by the use of activity theory presents a number of basic procedural challenges in the concrete research situation. Primary among these is the question of how to select and prioritize what should be observed and recorded in a data-rich environment, given the constraints of techniques in use, *e.g.* that one observer cannot accord equal attention to all aspects of an activity involving multiple actors and tools. Although the adoption of technological means – as in the Phase 2 video-based study - may help defer this problem to a later stage, the need to select and prioritize remains unavoidable in any field study. As outlined in Chapter 3, earlier work in ATIT has established the

usefulness of the concept of *breakdown* in this regard. The following section discusses how this notion became central to the research approach.

4.3.4 Breakdowns as Starting Points for Data Selection

The analysis of errors has traditionally been important in both HFE and HCI research (*e.g.* see reviews in Preece *et al.*, 1994, pp.161-2, Shneiderman, 1998, pp. 76-79, 356, Benyon *et al.*, 2004, pp. 389-90). As noted in §1.4.3.2, in the mid 1980s an influential critique of cognitivist HCI by Winograd and Flores drew on ideas developed within phenomenology to introduce the notion of *breakdown* as an "interrupted moment of our habitual, standard, comfortable 'being-in-the-world'…. revealing to us the nature of our practices and equipment" (Winograd and Flores, 1986, pp. 77-8). Work within the Scandinavian tradition, especially that of Bødker on focus-shifts in HCI (§3.3.1) connected this notion of breakdown to the dialectical materialist understanding of contradictions as the fundamental drivers of change and growth, an understanding influentially articulated in Engeström's formulation of CHAT (§2.5.2, 3.1.2). Chapter 3 pointed to numerous sources in the ATIT literature which report the effective use of interaction breakdowns to identify potentially design-relevant episodes in the data, including (Trigg *et al.*, 1991), (Suchman and Trigg, 1991), Bødker (1996a), and (Engeström and Escalante, 1996).

From the point of view of the initial research questions (§1.2), the occurrence of interaction breakdowns can be considered as not simply an interruption or problem, but as an indication of the presence of conditions for the kind of experiential learning-in-use postulated by AT as being central to skill development. This suggests that the observation and recording of interaction breakdowns should be used as a starting point for design-oriented analyses of the fieldwork data. As a guideline for observational activities, this implied that when multiple activities were taking place simultaneously (as was the case in both phases of field study), the observation of breakdown situations should be prioritized. Similarly, when undertaking data collation and analysis, specific measures should also be developed to prioritize and support the recognition, recording, description and analysis of incidences of breakdown. Such measures are described in the following chapter (§5.2.2.2).

4.3.5 Ethical Issues

The design of the ethical aspects of the research project was based on two primary sources: the principles and guidelines for research with human participants set out by the University of Glamorgan (University of Glamorgan Academic Registry Research Unit, 2002); and the *Principles of Professional Responsibility* of the American Anthropological Association (AAA) (AAA, 1986). These documents offer guidance to researchers on how to recognise and resolve the ethical issues that arise during the design, conduct and dissemination of a research project, both with regard to the discipline of research itself and to relations of the researcher with those studied. At the heart of these principles is the understanding that:

> Researchers have a responsibility to ensure as far as possible that the physical, social and psychological well-being of their research participants is not detrimentally affected by the research. Research relationships should be characterised, whenever possible, by trust. (University of Glamorgan Academic Registry Research Unit, 2002)

4.3.5.1 Ethical Guidelines & the Research Agreement

On this understanding - and taking into consideration the need for reflexivity and accountability outlined in §4.3.2 - some key commitments were developed as a foundation for the researcher's approach in the field:

1. The studies should be genuinely collaborative and based on authentic participation. All individuals taking part in the study should be made fully aware of the aims and objectives of the study, and should be asked to give their full consent, cooperation, and support to research activities;

2. The research should involve a continuing iterative spiral of formulating research questions, planning, acting, observing, reflecting, and then re-forming and refining the research questions in the light of not only the researcher's but also participants' emerging needs and understandings;

3. The research project should be designed and carried out in such a way as to be an integral part of the organizational and social setting, supporting teaching and learning practices and the Centre's general aims of promoting personal and social development through adult education. Research activities should be planned so as to always contribute toward, rather than interfere with or detract from, the fulfilment of OLC aims and objectives.

These principles acknowledged that the researcher aimed not only to study practice at the OLC, but to also play an active part in changing and developing it. They also implied that the studies should focus not only on making records describing, as accurately as possible, what actually happened during sessions, but also on the collection and analysis of participants' judgments, reactions and impressions about what happened during sessions. The aim was that the proposed research activities should function as part of a collective learning process, a process with potential benefits for all participants.

As one means of embedding the ethical guidelines into the structure of the research project, a research agreement was drawn up. This document (a version of which is included with the thesis as Appendix 1) sets out the nature and purpose of the studies, and gives an undertaking of confidentiality on behalf of the researcher. At the beginnings of both phases of field study each participant was asked to read and sign a copy. Additionally, at all stages of the study feedback on its conduct was elicited from participants, both informally and during formal interviews.

4.3.5.2 Respecting Privacy & Individuality

During the project all personal information relating to study participants was securely stored by the researcher at the University of Glamorgan in accordance with the Data Protection Act, 1998 (HM Government, 1998, Information Commissioner, 2005). Throughout this thesis, and in all other publications based on data from the research project, fictitious names have been used to identify study participants. Photographs of participants are reproduced with the informed consent of the persons concerned; faces and other distinguishing features have been blurred to minimise the chances of recognition. Wherever descriptions of participants' race, culture and ethnicity are provided (*e.g.* Chapters 6 & 8) the language used conforms to guidelines on the use of ethnic, racial, and cultural descriptions in published research developed for the British Medical Journal (McKenzie and Crowcroft, 1996).

4.4 Data Capture Methods

4.4.1 Phase 1: The Longitudinal Field Study

During Phase 1 the researcher employed ethnographic fieldwork techniques within a participatory action research approach. The principal data gathering methods were participant observation, recorded in field notes, and the (audio & video) recording and transcription of semi-structured interviews. Other data sources included photography, screen capture, and the collection of digital artifacts and paper documentation. Additional information came from interviews with senior managers in the School of Basic Skills, and from the researchers' attendance at several planning and evaluation sessions held by OLC staff and administrators pre, during and post course delivery.

4.4.1.1 Participant observation

Participant observation differs from direct (non-participatory) observation in not seeking to minimise interaction with the subjects and situations under observation. When (as here) carried out within a PAR study, it may involve frequent interventions into the situations under observation. Spradley (1980) identifies six main characteristics of participant observation:

1. It is *dual purpose,* involving both observation of the situation and active participation within it;

2. It requires the development of *explicit awareness,* that is, the overcoming of selective attention, and an opening up to normally ignored detail;

3. It requires a *broad awareness*, an opening up to the normally ignored wider context;

4. The participant observer must attempt to be simultaneously *inside and outside* the scene under study. Interactions with informants are dual, motivated by both the immediate requirements of the situation and those of the research;

5. It requires the observer to engage in *introspection*, what Spradley calls "learning to use yourself as a research instrument" (*ibid*., p. 57)

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6. Participant observation involves continual *record making and keeping*.

Note-taking

The principal means of recording participant observation was the making of notes, resulting in the production of text-based record of the fieldwork. The note-taking methods utilized were based on guidelines in (Hammersley and Atkinson, 1995, Spradley, 1980, Emerson *et al.*, 1995) and took two forms:

1. On-the-spot note-taking in the field, also known as "jotting" (Emerson *et al.*, 1995, pp. 19-35). Entries were either handwritten or typed (using the Notepad text editor) by the researcher on any available Workshop 3 PC. They mainly consisted of short phrases and paragraphs designed to act as prompts when making post-session field note entries. In common with other ethnographers (*e.g.* Emerson *et al.*, 1995, Hammersley and Atkinson, 1995), this researcher found that the field setting rarely favoured jotting. In many instances I was required to be "hands-on" with the technology, rendering note-taking impracticable; the frequent need to proceed immediately from involvement in one group's activities to another also gave little time to pause and write. Another problem with on-the-spot note taking is its potential to become an obtrusive and distancing activity, distracting participants and disturbing the focus of their activity. Accordingly, jottings were generally made only when I considered it essential in order to ensure accuracy when recording what appeared to be especially significant or complex incidents.

2. Post-session field note writing, which provided the bulk of the fieldwork record. In comparison with jotting, *post hoc* composition allowed more considered, extensive, and descriptive writing. The main disadvantages of this approach arose through the unreliability and partiality of human memory, and the unavoidable tendency toward both conscious and unconscious editing and interpretation. These disadvantages were partially addressed by composing the notes immediately, or as soon as feasible, after observation sessions, and with reference to on-the-spot jottings where available.

Two techniques were employed for post-session field note composition, both using digital technologies:

a.   *Keyboard entry.* I composed notes at the computer using the MS Word word-processing application, usually immediately after the session in the field study setting. The resulting document was then sent via email to my home PC. The text was reviewed, and additions made, as soon as possible, usually on the same day. The finalised version was then transferred, by email or disk, to an electronic archive at the University of Glamorgan.

b.   *Dictation.* Experimental trials were carried out with proprietary voice recognition software (Lernout & Hauspie VoiceXpress, version 5). Input to the PC was via a microphone headset. This technique enabled the rapid and relatively spontaneous recording of events and impressions as soon as possible after the session. One disadvantage was the need to access particular PCs with the necessary combination of hardware specifications and software installation (one machine in OLC Workshop 3 and the researcher's home machine) which were not always immediately available. Another was that, in practice, the quantity of spelling and grammatical errors generated by the software rendered this approach overly time-consuming. Frequently large sections of an entry were unintelligible, severely reducing the utility of the field note entry until corrected. However, given likely improvements in this technology in principle this remains a potentially useful approach and future research (discussed in Chapter 9) would seek to continue experimentation with voice-recognition dictation.

In addition to the methods outlined above, some verbal comments by the researcher were directly recorded on to audio and/or video tape during audiovisual data capture (see §4.4.1.3 below).

Organizing the Notes

On-the-spot notes were incorporated into post-session field note entries. Entries were spell-checked and corrected as required, with care taken to preserve speech idiosyncrasies. The finalised Word documents were labelled with a standard header containing fields showing a session number (a unique, sequenced identifier); the date, time, and location of the observation; total number of session participants; participant names and gender. Date, time and attending participant entries were cross-checked against course registers and ILP entries (see §4.4.1.4).

An example extract is shown in Figure 4.3; several full field note entries sampled from the archive are included as Appendix 2 of the thesis. Two electronic copies of each field note entry were made, one in MS Word document format (.doc, Windows/PC format) and a backup in cross-platform Rich Text Format (.rtf). Files were electronically archived. Each was given a unique identifier, and the collection was organized into directories, according to phases of study and date. During the research project the field note archive was periodically cross-checked for accuracy and consistency, both internally and against other forms of documentary evidence (class registers, ILP entries, etc; see §4.4.1.4). On these occasions any missing and duplicate entries, mistakes in labelling, *etc.* were identified and corrected. The master archive was stored on a University of Glamorgan network file server, and periodically automatically backed-up to tape. CD-ROM back-ups were also regularly made by the researcher, and a duplicate archive maintained on the researcher's home PC. Concurrent and post-study data analyses (Chapters 5, 6, & 7) utilized both digital and printed copies of the notes.

Figure 4.3: Field note entry showing header information.

4.4.1.2 Interviews

The other main data-gathering technique applied in Phase 1 involved the conduct of ethnographic interviews with learners and staff. Whereas the work of participant observation is primarily that of description, the ethnographic interview aims at knowledge elicitation or discovery (Spradley, 1979). Explanations and discussion in the interviewees' own language serve to

illuminate the collective meanings and personal senses that are being created and transformed in the practice under study. Thus, interviews allowed enquiry in those areas of user experience that would otherwise have been difficult for the researcher to assess (such as task motivation or feelings of satisfaction or frustration with the technology) and illuminated individuals' orientations within and towards sociocultural conditions in the emerging collaborative technology practice. Interviews are also active social encounters within which interviewer and respondent collectively construct meaning and explore their relationship, to each other and to the research (Holstein and Gubrium, 1995). In this sense, they also made a contribution toward reflexivity (§4.3.2) and offered essential feedback to the researcher on the ethical conduct of the research project (§4.3.5).

The design, conduct, and analysis of interviews were based on guidelines in Fetterman (1998, pp. 37-52), Spradley (Spradley, 1979, 1980), Handwerker (2001, pp. 105-145), and Hammersley & Atkinson (1995, pp. 124-174). Several techniques were used, each of which is described more fully in following sections: formal and informal interviews with learners, group discussions, self-interview by study participants, and interviews with OLC staff members. Formal interviews with learners, which provided the bulk of the interview data, involved a mix of survey, specific and open-ended questions (Fetterman, 1998, pp. 37-43). In each interview several questions were based on a recent analysis of some incident in the field notes involving the informant. Spradley's (Spradley, 1979) emphasis on the recording of participants' experience in their own words was supported by using audio recording, followed by literal transcription, wherever practicable.

Formal Interviews with Learners
Formal, one-to-one interviews were arranged to coincide with the regular six-weekly reviews required by learners' individual learning programmes (ILP, see also §4.4.2.4 below). Accordingly, interviews were designed to address the requirements of both the research and review processes, and also involved the interviewer and informant completing a review pro-forma which forms part of the ILP documentation. Formal interviews were semi-structured, that is they were verbal approximations of a questionnaire with formal research goals (Fetterman, 1998, p. 38). Outlines were prepared to guide the interview process,

with additional questions and prompts used when appropriate. The researcher's interview technique attempted to embody principles of ethnographic questioning and conversation outlined in Spradley (1979) such as *asymmetrical turn taking* and *restating informant's terms*.

All formal interviews were conducted in private and were recorded by the researcher using a portable voice recorder (see also §4.4.1.3). During the interviews the researcher also made handwritten notes recording gestures and other significant non-verbal actions. Recordings were transcribed as soon as possible after their event, with the material from the additional notes being inserted into the text as bracketed comments. The interview transcripts were labelled in a manner similar to the field notes, and electronically archived following the procedures outlined in §4.4.1.1. Example transcripts are presented for inspection in Appendix 3a. The main disadvantage of this type of interview was the difficulty of sustaining detailed discussions of UI features *etc.* out of sight of the computer artifacts concerned.

Informal, Brief Interviews & Group Discussions

During the longitudinal study numerous brief interviews with participants were conducted in the workshop. These were informal and opportunistic in nature, often prompted by incidences of interaction breakdown. Wherever possible, on-the-spot notes and/or audiovisual recordings were made. The resulting materials were transcribed, reviewed and incorporated into the field note entry for the session in which the interview took place. Example transcripts are presented for inspection in Appendix 3b. Being conducted in the presence of the task under solution and the computer artifacts in use, this approach had the advantage allowing the discussion to focus on more immediately specific and situational issues than was possible with the one-to-one interviews.

Several *Computer Creative* sessions included group discussions as part of the classroom activity. Tutors and learners discussed course-related topics, project ideas and planning, and technical and design issues. Wherever possible these talks were recorded and/or on-the-spot notes taken. This data was subsequently reviewed and incorporated into the field notes entry for the relevant session. One example was a debate that took place during Session 55, 5th March 2001. The topic was "What you need to be good at using computers". In this case,

participants initially wrote down their opinions, and then discussed what they had written.

Self-interview by Study Participants

During the longitudinal study learners took part in activities introducing them to the basics of digital video (DV) photography and desktop video editing. Toward the end of the study, three participant learners carried out a project involving the creation of a short DV movie in which seven other learners, the course tutor, and the researcher were interviewed about their experiences during *Computer Creative*. The process of filming, and the resulting video clips were viewed by all participants in Workshop 3 activities, and by a number of other learners and members of staff. A copy of the movie was archived by the researcher. Moreover, this exercise, (which recalls methods used in Finnish Developmental Work Research, §2.5.2.4), can be seen as an example of the participants' active and authentic participation in the research (§4.3.5). For the researcher, it also provided some reflexivity (§4.3.2).

Staff Interviews

Key materials to support cultural-historical and organizational-developmental understandings of the research setting were provided by an in-depth, formal interview with the then Head of the School of Basic Skills (§4.2.2.1), in which she reviewed her personal involvement in, and experience of, the development of ABE in the UK and Wales. This interview provided material for the account of the circumstances surrounding the introduction of ICT to the OLC given in Chapter 1 (§1.1.2) and §4.2 above. During both phases of study the researcher also conducted a series of informal post-teaching session interviews with the participant tutor, T. Informal discussions of the research work with other members of OLC staff took place both during monthly staff meetings and through informal encounters during the working day.

4.4.1.3 Audiovisual Data Capture

Photography & Screen Capture

A partial photographic record was made of the Phase 1 field study, using a Sony Mavica digital camera equipped with a 1 Mega Pixel CCD, fixed lens, digital zoom and automatic built-in flash. Image data was captured directly to 3.5-inch

floppy disk using JPEG compression. Capture settings were 640 X 480 pixels, 72 d.p.i., and 24 bit. In addition, some still images of all or a part of the screen display at various stages of user activity using were captured using inbuilt OS functionality and processed using a graphics application. Screen capture was manually triggered by the researcher using keystroke combinations on the keyboard of the PC in use. All image files were transferred to the hard disk archive (§4.4.1), structured into folders labelled by session number and date.

Audio & Video Recording

Analogue audio recordings of interviews were made onto standard IEC II/Type II 90-minute chrome audiocassettes using a Sony voice recorder with integral microphone. Audiocassettes were labelled, transcribed by the researcher using a word-processor (as for the field notes), and then archived.

In the final months of the longitudinal study the researcher made a number of analogue video recordings using a handheld Panasonic NV-G1B VHS-Compact Movie camcorder. In order to provide some basic labelling, at the start of each segment of recording verbal announcements of the date and time were recorded onto the audio track via the camera's built-in microphone. These recordings were opportunistic and experimental, as many of the considerations that militated against on-the-spot note taking (§4.4.1.1) similarly often rendered video recording impracticable. The use of the camera for research purposes began in earnest as an adjunct of the video-related course activities undertaken by participant learners in the later stages of the course (see §4.4.1.2 above). On several occasions additional video-only recordings were also made with two Logitech Web Cams installed on PCs in the workshop. All video tapes were briefly reviewed and their contents logged shortly after recording; capture into the digital domain and transcription was mainly carried out in the period between phases 1 and 2 of the field work, as part of the post-study analyses reported in Chapter 7. The techniques used for the conversion and transcription of the Phase 1 video data were essentially prototypes of those used in Phase 2 (see §4.4.2 below). They are described in detail in §8.3.3-4.

4.4.1.4 Other Data Sources

The Individual Learning Programme

In ABE the teaching and learning activities of each individual student are organized into a personalised agenda of study targets, assessment strategies and additional personal development activities. The student's agenda is formalized through the creation of an Individual Learning Programme (ILP), recorded in a multi-page paper document (one per student per course) which collates personal information, learning objectives, and the findings of six-weekly reviews (see 4.4.1.2 above). Each ILP contains a section in which, as an aid to reflection, learners (with the help of tutors) make a brief handwritten note of their activities and achievements at the end of each course session. ILP documents are stored on the premises in a Course File under the care of the principal course tutor. The maintenance of an ILP for each individual learner on each course is a standard practice within ABE and is central to student-centred teaching and learning practice at the OLC. During teaching hours the ILP is always available for scrutiny by all concerned parties (the student, course tutors, administrators, external examiners), and thus functions as a "boundary object" (Star, 1989), providing a basis for discourse and negotiation between learners, tutors and managers.[19] The ILPs of each participant learner attending *Computer Creative* were available to the researcher both during the course and following its completion.

Other paper documentation

During the longitudinal study the researcher made photocopies of the attendance registers as a means of cross-checking field note entries. Documents prepared by the tutors relating to lesson planning were also photocopied and archived, as were handouts prepared to support classroom activities. During the course learners produced portfolios of work containing notes, printouts of graphics and animations, program code, *etc.* as evidence for the assessment process; at its end, they completed feedback forms recording their comments on the course and suggestions for future developments. These student documents were archived at the OLC and made available for inspection by the researcher.

Digital & Material Artifact collection

All digital artifacts produced during the longitudinal study were collected and archived by the researcher. These included digital video (DV) files in AVI and QuickTime formats; animations in AS native format (.mng) and as compressed

AVI and GIF files; audio files in WAV format; graphics files in Paint Shop Pro (.psp), JPEG, GIF and Windows bitmap (.bmp) formats; HTML files; LOGO program files (.lgo); Microsoft PowerPoint (.ppt) presentations and Publisher (.pub) documents; and various executables (.exe) produced using multimedia authoring software. Digital artifacts were stored with the field note archive (§4.4.1.1); printouts gathered in the field were sorted, labelled and securely stored at the University. A number of physical artifacts, including sketchbooks, puppets, and miniatures were archived at the OLC.

4.4.2 Phase 2: The Video-based Field Study

As noted in §4.1, during Phase 1 the researchers' reflections on the data-gathering process highlighted various limitations of the observation and interview methods employed, in particular the difficulties encountered in capturing sufficiently continuous and fine-grained data to successfully support detailed micro-analysis of the observed activities. Toward the end of that study trials with video went some way to meeting these concerns. In order to further develop these techniques, the Phase 2 study adopted audiovisual recording via video cameras and screen recording software as its principal data-capture methods. Three camcorders were used, with camera positions chosen so as to capture both whole-group and small-group activity. Screen recording software was employed to capture cursor movements and mouse-button clicks. The raw video data was subsequently processed, archived, transcribed, and annotated by the researcher. Additional photography was carried out using the camera described in §4.4.1.3. Some on-the-spot notes were made, and paper-based artifacts and documentation were collected and archived. The data-capture, processing and analysis methods used in Phase 2 are described in detail in Chapter 8.

4.5 Summary

The researcher carried out two phases of empirical field study. The research practice was designed to take account of the aims and objectives of the research, its conceptual framing in activity theory and ATIT (Chapters 2 & 3), and the cultural-historical, socio-organizational, physical and technological characteristics of the research setting in Workshop 3 of the Open Learning

Centre. The fieldwork was carried out within clearly defined ethical guidelines based on the recommendations and regulations of relevant authorities. The first phase of study (introduced in §4.1, and discussed in Chapters 5, 6 & 7) involved participatory action research (PAR) using a variety of ethnographic techniques, with the identification of breakdowns providing one means of prioritizing what should be observed and analysed. The second phase (briefly introduced in §4.1 &4.4.2, discussed in detail in Chapter 8) was a direct observation study using video-recording. This change of methods was prompted by the researcher's reflections on his experience of utilising ethnographic methods within a PAR approach during Phase 1. One of the most challenging issues encountered was balancing the requirements of the research *vis-à-vis* data-gathering with the demands of the researchers' role as an assistant tutor during the *Computer Creative* course. Practically, numerous difficulties were encountered during Phase 1 in obtaining sufficiently continuous and fine-grained data to support detailed micro-analysis of the observed activities encountered in the longitudinal study.

Notes to Chapter 4

[1] This was the situation prior to the expansion of the EU from 15 to 25 member states, a process which began in 2004 and will be completed in 2007.

[2] An EU measure signifying the highest possible priority for social and economic regeneration funding.

[3] During the period of the research project Wales achieved partially devolved status following a national referendum in 1998. Some aspects of Welsh governance, including the provision of education, are now overseen by an elected Welsh Assembly Government based in Cardiff, the capital.

[4] Coleg Morgannwg was formed from the amalgamation, over the period 1997-2003, of the former Pontypridd (Taff Valley), Rhondda (Rhondda Valleys), and Aberdare (Cynon Valley) Colleges of Further Education. See http://www.morgannwg.ac.uk/ for further information.

[5] Much of the information in this section is drawn from interviews by the author with OLC managers, teaching and administrative staff, and volunteer teaching assistants; other sources are noted in the text.

[6] Although there is a longstanding consensus in UK education that ICT skills are essential for a modern workforce, there is an unresolved debate as to whether ICT skills are "basic" or "key" skills – a somewhat arbitrary distinction which, however, carries significant organizational and budgetary implications in terms of which parts of the sector should be responsible for their delivery and assessment. In 2004, ICT was briefly declared a basic skill by a UK Government Parliamentary spokesman, but this statement was later withdrawn. Subsequently, an ongoing reorganization of basic and key skills provision has resulted in the issuing of a national

curriculum for ICT as a "Skill for Life", a rubric encompassing both basic and key skills. However, many areas of this policy are currently (2005/6) unclear, with adult ICT skills training being delivered by a range of private and public organizations with widely varying standards. At the local level, this has both created a need, and brought the opportunity for, autonomy and innovation in provision (for further discussion of these issues see Harris and Shelswell, 2001b, Harris, 2002b, Harris and Shelswell, 2005).

[7] This information is based on audited accounts for the academic year 2004-5.

[8] GCSEs are examination and coursework-based summative assessments made on 15 and 16 year old school students. Qualifications at GCSE level are a prerequisite for entry into Further and Higher education.

[9] In the UK, floors are numbered 0 (ground), 1, 2… Workshop 3 is thus on the second floor above ground level, *i.e.* the uppermost floor of the three-storey building described here.

[10] Ethernet is a baseband local area network (LAN) commonly used for connecting computers and peripherals within the same building. Ethernet uses a bus or star topography and the CSMA/CD access method of handling simultaneous demands. Communication is via radio frequency signals carried by either coaxial or (as at the OLC) twisted pair cable. A 10BASE-T Ethernet was in use at the OLC during the study period, providing transmission speeds of up to 10 Mbps. This was barely adequate; network speed and reliability became severely degraded when handling multimedia files.

[11] An approach to the quantitative analysis of multivariate qualitative data based on Facet Theory (Dancer, 1990, Guttman and Greenbaum, 1998) was explored in the early stages of the study, but was rejected as being overly time-consuming in relation to the expected usefulness of the output. However, where suitable quantitative data was available some basic statistical analyses were carried out. See, for example, Note 6, Chapter 7.

[12] On the basis of the interim conclusions presented in §3.5.2, a number of techniques drawn from SSAAD (§3.3.2) were utilised during the later stages of the research project. These techniques have the potential to bridge between qualitative and quantitative approaches to activity analysis and design. Their limited, mainly exploratory application to the study data is described in Chapters 7 & 8.

[13] The researcher's history with the organization (§1.1.2) also meant that he had established personal relationships with those of the participant learners who had attended OLC courses in previous years.

[14] PAR is often referred to simply as Action Research. Other variants on the term include practitioner research, action science, community action research, and community action research. For a discussion of some of the roots, and different strands, of PAR, see (Stringer, 1996, p. xvi).

[15] Ethnographically-informed fieldwork techniques were introduced into HCI research in the mid 1980s, principally through the work of researchers associated with Xerox's Palo Alto Research Center (PARC, see also §1.4.3.2 & 3.1.1), *e.g.* (Suchman, 1987) and (Jordan and Henderson, 1995). Some ethnomethodologically inspired (see Note 16 below) ethnographers ostensibly reject "theory" (or at least theories of social order) on principle. In practice, the majority of ethnography projects make use of one or more theoretical frameworks. Theories used to frame HCI fieldwork include grounded theory, actor-network theory, situated action, distributed cognition, and of course activity theory; numerous examples are cited in Chapter 2.

[16] This kind of dialogic process can be seen in the development of a second generation of HCI (§1.4.3, Chapter 3), where critiques of traditional HCI developed in response to efforts by researchers such as Card, Moran, and Newell (1983) and Simon (1996) to articulate the central assumptions of the cognitivist paradigm.

[17] Ethnomethodology - the study of the ways in which people make sense of their social world – has made an important contribution to methodological developments within the social sciences since its introduction by Garfinkel in the early 1960s (Garfinkel, 1967). Ethnomethodology encourages a "living it" approach to research in the field, and restraint in attempting to impose theoretical constructs on what is being observed. Ethnomethodology also points to a need to practice "indifference", that is to refrain from characterizing informants in a way that obscures what may emerge from study of their language and actions, and to take account, and make an

account of, the 'accountable features' that make up the environment within which the study is being conducted - these accountable features being what informants *themselves* invoke as being important features of the situation under study.

[18] Following Honold (2000) in the use of this term here is not intended to imply the inherently dualistic, mentalist use of the "mental model" concept in cognitive science and neuroscience, as criticised by *e.g.* Gibson (Gibson, 1979) and Bennett & Hacker (Bennett and Hacker, 2003, pp. 180-198). Rather, it refers to activity-theoretical understandings of the dynamic situational reflection of reality – "situation awareness" in Western HFE – based on studies of activity self-regulation. An in-depth discussion of the activity-theoretical view of the role played by images and models in guiding mental and motor actions can be found in Bedny (Bedny and Meister, 1997, esp. pp. 131-139, and, Bedny *et al.*, 2004).

[19] For further discussion of the role of the ILP as a boundary artifact mediating interaction between tutors, learners, volunteers and managers at the OLC, see Harris (Harris, 2002b) and Harris & Shelswell (Harris and Shelswell, 2005).

5. Phase 1: The Longitudinal Field Study

This and the following two chapters (6 & 7) deal with the first phase of empirical research. This chapter provides a general introduction to, and overview of, the longitudinal study. It describes the principal features of the digital multimedia course which provided its subject-matter; discusses data gathering and analysis; profiles the study participants; briefly outlines the computer-mediated activities and tasks that were observed taking place; and gives a narrative description of a typical course session. The chapter concludes by outlining some general findings from Phase 1.

5.1 The *Computer Creative* Course

The researcher carried out a longitudinal field study from September 2000 to May 2001 at the Coleg Morgannwg School of Basic Skills Open Learning Centre (the OLC, §4.2.3). The study focused on the development and delivery of an experimental digital multimedia ICT/ABE course, *Computer Creative*. The course began on Wednesday 6th September 2000 under the guidance of full-time ABE tutor T (a pseudonymous codename; see §4.3.5.1 & Table 5.1). She was assisted by the researcher. Over the study period, 23 adult and 2 school students attended the course. Using a variety of materials and media they devised, planned, carried out, and evaluated group and individual projects in Web and multimedia authoring; digital video, graphics and animation; virtual reality (VR); and computer programming. The tutors worked to support learners' development of basic skills in literacy and numeracy, ICT, idea generation, researching, planning, collaboration and group work.

Computer Creative was delivered over 21 teaching weeks, divided into 3 terms, during the academic year 2000-2001. Each term included a one-week half-term break, and there were also two between-term holidays, at Christmas (3 weeks) and Easter (2 weeks). Workshop sessions occurred three times a week during term time. There were two 145 minute late-afternoon classes, one on Mondays 1600-1815, and the other on Tuesday 1600-1815; and a longer (210 minutes) class held on Wednesdays mornings, 0900-1230. The longer session included a half-hour break. By the end of the course (June 2001), 103 *Computer Creative* workshop sessions had taken place; the researcher was present at all but two.[1]

5.1.1 Designing *Computer Creative*

As noted in §1.1.2, preliminary plans for *Computer Creative* began to take shape during the academic year 1999-2000.These plans were initially inspired by accounts of ICT-based social regeneration projects developed in inner-city areas of the US,[2] particularly the Boston *Computer Clubhouse* project reported in (Resnick *et al.*, 1998) which was based on constructionist pedagogical principles. The planning process also drew upon ideas from situated learning (Lave and Wenger, 1991) and participatory design (§3.1.1), and was part of ongoing attempts to develop "communities of practice" in ICT/ABE learning at the Centre (for further discussions of the evolution of CoP approaches at the OLC see Harris, 2002b, Harris and Shelswell, 2005).

When ICT was first introduced into OLC activities in 1996-7 there was little authoritative guidance available on the educational uses of technology in adult basic education (Harris and Shelswell, 2001a, Harris, 2003). This remained the case in the summer of 2000. Consequently, when OLC staff began to design *Computer Creative*, one of their aims was to produce guidelines or principles which could be used not only to underpin the course development and delivery process, but which would also be sufficiently clear and coherent to be useful for (and communicable to) other ABE practitioners with similar needs.[3] A series of discussions between the researcher, the participant tutor, and other OLC staff members resulted in the identification of ten general principles to guide course planning and delivery. These were summarized in a 2001 report on the course as:

1. The use of ICT in the Adult Basic Education classroom should *always* be in support of the development of basic skills.
2. In ABE, information and communication technologies are tools to use to achieve goals, *not objects of study in themselves*.
3. Learning should be through designing.
4. Learners should be able to construct things that are of significance *to them*.
5. Learners should be supported to see projects through from conception to completion.
6. Emergent community should be cultivated.
7. ICT should be used to facilitate new kinds of learning.
8. The development of technological fluency should be supported.
9. The role of the tutor should be to *enable* and *focus* learning.
10. Appropriate accreditation frameworks should be provided and supported.

<div align="right">(Harris and Shelswell, 2001a, p.49)</div>

The application of these principles was reflected in some characteristic features of the *Computer Creative* course design, which can be summarized as:

- An emphasis on the participatory design of course activities, through encouraging and supporting learners in devising, planning, and carrying out group and individual projects (see also Harris, 2002b).

- Providing an "immersive" technological learning environment (*cf.* Cavallo, 2000a, p. 771) by making available a wider variety of software, hardware and non-technical tools than had previously been employed in OLC ICT-based ABE activities. At times this involved tutors encouraging and supporting learners in ICT-based activities of which they themselves had no prior experience.

- An emphasis on learning-in-use through exploration and experimentation, by keeping direct instruction by tutors (in either technology or literacy and numeracy skills) to a minimum and encouraging the sharing of participants' emerging expertise through collaboration and peer mentoring. The tutors' main pedagogical role was seen as being to identify, and act upon, "situated literacy events" (Barton *et al.*, 2000), opportunistically intervening in course activities to support, focus and encourage reflection upon learner's developing skills.

- Encouraging the emergence of collaboration and peer mentoring by *not* using volunteers to assist with course activities – the use of volunteer assistant tutors otherwise being standard in OLC teaching and learning practice at this time. It was judged that the presence of voluntary staff might inhibit the development of peer mentoring activity, and that the need for tutors to actively manage volunteers would also militate against the emergence of a (relatively) non-hierarchical "community of practice" in the classroom.[4]

- The scheduling of an unusually high (for ABE) amount of classroom contact, around 241 hours over the duration of the course. On the basis of previous OLC experience and readings in the literature, this long-term, intensive engagement was considered likely to be an essential prerequisite for the formation of a "community of technology-based practice", and for the development of individuals' ICT skills within that community.

5.1.2 Outcomes of *Computer Creative*

Reviews carried out by OLC staff following course completion indicated that *Computer Creative* had been effective in achieving appropriate results in terms of recruitment, retention, and formal accreditation of learning.[5] Both tutors and learners considered that they had further developed their ICT skills by participating in the course; learners' motivation and satisfaction (as indicated *e.g.* by verbal and written feedback, attendance, and participation in project activities) appeared to have remained high throughout the course. Twelve of the core of nineteen adult learners who joined the course when it began completed it, and eleven achieved more than 90% attendance (see Table 4.1 below). 17 learners gained accreditation[6] for literacy and ICT skills development on the basis of their portfolio of work developed during the course. Overall, these outcomes compared favourably with then current ABE benchmarks. The course design was evaluated as providing a viable alternative to CLAIT, and was adopted as a model for subsequent ICT-based developments at the Centre (Fig. 1.1).

However, the course also produced some tensions and points of conflict. Institutionally, various difficulties were experienced with Coleg Morgannwg's information services technicians around installing and maintaining software packages and network access. In the classroom, there were a number of interpersonal "legitimation conflicts". These were occasions when the legitimacy of a participant's presence or contribution was brought into question by other members of the learning group (such incidents are discussed further in Harris and Shelswell, 2005).

5.2 Observing & Analysing *Computer Creative*

As envisaged by the initial formulation of the research practice (§4.3), the longitudinal study involved the researcher carrying out an iterative process of data-gathering and analysis, with additional and more specific research questions emerging from the interim findings. In the early stages of the study the researcher's main analytical goal was to identify distinctive features and broad patterns in the activities under observation, as a basis for further refining and focusing the data-capture methods (described in §4.4.1). Initially, this was

principally achieved through the weekly compilation, re-reading, correction, annotation, and sorting of field note entries and interview transcripts.

As the study proceeded, the researcher's growing experience in the field and his ongoing research in the literature (discussed in Chapters 2 & 3) provided a basis for further development of the analytical approach. This mainly involved the correlation, comparison and critical analysis of multiple data sources, a process outlined in §5.2.2.1 below. Due to the multivariate, inconsistent, and incomplete nature of the field data the analytical processes used in the study were necessarily highly interpretive; therefore, the findings outlined in this and following chapters are tentative and must be considered as being of mainly heuristic value. As noted earlier (§4.3), the aim was to generate AT-based design guidelines and methods to usefully inform design practice, at various stages and levels of detail, based on the study findings. One assumption made by the researcher was that future work (see Chapter 9) will aim to develop models or prototypes based on guidelines emerging from the research project, thus allowing further investigation and validation of the study's findings by other (*i.e.* experimental) methods.

5.2.1 Data-gathering

A total of 83 (56 2-hour and 27 4-hour) participant observation sessions were recorded in the field notes over an 8-month period. During this time 31 ethnographic interviews were also completed by the researcher: 12 formal one-on-one interviews with learners; [7] one in-depth interview with the centre manager; and several dozen informal interviews and discussions with learners and staff during teaching sessions and staff planning meetings. Approximately 340 still photographs, 50 screen captures, and 92 minutes of video were recorded. Numerous digital and physical artifacts produced or used by study participants were also collected and archived, as was all documentation connected with the course.

Not all data-gathering techniques were applied throughout the course. The final session of *Computer Creative* took place on Wednesday 1st August 2001. However, the last complete field note record was made immediately after Session 83 on Wednesday 2nd May 2001 and formal interviews were also discontinued around this time. By this stage of the course the pace of collaborative computer-

mediated activity had noticeably accelerated. During course sessions both the tutor and the researcher were continually called on to facilitate group work by organizing resources and providing feedback and assistance. Immediately post-session, T and SRH were usually fully occupied auditing learners' portfolios of work and completing the necessary paperwork for course accreditation procedures.

From a personal point of view, this increased involvement with teaching and learning activities made it impracticable for me (SRH) to continue systematic note-making and interviews. However, for the remaining 20 sessions I continued to track participant activities through informal observation, on-the-spot note writing, artifact and document collection, and frequent discussions with the participant tutor, T. I also made a number of video recordings during this period (§4.4.1.3). Thus, the active data-gathering stage of the longitudinal study did not have a distinct endpoint, but rather "wound down" over the closing two months of the course. My decision to prioritize teaching over research activities was based on point 3 of the ethical guidelines adopted for the project (§4.3.5): "Research activities should… always contribute toward… the fulfilment of OLC aims and objectives." Recognition of learners' achievements is central to the ABE teaching and learning process. It was also important to OLC staff to provide evidence that experimental ICT/ABE courses could achieve outcomes comparable to traditional provision. Reflection on the difficulty in maintaining an appropriate balance between observation and participation during Phase 1 contributed toward my decision to adopt a somewhat different approach for the second field study.

5.2.2 Data Analysis

Although the outcomes of *Computer Creative* (discussed in §5.1.2 above) were valuable in terms of informing pedagogic practice at the OLC, the aims and objectives of the research project (set out §1.3.2) went beyond simply confirming and systematizing the experience gained in previous ICT/ABE work at the Centre. Rather, its main concern was to identify those aspects of the observed situations where design interventions might prove fruitful in terms of further and better supporting the development of learners' ICT skills in order to produce

some detailed suggestions as to how such interventions might be successfully carried out. However, the use of ethnographic and participatory research methods presents numerous challenges in this regard, including that of how to organize and interpret the mass of observational and other data in such a way as to allow the production of design-oriented findings. Indeed, the problem of how to successfully bridge between descriptive field studies and prescriptive design activity is fundamental to second-generation, context-aware HCI in general, including activity-theoretical HCI (Bertelsen, 2005, Harris, 2002a).

5.2.2.1 "Indefinite Triangulation"

The interpretation of the field data by the researcher involved an iterative and reflexive interpretive process loosely based on the "indefinite triangulation" approach developed by Cicourel (Cicourel, 1964). Firstly, possible relationships between the design of the computer artifacts in use (and their use settings) and the observed developments in ICT skills were identified through repeated scrutiny of the study data. These preliminary findings were then refined and accorded more or less weight according to the extent to which they were supported by further analyses and the comparison and correlation of multiple, intersecting data sources, principally:

1. The joint evaluation of learners' ICT-enabled activity by the researcher (SRH) and participant tutor (T) during the longitudinal study, based on participant observations of the scope and nature of ICT tasks devised, undertaken and completed, methods and strategies employed, tools and combinations of tools used, assessments of motivational state of learners, *etc.*;

2. Participant learners' self-evaluation of, and reflection upon, their (individual and collaborative) activity during the study, expressed in conversations and discussions during course sessions, end-of-course feedback, and interviews;

3. Joint tutor-learner evaluations of participants' ICT skills development while completing ILP entries (§4.4.1.4) at the end of each course session;

4. Concurrent and post-study scrutiny of the field data (by the researcher) for indicators of ICT skills development such as: increasing complexity of tasks

undertaken and artifacts produced; the occurrence, nature, and impact of interaction breakdowns, and factors contributing toward recovery from breakdown; and the relative complexity, learnability, usability, and frequency of use of the various applications incorporated into participants' activity.

Three main analytical approaches were employed by the researcher: (1) the generation and application to the data of analytical questions based on AT; (2) the identification, description, and classification of breakdown incidents; and (3) parametric analyses of the field data (of the number and type of tasks observed, type and number of tools used, *etc.*) which provided a general underpinning for the other approaches. Toward the end of the Phase 1 study, and in the post-study period, additional methods were used for further macro- and micro-analysis of the data, including usability evaluations and walkthroughs and ATIT techniques such as contradictions, focus-shift, and systemic-structural analysis. These are described in Chapter 7.

5.2.2.2 Differentiating the Structure, Components, & Parameters of Activity

Checklists were used to focus data-capture in the field. Initially these were simply loosely formulated sets of questions based on lists compiled by Bødker (see §3.3.1.1, Table 3.2 & Fig.3.1), Bærentsen (2002, see Fig. 2.2b), Honold (2000, see §4.3.3) and other sources in the ATIT literature. Later in the study a checklist of questions aimed at more clearly differentiating the structure, components, and parameters of the activity under study was developed. This "design artifact" was a simplified and modified form of the Activity Checklist produced by Kaptelinin, Nardi and Macaulay (1999, described in §3.4). The questions were either directly addressed to participants (including the participant tutor and researcher) during observation sessions, or used retrospectively by the researcher to interrogate the observation data recorded in the field note entries *etc*. This list of questions was continuously refined and improved throughout the remainder of the study; future work (Chapter 9) would seek to develop it further. A version of the checklist, showing which aspects of activity the example questions apply to and their activity-theoretical basis is presented as Table 5.1.

Table 5.1 (overleaf): Checklist - questions used in the analysis of longitudinal field study data.

Aspect of Activity	Example question	Differentiates	Relates to	Analytical perspective or approach
Structure	**Why** are you/they doing that?	Activity, Activity System	Explicit or implicit needs and motives, personal sense	Longer-term process; Macro-Functional analysis
	What is the main thing you/they hope to/have to achieve by doing what you/they are doing?	Task	Conscious goals (of task overall), objective meaning	Medium-term/shorter term processes; Macro-Functional analysis
	What are they doing now?	Action	Conscious goals (intermediate in relation to task), objective meaning	Shorter-term process; Micro-Functional analysis
	How are they doing what they are doing now?	Operation	Conditions, sensory fabric (internal and external environment)	Immediate responses; Micro-Functional analysis
Components	**Who** is doing it? **With whom** are they doing?	Involved subjects; community	Motivation, culture, historicity	Cultural-Historical perspective
	What tools and resources does this activity require?	Means of work, tools	Mediation	Objectively-logical perspective
	What is it being explored or transformed?	Work object	Object-practical activity	Objectively-logical perspective
	What are the expected and actual outcomes of the transformation	Goal, result	Goal-orientation, self-regulation	Individual-psychological perspective
	In what ways are the people involved in the activity constrained, allowed or expected to take part?	Rules and norms, methods, procedures	Culture, historicity, communicative (subject-oriented) activity	Cultural-Historical perspective
	Who is doing what at each moment in this activity? **How is it coordinated**?	Division of labour	Communicative (subject-oriented) activity	Individual-psychological perspective
Parameters	**How long** does it take?	Duration, time-structure	Tasks, subtasks, actions, operations	Time-structure analysis
	In what order are things to be done, or are they actually done?	Related, prerequisite, and consequent activities, tasks and actions	Logical structure and nature of tasks, subtasks, actions, & operations; interaction of subjective and objective task components	Algorithmic analysis, functional analysis
	What goals have been set for this task? **What are the outcomes**, and when must it be completed?	Task conditions and requirements; product or result	Task, subtasks, actions, operations	Task/Work-process analysis

5.2.2.3 Recording & Analysing Breakdowns

During the development of the research practice (§4.3.4) the decision was taken to prioritize the observation and recording of breakdown incidents. In order to implement this decision, a Breakdowns Pro-Forma (BDPF) was designed to support the recognition, recording, description and preliminary qualitative analysis of interaction breakdown and recovery across all longitudinal study data.

The BDPF fulfilled several functions:

1. As a focusing device in the field, it supported the capture of detailed data on incidences of breakdown and prompted participant observation or informal interviews around themes raised by incidents. When completed concurrently with observation it provided an additional means of "jotting" (§4.4.1.1).

2. It provided support for post-session note making, and for analysis and reflection when reviewing field note entries or during the review of audiovisual data.

3. As an organizing device, the BDPF supported correlation of the field note record with other data sources.

Figure 5.1 shows a completed BDPF, which is an A4-sized paper document; further examples are attached for inspection as Appendix 4 of the thesis. Each individual BDPF records a single incident. The pro-forma provides the following fields for data entry: a unique identifier; date and time of the breakdown, and the course session during which it took place; the name of the application or applications in use; a note on the activity in progress; nature of the problem(s) encountered; interface elements involved; the outcome of the breakdown, *i.e.* whether and how recovery was achieved; the actions and/or operations of the user which may have initiated the breakdown; descriptions of the nature of the problems encountered; users' and researcher's verbal comments or dialogue around the incident; checkboxes linking the pro-forma to related data sources such as photographs, video, or audio recordings; and space for the application of coding schemes.

Figure 5.1: Example of a completed Breakdowns Pro-Forma.

A total of 60 pro-formas were completed, sorted and coded during the longitudinal study. The data was compiled into a (Microsoft Access) database and cross-indexed with related materials in the field note, video and interview transcript archives. SQL (Structured Query Language) queries were used to extract summary information from the database. Results are presented below and in Chapters 6 & 7. Due to the design (§4.3) and operational constraints (§5.2.1) of Phase 1 the BDPF record represents a (not precisely determinable) fraction of the total breakdowns occurring during the course. Thus, the BDPF data supplemented the information gained from other data sources, contributing to the triangulation process outlined in §5.2.2.1, but did not in itself provide any useful basis for generalization. The discussions that follow make a basic distinction between the two main types of interaction breakdown represented in the BDPF record. "Constructive" breakdowns are those observed as giving rise to learning-in-use (as evidenced by recovery, *i.e.* resumption of the task within a short time-frame) and consequent improvements in skill and confidence. This type of breakdown accounted for around 68% of the total recorded. "Catastrophic" breakdowns, on the other hand, are those which did not lead to recovery and

learning, but rather to abandonment of either (or both) tool and task. This latter type accounted for around 18% of the total recorded, with the remainder uncategorised.

5.3 Longitudinal Study Participants

A total of 27 persons participated in the longitudinal field study, comprising 25 learners and two staff (of which one was the researcher). Table 5.2 shows their gender, age, employment status, attendance at course sessions, and literacy, numeracy, and ICT skills levels as assessed on entry to the course. Skills assessment is discussed further in §5.3.3 below.

5.3.1 Participant Learners

25 students (13 male, 12 female, $n(L) = 25$) participated in the study. Of these, 23 were adults while two, CR and KY, were 15 year old schoolboys. The ages of the adult participant learners (11 male, 12 female, $n(AL) = 23,$) ranged from 18-73; median 38, average 38 years 9 months. Table 5.2 shows individual ages.

5.3.1.1 Ethnicity[8] and Financial Status of Participant Learners

All participant learners were white, British-born, UK nationals resident in the UK.[9] All were born, raised, and schooled in south Wales, with the exception of learner VB, who was born in the north of England and relocated to south Wales as an adult. At the time of the study all participant learners resided within 15 miles of the Open Learning Centre. All spoke English as their first language.[10]

All participant learners were from the low-income backgrounds associated with social grades D (semi- and unskilled workers) and E (individuals dependent on state benefits).[11] Four of the adults (learners 6, 20, 24 & 25, Table 5.2) were retired and dependent on the state pension. At the beginning of the study the single adult participant learner in employment, JM (learner 12, Table 5.2), worked only part time; she left the course after only two sessions. Two adults (learners 2 & 11) were in receipt of long-term sickness/disability benefit. All other adult participant learners (16/23) were unemployed and in receipt of state unemployment or supplementary benefit.[12] 11 had not worked for more than a year; the remainder (5/23) had been registered as unemployed for less than 12 months.

Table 5. 2: Profile of Phase 1 field study participants.

	Code[1]	M/F	Age	Status[2]	Attendance[3]	Lit.[4]	Num.[5]	ICT[6]	Comments[7]
1	AH	F	32	L/TU	4-19	E3	E2	E1	
2	BD	M	44	S/DB	C	1	2	2	
3	CP	F	32	L/TU	C	E2	E3	E1	
4	CR	M	15	S	69,72, 78, 81,	N/A	N/A	E2	
5	CW	F	18	U	66-75	1	N/A	E2	
6	DC	F	60	R	C	1	2	E2	
7	DE	M	19	U	66-77	E2	E1	E2	
8	DH	M	29	L/TU	C	E3	E2	E1	SLN
9	DK	M	33	L/TU	C	E3	1	1	
10	JE	M	57	L/TU	1,2	E3	E2	E1	
11	JH	M	34	S/DB	49-62	1	1	2	SLN
12	JM	F	49	P/TE	3,6	2	1	PE	
13	KY	M	15	S	69,72,74,78,81,84	N/A	N/A	E2	
14	LR	M	39	U	C5	E3	E3	E2	
15	LT	M	17	U	46-51	1	E3	E2	
16	MK	F	43	U	2-20	1	1	E1	
17	MM	M	26	L/TU	C	E3	E3	2	
18	NE	F	49	L/TU	1-38	E1	E1	PE	
19	PC	M	38	L/TU	C	E1	E2	E3	
20	PR	F	62	R	C	1	1	E2	
21	SC	F	28	L/TU	C	E3	E1	E1	
22	SM	F	36	L/TU	C	PE	E1	E2	SLN, HI
23	VB	F	51	L/TU	17-32, 48	E3	1	E1	
24	WE	F	61	R	C	1	2	E2	
25	WH	M	73	R	1-7, 14-25	2	1	PE	
	Total participant learners = 25 (M = 13, F = 12); 23 adult learners; 2 under 18.								
26	T	F	44		C	PG	G	2	Tutor[8]
27	SRH	M	44		C	PG	G	PG	Researcher[8]

Notes:

1. The initials used as the basis of participant identity codes are derived from pseudonyms.

2. Status: L/TU = Long-term unemployed; U = Unemployed; R = Retired; P/TE = Part-time Employed; S/DB = claiming Sickness or Disability Benefit; S = School student attending under special arrangements.

3. Attendance: Single numbers or ranges indicate specific course sessions attended. Codes: C = Completed 103-session course with more than 90% attendance. C5 = Completed course with more than 50% attendance.

4. Lit = Literacy level at course commencement as assessed by ABE tutor. Categories drawn from UK national standards & qualifications framework. Codes: PE = Pre-Entry Level (indicates severe deficits) E1 - 3 = Entry Level 1 -3; L1 = Level 1; L2 = Level 2. N/A = Not assessed.

5. Num = Numeracy level at course commencement as assessed by ABE tutor. Categories drawn from UK national standards & qualifications framework. Codes as for literacy.

6. ICT – experience with ICT at course commencement assessed by researcher. Codes based on draft national ICT curriculum. PE = Absolute beginner, no prior ICT experience whatsoever; E1 = Novice, some very limited experience; E2 = Advanced novice, slightly more experience than novice but few transferable skills; E3 = familiar with a small range of tasks and applications; 1 = Intermediate user, familiar with more applications and tasks; 2 = daily computer user, capable of some problem-solving with many applications.

7. Comments: SLN = Special Needs/Special Learning Needs. Indicates diagnosed conditions such as dyslexia, learning difficulties *etc.* HI = Hearing Impaired.

8. Tutor and Researcher skill ratings reflect attainment within the national qualifications framework for higher education. Codes: PG = Postgraduate level; G = undergraduate degree level.

During the course DH (learner 8), began a semi-skilled part-time job with a non-governmental organization which provides employment for disabled people;[13] he

considered ICT experience gained on the course as a factor in his successful application, and continued to attend course sessions to completion. The two school students who attended (learners 4 & 13) were from single-parent households.

5.3.1.2 Recruitment of Participant Learners onto the Course

More than half of the learners (14/25) were enrolled onto *Computer Creative* in September 2000. The remainder joined at various times later in the academic year (see the *attendance* column, Table 5.2).[14] The recruitment of learners took place in two ways. The OLC staged several recruitment campaigns over the previous summer involving local newspaper advertisements, leaflets, posters, and local radio. A majority of learners (15/25) initiated contact with the OLC, either in person or by telephone, having learned about the course either through this publicity or from personal contacts. Of this "self-directed" group, almost half (7/15) had previously attended courses at the Centre. The remaining eight learners joined the course as a result of their involvement in schemes which offered *Computer Creative* as an optional component within a mandatory training program. The six adults were taking part in a government "return to work" program, *Work Choices*, which required long-term state benefit claimants to undertake education or training activities; at this time the OLC being a regional contractor for the ABE components of the program. The two school students (CR and KY) who attended a number of sessions were taking part in a pilot scheme where enrolment on a range of OLC courses was offered as an alternative to conventional classroom schooling for pupils identified (by their non-attendance, poor results *etc.*) as being in need of special basic education measures.

5.3.1.3 Recruitment of Participant Learners into the Study

Learners became part of the longitudinal field study as a corollary of their enrolment onto *Computer Creative*. During their introductory session they were advised that the course was being undertaken as part of a research project, given a brief outline of the aims, objectives, and methods of the research, assured that participation in the project was not compulsory, and informed that alternative provision was available if required. All applicants joined the study and none

subsequently chose to opt out of research activities. In practice, learners'
activities were little affected by the mainly non-intrusive data-gathering
techniques, and participants quickly and easily became accustomed to research
activities taking place during course sessions. In interviews several learners
reported that they saw the connection to the research project as enhancing the
quality of the course. All learners were asked to formally signal their informed
consent to participate in the research by reading (with support when required)
and signing a research agreement (see §4.3.5 and Appendix 1).

5.3.2 Participant Staff

Two OLC staff participated in the study: full-time tutor T, who was also manager
of the centre; and researcher and part-time tutor SRH (the author; see §1.1.2).
Both were educated to degree level and held appropriate ABE teaching
qualifications. At the time of the study T had worked as an adult education
teacher and administrator for 20 years, while SRH had been teaching in ABE for
3 years.

5.3.3 Initial Skills Profile of Study Participants
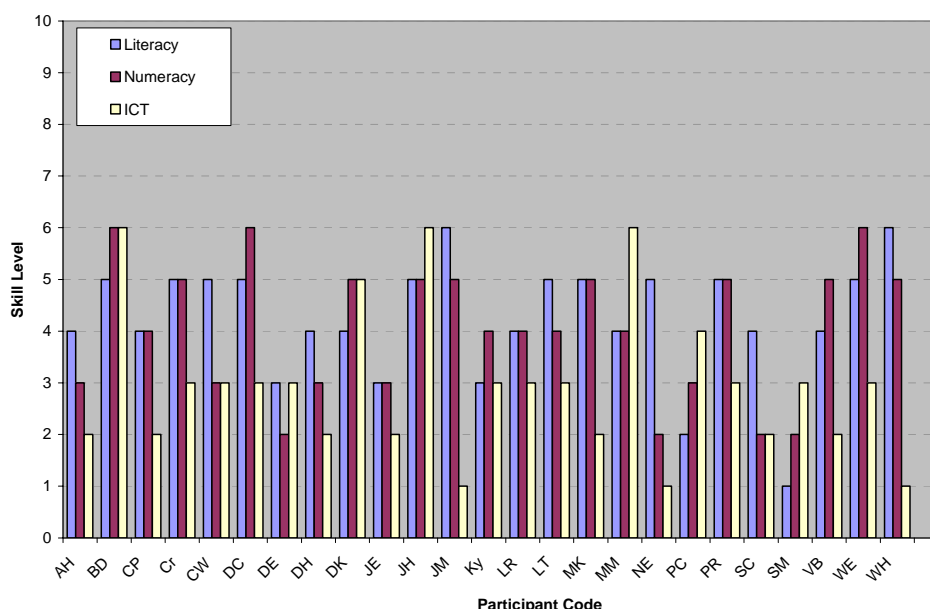
Figure 5.2: Participant skills at commencement of longitudinal field study. Key to skills levels:
    1 = Pre-entry; 2 = Entry Level 1 (E1); 3 = E2; 4 = E3; 5 = Level 1; 6 = Level 2.

On entry to an ABE course learners are subject to an initial skills assessment.
The results are used by tutors to structure the learner's individual learning

programme (see §4.4.1.4) by helping to identify the appropriate level of instruction and suitable learning resources and accreditation strategies (Brooks *et al.*, 2005). Initial assessments are based on the UK national standards and qualifications framework (Qualifications and Curriculum Authority, 2004) which provides unified and comparable standards for teaching and assessment across all levels of the UK education system, from basic literacy and numeracy provision to postgraduate University education. Figure 5.2 shows participants' skill profiles on commencing *Computer Creative*. The initial evaluation of literacy and numeracy skills was carried out by T (a trained ABE assessor), using in-house protocols.[15] In the case of those participant learners who also attended other courses at the OLC in the same academic year, evaluations were cross-checked through comparison with pre-course assessments conducted by other tutors. The assessment of participant learners' initial ICT skills was undertaken by the researcher on the basis of observations made during initial course sessions. ICT assessments were later cross-checked and updated against specifications in the 2004 version of the UK draft curriculum for ICT, which places basic ICT skills within the national standards and qualifications framework.[16]

Basic skills are evaluated at 6 discrete levels: Pre-Entry; Entry Levels 1, 2, and 3 (E1, E2, and E3); Level 1; and Level 2 (Basic Skills Agency, 2001, p. 4). On the y-axis of Fig. 5.2, a score of 1 equates to Pre-Entry level (little or no skill), 2 to Entry Level 1 (E1, some minimal skill), and so on. A value of 6 represents Level 2, the highest possible level at which skills can be taught within ABE; learners at Level 2 are considered fully competent in literacy, numeracy, or ICT, and ready to participate in mainstream education. The chart clearly illustrates the generally uneven skills profiles of the participant learners, a recognised phenomenon among ABE students.[17] Overall, it can be seen that participants were slightly more literate than numerate, which is in line with findings for the UK as a whole (Moser, 1999). In terms of ICT skills, there were three complete beginners, (NE, JM, and WH). All were assessed as having literacy skills at Level 1 & 2, while two also had numeracy skills at level 1. However, the learner with the lowest literacy skills (SM) was assessed as having comparatively more highly developed (E2) ICT skills. Among the other learners, the highest level of ICT skills were those of three participants (MM, JH, BD) who were frequent ICT users, found to

be capable of some problem-solving with a variety of applications.[18] Only one of the three (BD) was among those in the group with the highest literacy and numeracy skills.

5.4 Activities & Tasks Observed During the Study

During the longitudinal study participant learners were observed as they devised, planned, carried out, and evaluated group and individual projects using ICT. Figure 5.3a gives an overview of the temporal structure of learners' activities and tasks, showing that the observed activity fell into three main periods. Firstly (timeline 1, Fig. 5.3a), there was a short *introductory* period during which participant learners were guided by tutors as they engaged in whole-group activities, introducing the key skills and core tools of the course: idea-generation and planning techniques, and the use of digital graphics and animation software.

This was followed (timeline 2) by a *project-based* period where the learning group split into various subsets to pursue self-directed projects. Towards the end of the course came a *rounding-up* period (line 3) during which participant learners was encouraged to complete their portfolios for the accreditation process. They also prepared a talk on some aspect of the project work they had been involved with which was then presented to the whole group.

The three major periods of course activity shown in Fig 5.3a partly overlapped, several learners having embarked on self-directed projects while others were still involved with introductory activities. In later stages, some learners undertook rounding-up activities while others continued to carry out project-based work.[19] Within the period of project-based activities, the projects themselves can be categorized in several ways; number of learners involved, duration, *etc.* Timelines 4-10 in Fig. 5.3a group together project-based activities according to what they aimed to produce (computer graphics, video film, accreditation materials, computer programs *etc.*). All projects, whatever their goal, involved elements of planning, execution and development; all involved the use of a variety of digital and traditional tools; and all called on skills in literacy, numeracy and ICT.
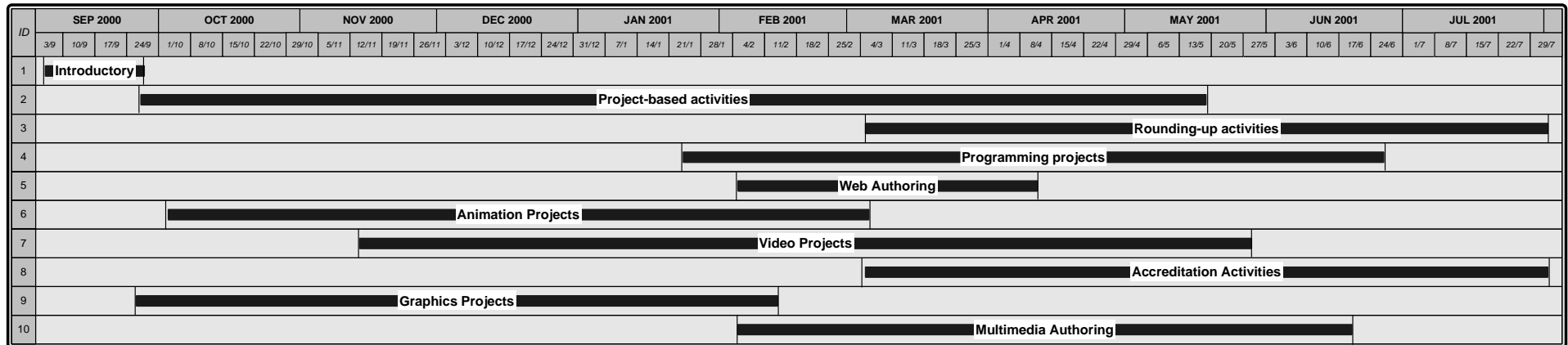
Figure 5.3: Timelines of the Computer Creative course. 5.3a (above) gives a general overview of course activity and tasks. 5.3b (below) shows 2nd & 3rd level task decomposition for animation and video projects (lines 6 & 7 in Fig. 5.3.a), indicating individual projects & their principal participants.
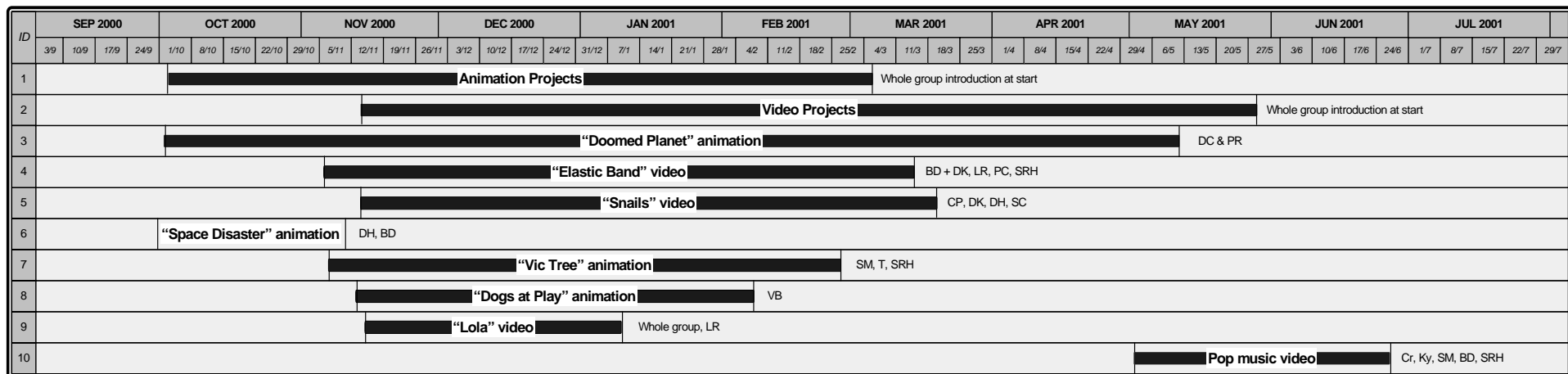
5.4.1 Task Complexity

The issue of task complexity and its impact on user interaction has been extensively discussed within the HCI and IS literature, albeit mainly within the cognitive science paradigm (for an overview see Diaper and Stanton, 2003). Many studies draw on Newell and Simon's HIP model of problem-solving (Newell and Simon, 1972), and typically characterize task complexity in terms of a number of attributes or dimensions such as how repetitive the task is, how amenable it is to analysis, whether its outcome can be determined *a priori*, the number of alternative paths task performance can take, the degree of novelty of the task outcome, the number of goals involved and the conflicting dependencies among goals, uncertainties about performance and goals, the number of inputs, cognitive and skill requirements, and the time-varying conditions of task performance (see *e.g.* Byström and Järvelin, 1995, Gururajan, 1999). Researchers working in applied activity theory (§2.4.3.1, 2.5.3) have also proposed a variety of qualitative and quantitative task complexity evaluation methods.[20] As general evaluation criteria, Bedny & Meister (1997 pp. 23-24) and Tikhomirov (Tikhomirov, 1988) suggest attributes such as the degree of dependence of one task or action on another; the number of static and dynamic components of the task and situation and the number of interactions between those components; the extent to which task instructions are clear and specific; how much information is available to support task solution; and how indeterminate the task goals and outcomes are.

Although quantitative task complexity analyses were not undertaken during the research project, some qualitative evaluations can be made on the basis of the foregoing considerations. As can be seen from Fig. 5.3a, in general the tasks undertaken during *Computer Creative* can be considered as tending to increase in complexity over time. Although the course began with some relatively simple, often whole-group, tutor-led introductory activities, it had progressed to small-group graphics and animation projects within the first few weeks. In many of the observed activities two or more tools were used in conjunction, usually with the output of actions with one tool providing input for actions with another. By midway through the course (January - February 2001) most participants were

involved in video and multimedia authoring tasks. In DV projects, movie titles and captions were initially developed through discussion, composed as a text outline using a word-processor, created using a graphics editor, assembled into clips (short multi-frame animation sequences) using animation software, and finally inserted into the movie using DV editing software. Further examples of complex work processes are given in following chapters.

This informal evaluation strongly suggests that the majority of tasks undertaken during *Computer Creative* should be considered as exhibiting moderate to very high complexity. With regard to support for the development of ICT skills, it is also important to note that functional-analytic approaches in modern systems-structural AT (§2.5.3, 3.3.3.2) distinguish task complexity from task difficulty. Whereas complexity is considered to be an objective (*i.e.* supra-individual) property of the task, difficulty is the acting subject's idiosyncratic evaluation of that complexity in the current situation. Such subjective evaluations are critically dependent on users' motivation, previous experience, and the significance the task holds for them (Bedny *et al.*, 2004, Bedny *et al.*, 2005a, see also Fig. 3.7 where several function blocks relate to the subjective evaluation of task-conditions). This distinction and its relevance to observations made in the study are discussed further in following chapters.

5.4.1.1 Task Complexity & Breakdown

Table 5.3: Interaction breakdown by user. User codes as per Table 5.2.

User	BDPF ID numbers	Total
DH	19, 20, 26, 34, 44, 52, 60	7
BD	8, 6, 25, 30, 31, 32, 35, 41, 42, 49, 53, 55, 56, 57, 59	15
CR & KY (School Students)	58	1
DC	2, 5, 7, 10, 12, 22, 27, 36, 38, 40, 53, 56	12
LR	8, 9, 13, 14, 26, 37, 43, 47, 48, 54	10
CP	45, 64	2
DK	3, 51	2
PR	2, 5, 7, 10, 12, 17, 22, 27, 36, 38, 40, 50	12
JH	29, 46	3
MM	6, 15, 45	3
SM	23, 24, 33	3
WE	31	1
SRH (Tutor/Researcher)	6, 7, 15, 28	4
T (Participant Tutor)	16, 23, 24	3
PC	11, 18	2
MK	4	1

It is generally agreed (in both HCI/ISD and HFE, and from most theoretical standpoints) that the more complex the task, the greater the cognitive, motor, and affective demands on the user, and thus (in many situations) the greater the possibility for error or breakdown during interaction (*e.g.* Shneiderman, 1998, pp. 356-364, Benyon *et al.*, 2004, 33-36, Bedny and Meister, 1997, 262-271). Table 5.3 summarizes the relationships between individual user(s) and the BDPF data; §5.2.2.3 discussed the use (and limitations) of BDPFs for recording and analysing interaction breakdown incidents. The second column of the table lists the BDPF ID relevant to each breakdown incident in which the user concerned was involved. Column 3 of each table shows the total number of BDPFs on which a breakdown involving the user was recorded. BDPFs were numbered sequentially according to date; the lower the ID value in Table 5.3 the earlier in the study the incident was recorded. It can be seen that the highest numbers of incidents recorded took place in the later stages of the study and are associated with a small subset (4) of the participant learners: BD, DC, LR and PR, all of whom are profiled in §5.3.1. Examination of the individual BDPFs associated with these learners shows that the majority of incidents took place during highly complex computer-mediated work activity: in the case of DC and PR, their collaboration on the ambitious graphics and animation project *Doomed Planet* (timeline 3, Fig. 5.3b); for LR and BD, during video editing and programming activities. BD, the participant learner who appears most frequently in the BDPF record, was particularly active in peer-mentoring, and took an active part in almost every project undertaken during *Computer Creative*. Patterns of collaboration are discussed in the following section. Detailed accounts of some of the breakdown incidents involving these users are provided in Chapter 6, while the case study in Chapter 7 undertakes an in-depth analysis of the relationship between task complexity and interaction breakdown in computer-mediated activity.

5.4.2 Collaboration & Co-location

Throughout the study learners worked together in various combinations: pairs, trios, and larger groups of up six individuals (Fig. 5.4). In general group-working involved an informally negotiated division of labour, with group members agreeing among themselves to take on different roles in the activity. In keeping

with the social-constructivist design of *Computer Creative* (§5.1.1), collaboration and discussion were encouraged and supported by tutors, whereas (for the reasons outlined in the discussion of CLAIT in §1.1.2) individual, isolated working was actively discouraged, particularly during the early part of the course. On numerous occasions the whole group took part in collective teaching and learning activities, as for example during introductory tutorials with software packages.
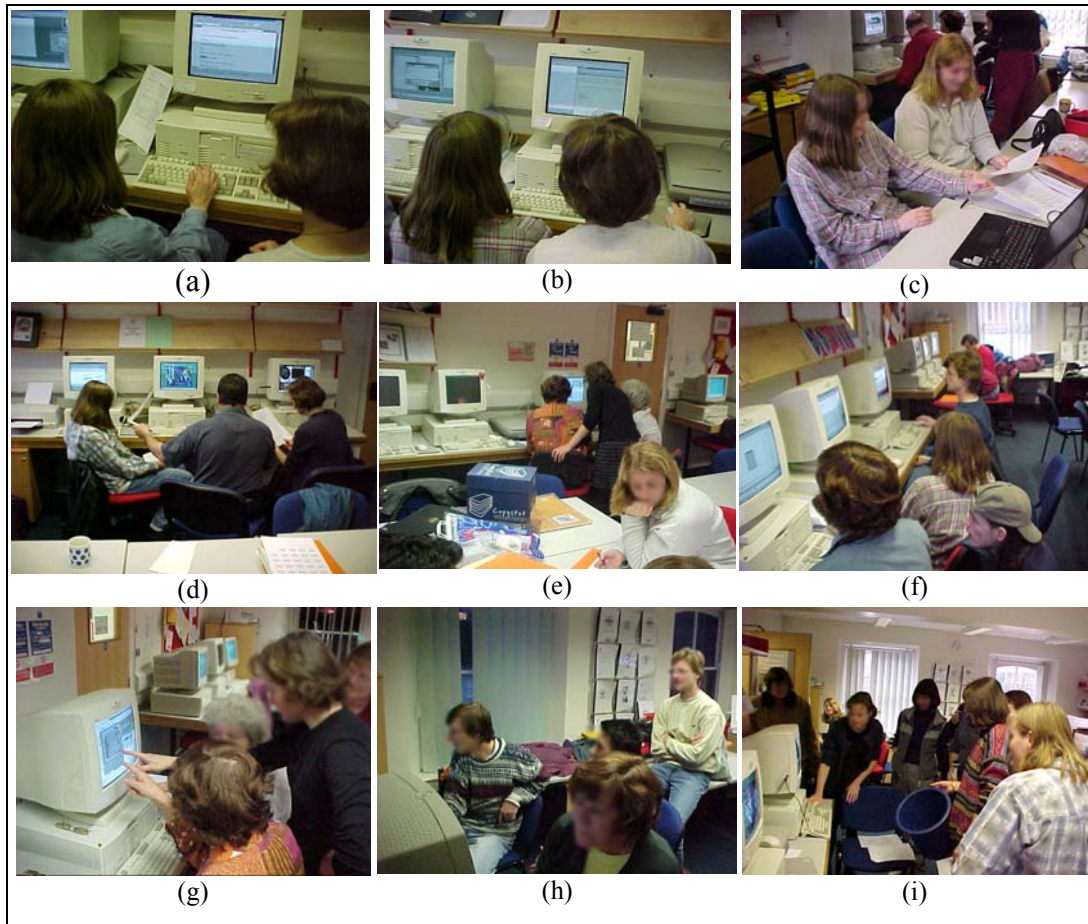
Figure 5.4: Examples of collaborative computer-mediated activity during *Computer Creative* involving pairs (a, b, c); trios (d, e, f) and larger groups (g, h, i). Note: shared control of input devices (a, b); joint touching of paper (c) and screen (g); use of multiple PCs for one task (d, f); division of labour around 1 PC (a, b, c, h, i).

In order to illustrate these changing patterns of collaborative work Figure 5.3b presents a breakdown of the principal participants in the video and animation projects shown in timelines 6 and 7 in Fig. 5.3a. It can be seen that while all members of the learning group initially participated in introductory whole-group video and animation activities, a smaller sub-set went on to make video or animation the focus of their self-directed work during the project-based period.

Fig. 5.3b also indicates the way in which many participants could be involved in more than one project-based activity, either sequentially or simultaneously, *e.g.* learner DK worked on two video projects simultaneously (timelines 4 & 5). Although the figure only shows those participants consistently associated with a specific project, in practice the other learners (especially those more active in peer-mentoring such as BD, see §5.4.1 above) would often "muck in" to briefly assist with a task when extra help was needed. The physical layout of the room, with clear line-of-sight between workstations (Figs. 4.1 & 4.2), allowed learners to continually monitor each other's work.

5.4.2.1 Localization & "Ownership"

During the study it was observed that many participants preferred to sit in the same seat and/or use the same PC over many sessions. In addition, several participants appeared to develop a strong sense of 'ownership' of specific PCs during the course, sometimes actively seeking to discourage others from using them. There being fewer machines (and operator positions, see Fig. 4.1) than participants, these tendencies gave rise to a number of practical difficulties, including occasional conflicts between learners.[20] In the early stages of the course there appeared to be few practical reasons for preferring one machine over another, as all the Workshop 3 PCs offered similar functionality (differences are noted in §4.2.3.2 and Table 6.1). However, by the latter stages of the study some learners had built up considerable portfolios of digital artifacts on specific machines, both reflecting their history of continuous use of one machine and providing some justification for continuing to do so.

Several interventions[22] by the tutors attempted to encourage greater mobility among seating positions and machines, including promoting learners' use of the network to transfer files from one machine to another. [23] These interventions were found to have little impact on participant behaviour. This suggests that individuals' and groups' attempts to consistently occupy various locations within the workspace, while partly reflecting practical concerns, also performed important individual-psychological and sociocultural functions such as providing participants with a sense of personal security and demarcating personal and group allegiances.

5.4.2.2 Material Mediation & Non-verbal Communication

It was observed during the study that not only the layout of Workshop 3, but also the material properties of the artifacts it contained, played an important part in mediating collaborative work processes. Those learners not directly involved in operating the PCs frequently indicated their (more-or-less) active participation in joint activities by touching the equipment in use (especially input devices such as the mouse); leaning on the chair, desk, or monitor of the operator; or through other gestures signifying interest and involvement, such as holding paper notes, printouts and other artifacts associated with the work in progress. The photos in Fig. 5.4 show some examples of leaning, holding, and pointing. These observations of the various ways in which users coordinated their collective activity[24] can be related to the work of Bardram (§3.3.1.5); their implications for the application of activity theory to interactive system design are discussed further in following chapters (see also Harris, 2003).

5.5 A Typical *Computer Creative* Session

This section concludes the study overview with a composite first-person narrative of a course session derived from the field note record. The aim is to sketch the "look and feel" of a typical *Computer Creative* session, illustrating the range and variety of interpersonal and human-computer interactions observed during Phase 1 and providing concrete examples of some of the general features of the course discussed earlier in the chapter. This episode combines and condenses field note entries for course sessions 42, 24th January 2001; 45, 31st January 2001; 48, 7th February 2001; 51, 14th February 2001 54, 28th February 2001; and 57; and 7th March 2001. The interaction breakdown incidents described are recorded in BDPFs 24 and 45 (§5.2.2.1). For purposes of comparison, a representative sample of unedited field notes from various stages of the course is supplied in Appendix 2; examples of completed BDPFs can be found in Appendix 4. Participants are referred to by the codenames listed in Table 5.2; as in the field notes, the account is written from the perspective of the participant observer, researcher/tutor SRH. Chapters 6 & 7 deal in detail with the various software packages whose use is described.

Wednesday Morning, Mid-course.

I arrive at the OLC early and set about booting-up and logging-on the computers in Workshop 3. T puts her head around the door and tells me she will join the group as soon as she finishes some administrative tasks. The first learner to arrive is PC. He's cheery, and tells me that he plans to finish an animation he has been working on. He's used a Web Cam to film (in stop-motion) some small figures he modelled, and then imported the digital video (DV) file (in .avi format) into AS to add effects, transitions, and titles. In yesterday's session he downloaded a number of audio files (in .wav format) from the Internet, and he plans to spend today using video editing software - UVS - to combine the audio and video files. As PC and I chat MM arrives and settles in on his usual machine, next to PC. MM tells me that today he plans to use Multimedia Builder - a shareware multimedia authoring package he downloaded from the Web a week ago - to create a 'stand-alone' player to package PC's movie so that it can be played on any system. The idea he sketches out is that he will import the .avi file into Multimedia Builder, add some control buttons, and then export the result as a stand-alone executable. As I turn away to greet the other learners who arriving, MM begins to work. He spends his time prior to the morning tea break exploring the Multimedia Builder UI, "hacking away" as he puts it – trying out commands to see what effect they have. PC proceeds steadily with his editing task throughout the first half of the session, and is already at the "make movie" stage of the editing process – where a finished clip is compressed and output – by the morning tea break at 11 am. Over his period of attendance at *Computer Creative*, PC has steadily developed his "technological fluency". He now works autonomously and confidently for long stretches at a time, and the extreme shyness he showed in September has been replaced by a relaxed confidence; he constantly discusses what he is doing with MM, who sits next to him. I now have to be alert to notice when he experiences breakdown, as he rarely asks for help, preferring to problem-solve his own way out of any difficulties.

BD, CP, DH, and WE arrive. Today, this small group will do some filming for BD's project, a stop-motion animated movie. BD is using a cardboard model stage and small puppets made from craft materials; he plans to synchronize the animation footage with a digital music file he has composed and recorded. They are using an analogue video camera hooked up to a PC with a video-capture card. I brief WE, a widow in her early sixties who is to act as the computer operator, on how to use the card's software. Previously unfamiliar with ICT, WE has become increasingly engaged with technology as the course has progressed, and is now about to buy her first home computer. During the morning the ATI capture software crashes several times, each time requiring a system reboot. The cause is not immediately apparent, although I suspect that is partly due to RAM limitations. After each crash, WE patiently goes through the start-up and log-on procedure. The rest of the group indicate their support by clustering around the computer, leaning on the back of her chair or lightly touching the monitor. Toward the close of the session, when filming is complete, I prompt BD and WE to complete their task by recompressing the clips and exporting them to another machine on the network, ready for editing. BD can't recall how to do this, despite having performed the operation several times over previous weeks. I note he has previously always carried out this task in collaboration with LR, who is absent this morning. I demo the procedures for BD and WE, which they then carry out together without problems until the end of the session. As WE leaves she tells me that she "really enjoyed herself".

DC and PR, two ladies in their early sixties, arrive together and spend the session working on their joint production: an animated movie, which they are creating using Paint Shop Pro (PSP) and Animation Shop. They have developed a unique approach to this work, gradually building on techniques introduced in a group tutorial in the early weeks of the course.   Each of them sits at a computer working on individual files, and between them they have a third which they use to search the Internet for background material and images. PR is using PSP to edit a master image which contains multiple layers - at times as many as 27 - which represent successive frames in her animation sequence. Each time she is happy with a layer, she copies it and pastes it into the file she has open in AS - which is also running on her desktop - as a new frame. Meanwhile, DC is using PSP to manipulate an image that will form the basis for another sequence. She made and photographed a model, and is now incorporating its digitized image into a digitally painted background, removing unwanted features and adding effects. DC is using only 3 layers. While PR works steadily, DC frequently breaks off from her task to use the extra computer next to her, or to stand at PR's shoulder, leaning on her chair, watching and commenting as she works. Throughout the session, they talk constantly, commenting both on each other's actions and their own, laughing and joking, continually appraising the work in progress.

When SC arrives, at about 9.30, I sit down with her and we begin to explore the Mach Turtles Logo application together. In the previous session she had mentioned that she wanted to learn something new, and when I suggested that she might find programming interesting, describing what I knew about Logo, she readily agreed. After we briefly examine the main features of the interface together - a large window for graphical output and a smaller for command-line input - I suggest that we might look at the online tutorials, which are in HTML format. I am unsure what reaction to expect, as my experience has been that the learners generally do not want to use documentation – and I know SC's reading skills are not well developed. However, she agrees, and we start working through the *Starting with Logo* texts, which are brief and simple. SC reads some, finds she can follow them, and sets about printing them out. Working from the hard copy, SC quickly completes the first few exercises – within an hour she has written code that calls a repeat loop, causing the "turtle" cursor to draw a square in the graphics window. She is delighted, and grins broadly. I draw a more complex polygon on a sheet of paper, and suggest to her that she try to write the code to draw it. She readily agrees - her confidence seems high - and proceeds carefully. At one point she gets slightly confused between coding measurements (in arbitrary "steps") and angles (in degrees). We look at the output screen and discuss what might have happened; she checks through the code, recognizes, and then corrects her mistake. This time, the code executes perfectly, and I make everyone in the room laugh by jumping up and down so much I shake BD's animation setup and spoil a frame! For the rest of the session SC continues to explore Logo. When I ask her why she feels that she is getting on so well, she says that she is "normally quite good at maths, the normal basics, anything else, no…" This is the first time I have heard her describe her skills in such a positive way.

SM, a woman in her mid-thirties, is editing video using UVS. She is growing increasingly frustrated with the difficulties she is encountering. She is trying to match audio files - recorded onto computer through a microphone, with other participants as "actors" reading from her script - to her video clips by dragging and dropping on the UVS timeline. Frustratingly, each set of adjustments requires the whole file to be reprocessed before it can be played back with sound, a task that executes increasingly slowly as the piece is built up.

Rendering the project takes almost 10 minutes each time, and subsequent viewing reveals that SM is simply redistributing the problems, rather than solving them. Each time this becomes apparent she suggests, only half-joking, "Can we just scrap it?" DK, a man in his mid-thirties, is working with her. Characteristically taciturn, each time I enquire of him how the project is going, he says "don't ask" with a wry expression. Although much of the time there is actually little concrete to do, he expresses his participation in, and support for, the work, by maintaining a constant presence at the computer next to the one SM is working on. Between times he browses the Internet, ostensibly looking for sound effects to add to SM's film.

At 12.15 the session begins to draw to a close. MM tells me he has succeeded in creating a small multimedia application that incorporates PC's video file, and calls me over for a demonstration. He runs the executable and then stares at the screen as a succession of error messages appear. MM hard reboots the machine and tries again, several times; each time the system crashes. I move around the group checking other learners' progress, returning to him every few minutes. Finally, just before we leave, he plays me the application from inside the authoring environment and I can see that he has used the package's capabilities to produce some interesting effects. He seems undaunted, avowing that he will "force it to work" next time we meet. I ask everyone to finish what they are doing, and as people begin to leave sit down to write up my field notes. DC and PC interrupt to ask for help with saving their files. As there is no central server, all files being stored on local hard drives, the ladies use a shared directory and copy their data around the network. In the process they frequently lose track of where files are and which are the appropriate versions, often requiring them to search several machines on the network before work can begin. Today they have no problems transferring their files, and leave the session happy. As is usually the case, they continued to work through the break, and remain long after everyone else has gone home.

5.6 Summary

The first phase of fieldwork involved a longitudinal study of the experimental ABE/ICT course *Computer Creative*. During the study the researcher observed, interviewed and recorded a group of ABE students as they collaboratively devised, planned, carried out, and evaluated digital media projects. At its completion the course was evaluated as having been successful in sustaining learners' engagement and motivation and supporting their learning and development of ICT skills. Both during and after the study a variety of activity-theoretical techniques were used to interrogate the fieldwork data with the aim of eliciting detailed, design-oriented information on the observed human-computer interactions. This was organized through a process of "indefinite triangulation" involving the comparison, correlation and analysis of evidence from multiple data sources. The analytical methods employed involved the systematic differentiation of the structure, components, and parameters of the observed activity, using checklists of questions, the identification and recording of

breakdown incidents using a specially designed pro-forma, the BDPF, and other techniques (which are described in Chapters 6, 7, & 8). Twenty-three adult and two school-age learners participated in the study. All were from low-income, low education backgrounds. At the commencement of the study most participants were slightly more literate than numerate; only three had more than beginner's ICT skills. During the course activities fell into three main periods: introductory, project-based, and rounding-up; the majority of tasks observed involved digital graphics, animation, and video. Most tasks undertaken during the study were estimated to be of moderate to high complexity; tasks tended to increase in complexity as the course progressed. Throughout the longitudinal study participant learners worked together in groups of various sizes. The physical properties of the workspace, and participants' location within it, were observed to be factors affecting both interpersonal (communicative) and human-computer interaction. During a typical course session a wide variety of human-computer and interpersonal interactions were observed and recorded.

Notes to Chapter 5

[1] In the researcher's absence the participant tutor, T, recorded observations on his behalf.

[2] Primarily in papers from the 1996 MIT colloquium on the use of IT in low-income communities collected in (Schön *et al.*, 1998).

[3] *Computer Creative* and other OLC courses (§1.1.2, Fig. 1.1) have informed the development of ICT-based ABE at the national (Wales & UK) level. Dissemination of experience gained at the OLC to other members of the profession was accomplished through presentations, discussions and publications (mainly by the author and participant tutor) involving a number of adult education organizations. Over the period 2001-4 these included: the Forum for Adult and Continuing Education (FACE); the Basic Skills Agency (BSA); the National Institute of Adult & Continuing Education (NIACE); and the Research & Practice in Adult Literacy network (RaPAL). Work at the OLC also contributed to a series of research studies into the effective uses of ICT in ABE conducted by the National Research and Development Centre for Adult Literacy & Numeracy (NRDC), based at the Institute of Education, London (see *e.g.* Mellar *et al.*, 2001, Kambouri and Mellar, 2003, Harris, 2005b).

[4] The positive and negative outcomes of this design decision (in both pedagogical and socio-political terms) are discussed in (Harris, 2003) and (Harris and Shelswell, 2005).

[5] This evaluation was subsequently confirmed both by an independent quality assessment undertaken by the Basic Skills Agency and in an education inspectorate (OFSTED) report on OLC activities.

[6] Via the UK's national Open College Network (OCN) which provides accreditation services for adult learning, offering qualifications and programmes in a wide range of subject areas. See http://www.nocn.org.uk/

[7] One-on-one interviews with learners were carried out in two separate series, the first taking place on October 16th 2001 and involving 5 interviewees, the second on February 7th 2002, with 7 interviewees.

[8] The method of describing participant learners' race and ethnicity used here conforms to the guidelines on the use of ethnic, racial, and cultural descriptions in published medical research given in (McKenzie and Crowcroft, 1996). See also §4.3.5.1.

[9] At the time of the research, there were relatively few members of ethnic minorities resident in the south Wales Valleys (around 2% of the local population compared to 12% for the UK as a whole).

[10] South Wales is not a predominantly Welsh-speaking region.

[11] These classifications are drawn from the UK National Readership Survey (NRS). NRS social grade definitions are an established generic reference series for classifying and describing social classes, widely used for consumer targeting and market research. The definitions are based on annual surveys which involve interviews with 35,000 individuals aged 15 and over in Great Britain. See http://www.nrs.co.uk/open_access/open_methodology/2003demogdefinitions.cfm for the full set of NRS social grade definitions and examples of associated occupations.

[12] In the UK welfare system at this time, unemployment benefit (now called income-based jobseekers allowance) was a time-limited payment provided on the basis of an applicant's National Insurance contribution record. Supplementary benefit (income support) is a means-tested benefit payable to non-working persons ineligible for contributions-related unemployment benefit. Both benefits were provided on condition that the beneficiary is available for, and actively seeking, employment. There have been some changes to the system of state benefits since the period reported here.

[13] Remploy Ltd., for details see http://www.remploy.co.uk/

[14] Unlike other Further Education provision, but in common with many other ABE providers, the OLC employs a "roll-on, roll-off" policy of continuous enrolment to courses throughout the academic year, in an effort to be responsive to the varying needs of adult learners.

[15] At this time (September 2000) nationally standardised ABE initial assessment resources such as the Target Skills package (see Brooks *et al.*, 2005) had not yet been established and it was accepted practice for major ABE centres such as the OLC to develop and apply their own assessment protocols.

[16] Further information on the ICT standards is available via the UK Qualifications and Curriculum Authority Web site at http://www.qca.org.uk/index.html. The author was involved in the consultation process that produced this document.

[17] ABE practitioners commonly refer to this inequality in skill levels as a "spiky profile".

[18] This grouping also included the participant tutor, T, whose ICT skills were equalled by the three most skilled learners. Historically, the use of ICT in the ABE classroom has tended to blur traditional divisions between teacher and taught (Mellar *et al.*, 2001, Kambouri and Mellar, 2003, Shelswell, 2005). As can be seen from the case of learner SM, the relevance of ICT for an empowerment-oriented ABE practice is the chance it offers those with very low traditional basic skills to succeed (perhaps for the first time) in an academic setting.

[19] The account of a typical Computer Creative session presented in §4.1.4 represents activities during the project-based period of the course (Fig.5.3a, timeline 2).

[20] A detailed discussion of activity-theoretical complexity evaluation methods lies outside the scope of this thesis, principally because these techniques are only beginning to be introduced into the English-language research literature at the time of writing (*e.g.* Bedny *et al.*, 2005a). As a consequence task complexity evaluation methods have so far been little-used in ATIT, where currently even the concept of task as a unit of analysis is problematic (see §3.5.2). The forthcoming publication of an English-language textbook on SSAT by G. Z. Bedny containing several chapters (reviewed in draft in late 2005 by the present author) on the qualitative and quantitative evaluation of task complexity may help to resolve this situation.

[21] For example, the field notes for Session 61 (19th March 2001) record clashes between learners PR, CP, MM & DK.

[22] The earliest such intervention was undertaken in Session 5, 18th September 2000, when the group was divided into pairs and each pair arbitrarily assigned to a specific PC by the tutors, the aim being to break up the pattern of preference for particular machines which had already become evident. Such active management of the group was undertaken at intervals throughout the remainder of the course, for both practical and pedagogical reasons. It was consistently observed that some learners arranged to return to 'their' PC as soon as possible after the intervention ceased.

[23] It is possible that the operational characteristics of the OLC network discussed in Note 10, Chapter 4 also strengthened the trend toward localization.

[24] That is, due to the open-ended, creative nature of the course activities the most prevalent types of collective activity were co-operation and co-construction (Fig. 3.5); and the dominant modes of activity coordination were instrumental and communicative (Table 3.3).

6. Phase 1: Computer Artifacts in Use

The previous chapter provided an outline of the Phase 1 field study, mainly focusing on the study participants and tasks observed. This and the following chapter (7) use activity-theoretical techniques to approach the Phase 1 data from a tool perspective (§3.1.1), examining the ways in which ICT-enabled work and learning processes were affected by the design of the artifacts in use. The chapter begins by providing an overview of the software packages which mediated participants' activity during Phase 1, going on to discuss each application in turn through a series of examples and case-studies. These analyses draw on the field note and interview transcripts (§4.4.1.1, 4.4.1.2), Breakdowns Pro-Forma (§5.2.2.1) and other data sources (§4.4).

6.1 Overview of Software Used in the Longitudinal Study

Section 4.2.3.2 described the material resources and computer hardware available in OLC Workshop 3. Table 6.1 provides an overview of the software used during the longitudinal study. The applications are clustered into types according to their principal role in mediating the observed activity.[1] At the commencement of the study each of the 10 PCs in OLC Workshop 3 (Fig. 4.1) was equipped with the Windows 98SE OS and its standard accessories, including Notepad and Internet Explorer; the Microsoft Office 98 bundle;[2] and Jasc Paint Shop Pro and Animation Shop.[3] Other applications listed in Table 6.1 were installed as the course progressed. Packages were installed on all machines, with the exception of those (*e.g.* the scanning/OCR and video capture software) associated with specific hardware and/or peripherals. These cases are detailed in footnotes to the table. Following sections of the chapter discuss each of the software packages listed in more detail.

Table 6.1: Overview of software used by participants during the longitudinal field study

Type	Tool	Description	Manufacturer	Abbrv.
2D & 3D Graphics	Bryce 3D[1]	3D painting	Bryce	
	Cool3D[1]	3D wireframe & painting	Ulead	
	Paint Shop Pro 6, 7	2D Raster and vector painting & drawing; photo enhancement	Jasc	PSP
	Painter 3D[1]	3D wireframe & painting	MetaCreations	
	The VR Worx[2]	QuickTime VR authoring tool	VR Worx	
Animation	Animation Shop 3	2D animation, frame-based	Jasc	AS
	Poser	3D drawing & animation	MetaCreations	
Audio Recording & Editing	Cakewalk[3]	Wave and MIDI multi-channel recording & editing	Cakewalk	
	Cool Edit Pro	Wave recording & editing	Syntrillium	CEP
	Sound Recorder	Audio recording utility	Microsoft	
Video capture and editing	ATI Multimedia Centre[4]	TV/VHS capture, editing, & playback software suite	ATI	
	Video Studio	Digital video capture & editing	Ulead	UVS
Software Utilities	HP ScanJet[5]	Scanning & OCR utilities	Hewlett Packard	
	Nero Burning Rom	CD-R creation utility	Nero	Nero
	Windows Explorer	File management utility	Microsoft	WE
	Windows Volume Control	Audio input and output control	Microsoft	
Web authoring, browsing and searching	Blogger	Online weblog authoring tool	Pyra Labs	
	Dreamweaver	WYSIWYG HTML editor	Macromedia	
	Notepad	ASCII Text editor	Microsoft	
	Internet Explorer 5	Web browser	Microsoft	IE
	Google	Online text and image search Engine	Google Inc.	
Miscellaneous Software	Turtles Logo	Graphical and command-line programming environment	Mach	Logo
	WinAlice	ChatBot	Open source	
	Multimedia Builder[2]	Multimedia authoring software	Mediachance	MMB
	MS Word	Word processor with drawing & DTP functions	Microsoft	Word
	PowerPoint	Presentation slide authoring and viewing	Microsoft	

[1] Installed on Mill53 only. [2] Mill52 only. [3] Mill54 only. [4] Mill55 only. [5] Mill59 only. Workshop 3 PC Network IDs as shown in Fig. 4.1

6.1.1 Processing & Memory Requirements

Section 5.4.1 introduced the issue of task complexity and its relationship to participant learners' motivation, and engagement. As major elements in the work activity (Fig. 2.6), the processing and storage requirements of the applications used in the study have some relevance in this regard, inasmuch as the extent to which the hardware platform meets a package's operational requirements directly affects the quality of the user experience. In use, the hardware/software relationship partially determines the responsiveness of the application to user input, both in terms of feedback through changes in the UI, and in the time taken to deliver output from intensive processes such as copying large files or rendering animation and video.

Table 6. 2: Examples of software processing & memory requirements.

Tool	Installation Requirements (minimum)	Running Requirements	Output File Size Range (in native format)
Word	128 MB of RAM 217 MB HDD (for Office bundle)	8 MB RAM	50KB - 500 KB
Paint Shop Pro	128 MB of RAM 400 MB HDD	Not known	150KB – 1.01 MB
PowerPoint	128 MB of RAM 217 MB HDD (for Office bundle)	8 MB RAM	600 KB – 1.45 MB
Animation Shop	128 MB of RAM 75 MB HDD	Not known	500 KB – 9.5 MB
Ulead Video Studio	128MB of RAM 80 MB HDD	32 Mb Ram, 500 MB -several GB HDD	50.3 MB – 151MB

Notes:

1. RAM = Random Access Memory; HDD = Hard Disk Drive.

2. 1 Gigabyte (GB) = 1,000 Megabytes (MB); 1 MB = 1,000 Kilobytes (KB); 1 KB = 1,000 Bytes; 1 Byte = 8 Binary digits.

3. Output file size ranges are those typically observed during the study.

Table 6.2 compares the installation, running requirements and output file size range for five of the most frequently used applications in the study, as set out in the manufacturers' documentation. The table illustrates the increased processing and storage requirements of graphical (PSP) over word-processing applications (Word); of animation (AS) over graphics; and of video (UVS) over animation. In the light of the discussions in the previous chapter, it can be seen that as the study progressed and task complexity increased there was increasingly intensive utilization of computational resources. The descriptions in following sections

(*e.g.* §6.5.2) provide examples of the impact of this escalation on the observed computer-mediated collaborative activity.

6.1.2 Applications, UIs & Interaction Breakdown

Tables 6.3 and 6.4 show data from the BDPF record (§5.2.2.3, Table 5.3) on the involvement of individual applications and user-interface features in some of the breakdown incidents observed during Phase 1. The second column of each table lists the relevant BDPF ID numbers for each entry. BDPFs were numbered sequentially according to date; the lower the ID value the earlier in the study the incident was recorded. The rightmost column of each table shows the total number of BDPFs on which a breakdown involving the application or UI feature was recorded. For the reasons noted in §5.2.2.3, the BDPF data cannot be considered sufficiently complete or reliable in itself to provide any clear correlation between specific features of application or UI design and interaction breakdown. However, it does provide some general background and supporting evidence for the discussions which follow.

Table 6.3: Interaction breakdown by application.

Application in use	BDPF ID numbers	Subtotal	Total
Paint Shop Pro 6	1, 2, 3, 7, 9, 12,	6	
Paint Shop Pro 7	17, 18, 19, 20, 25, 29, 33, 55, 58	9	
			15
Animation Shop 2	4, 5, 8, 22	4	
Animation Shop 3	27, 38, 58, 59	4	
			8
Ulead Video Studio	13, 14, 16, 23, 24, 30, 31, 32, 35, 36, 38, 40, 41, 42, 53, 56, 57		17
Internet Explorer	26, 34, 44, 52, 60		5
Notepad	26, 44, 50, 60		4
Windows Explorer/My Computer	01, 44, 45		3
Multimedia Builder	45, 50		2
Mach Turtles Logo	37, 43, 47, 48, 54		5
Windows OS	7, 10, 16, 28		4
Nero Burning Rom	6, 15, 46, 51		4
HP ScanJet	19		1
Word	29		1
CD Player	46		1
Windows Sound Recorder	47		1
ATI Multimedia Studio	49		1
VR Worx	21		1
WinAlice	28		1

Table 6.3 shows data from the BDPF record (§5.2.2.3) on the involvement of individual applications in breakdown incidents observed during Phase 1. It can

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be seen from Table 6.3 that – as might be expected from earlier discussions - the majority of breakdowns recorded on BDPFs were associated with those applications and tasks evaluated as exhibiting the greatest complexity. The highest number of recorded incidents (17) involved the video editing software Ulead Video Studio (UVS, discussed in detail in §6.5.2 below). Next in the ranking are the graphics software Paint Shop Pro (PSP, see §6.2 below) and its bundled animation software, Jasc Animation Shop (AS, §6.3.2). The impact of changes in UI design on user interaction can also be inferred from Table 6.3, which differentiates between the versions of PSP and AS in use, as these applications were upgraded during the longitudinal study. It can be seen that there was an increase in breakdowns with PSP immediately following the upgrade, in which some UI elements (arrangement of pull-down menu items, palettes) were significantly changed (see also §6.2.1.1 below). With AS, where the design changes were minor, there was no evidence of an increase.

Table 6.4: Interaction breakdown by interface feature. *Cf.* Tables 5.3 & 6.3.

Feature	BDPF ID numbers	Total
Buttons	15, 21, 27, 34, 44	5
Icons	10, 16, 21, 28, 45	5
Cursor	27, 45	2
Windows, general	7, 10, 16, 19, 26, 34, 44, 46, 50, 60	10
Dialogue	3, 6, 7, 11, 15, 16, 18, 19, 32, 35, 41, 49, 50, 51, 55, 57	16
Alert	32, 35, 38, 40, 45, 57	6
Pull-down Menu	3, 4, 5, 7, 9, 19, 20, 22, 29, 37, 50, 58, 59	12
File	3, 6, 7, 11, 14, 16, 37, 41, 45, 50, 57, 58	12
Open File Dialogue	7, 16, 41, 50, 57	5
Print dialogue	18, 55	2
Wizard (Nero)	6, 15, 46	3
Frames	4, 5, 22, 42, 58	5
Mode/Tab (UVS)	12, 13, 14, 21, 23, 24, 30, 31, 32, 35, 36, 38, 40, 41, 42, 53, 56	17
Timeline (UVS)	5, 8, 13, 22, 23, 30, 31, 38, 42, 53, 56	11
Storyboard (UVS)	13, 24, 30, 31, 36, 38, 42, 56	8
Desktop Taskbar	26, 44	2
Palettes (PSP, AS)	1, 2, 12, 17, 20, 25, 33	7
Layer (PSP)	17, 20, 33	3
Selection tools & menus (PSP, AS)	9, 17, 20, 22, 25	5

Table 6.4 lists user-interface features noted as being associated with breakdown incidents for which BDPFs were completed. For example, it can be seen that problems with the mode/tab, storyboard and timeline elements of the UVS UI (§6.5.2 below) contributed to 24% of all breakdowns in which a specific interface feature was noted as a contributing factor. Problems with dialogue and alert boxes account for 17.4% of breakdowns, and the table also shows a fairly even spread across the BDPF data of problems with file-related actions (a total of

17 instances). An example of interaction problems with windows (10 incidents listed) is discussed in Chapter 7; breakdowns involving the other UI features listed are provided in following sections of this chapter, which deals with each of the applications listed in Table 6.1 in turn.

6.2 2D & 3D Graphics

6.2.1 Paint Shop Pro

The principal 2D graphics editor employed during the study was Jasc Paint Shop Pro, (PSP). PSP was used for the majority of tasks where digital graphics were the primary output (timeline 9, Fig 4.3a), and also to develop materials for animation (timeline 6, Fig 4.3a) and video (timeline 7, Fig 4.3a) projects. Following brief whole-group introductions by the tutors in Sessions 2-9 (September 2000), all participants used PSP extensively throughout the course, some achieving highly skilled operation. Figure 6.1 shows the PSP 6 user interface, which utilizes multiple windows.
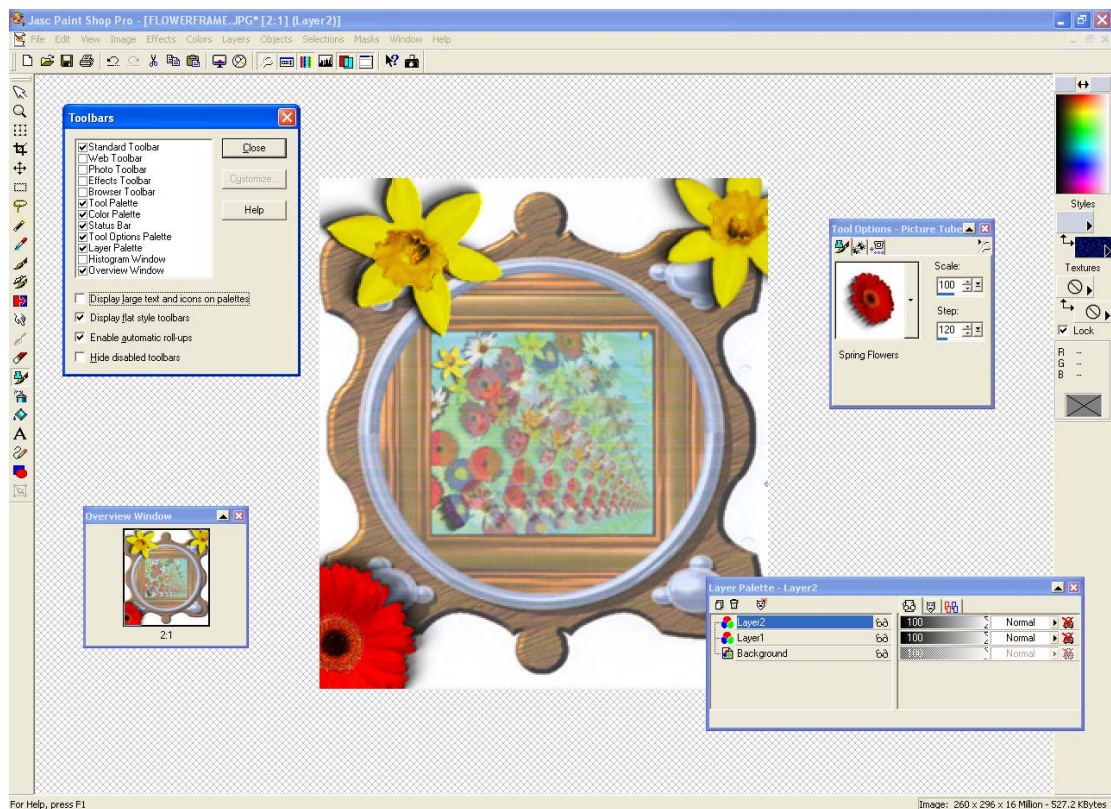
Figure 6.1: User interface, Jasc Paint Shop Pro 6. Showing (on periphery, clockwise from top-left) fixed pull-down menus and the Standard toolbar, the Materials palette, status bar and Tools toolbar; and (floating inside, clockwise from top-left) Toolbar dialogue box, painting canvas, Tool Options dialogue box, Layers palette and Overview window.

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In use, one or several windows represent a painting "canvas", each of which can contain multiple layers or overlays. Image content is created and modified using commands invoked from an array of fixed and floating "palettes", pull-down and context menus, and dialogue boxes. As with most graphics editors, the interface configuration is highly user-customisable; its design centres on the need to preserve maximum visibility of the work-in-progress in conditions of limited screen "real-estate". Although catastrophic breakdowns with PSP were rare, constructive breakdowns (see §5.2.2.3) were frequently encountered. These mainly involved UI features such as tool palettes, selection operations, and the manipulation of layers. Such breakdowns are discussed further below, following some general remarks about the initial adoption of the application.

6.2.1.1 Problems of Skills Transfer

When PSP was first introduced to the course (sessions 2-9) three participants who had previously developed skills with another home graphics package, CorelDraw,[4] reported difficulties in learning and using PSP. It was observed that differences in functionality and UI design between PSP and CorelDraw led learners BD, WH and LR to encounter frequent breakdowns when attempting previously familiar tasks such as basic line-drawing. Those concerned appeared to find their experience of breakdown frustrating and disheartening. During a group discussion (in Session 7, Wednesday 20th September 2000) WH and LR suggested that PSP should be replaced (preferably with CorelDraw); other participant learners argued for its retention, expressing their liking for the application. It was subsequently arranged that the three learners receive additional tutor and peer support when working with PSP. However, having previously informed other participants of their established skills during the introductory sessions, it was observed that – at least initially - they appeared to dislike being seen by others in the group to require this extra assistance. In the case of learner WH this dislike was acute. While by Session 20 both BD and LR had become reasonably proficient with PSP and no longer expressed objections to its use, WH progressed more slowly and continued to express dissatisfaction with the package.[5]

As noted in §6.1.2 and Table 6.3 above, during Sessions 42 and 43 (24th & 29th January 2001) PSP was upgraded from version 6 to 7. The upgrade contained

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several changes to the application's interface and functionality. Subsequently, around a dozen incidents were observed in which similar difficulties in skill transference appeared to be involved; such breakdowns, which appeared to be mainly constructive, were no longer occurring by Session 53. Using Bødker's nomenclature (§3.3.1.3 and Bødker, 1991, pp. 26-28) this phenomenon of difficulties with the transfer of existing skills can be identified as a failure of users' established "repertoire of actions and operations" under new operational conditions.

6.2.1.2 Interface Instability: Palettes

The field notes for Session 3 (an introductory PSP session held on 12th September 2000) record that: "Everyone has some difficulty with the 'disappearance' of the Tool Options palette, and this aspect of the interface design seems to be a significant stumbling block". This refers to two aspects of the default UI functionality: (1) "floating" palettes and toolbars (*i.e.* those not docked at the margins of the UI, see Fig. 6.1) automatically 'roll up' (*i.e.* minimise to a narrow bar) when not in use; (2) non-visible palettes and toolbars (*i.e.* those inadvertently closed by the user and/or not visible by default on application start-up) are restored to view by a process involving selecting the appropriate option from the VIEW pull-down menu sub-list "Palettes".

Although both of the UI features described could be overridden by users, the circumstances obtaining in the use setting meant such choices could not be permanently "locked-in" from session to session. As Workshop 3 machines might be used by other learners during the session and by other groups of learners at other times, it was not possible to predict whether a stable PSP UI configuration could be maintained on any given machine. Thus, the semi-automated conservation of screen space and high level of user customisation designed into the PSP UI – arguably objectifying (§3.5.1) an assumption of mainly single-user interaction - often proved counter-productive in a collaborative use setting. Participant learners appeared to find the apparent inconsistency and autonomy of the interface disconcerting. For example, in interviews several users pointed to the automated "roll-up" of palettes as an example of "the computer having a mind of its own", diminishing their feeling of control over the application.

6.2.1.3 Layers, Modality, & Selection Persistence

In the later stages of the study (Session 41 onwards) problems with the PSP selection tools were frequently observed. In Session 45 (31st January 2001; BDPF 20) learner DH was engaged in creating a poster. The design called for the careful placement of several vector text items on separate layers, an operation with which he was familiar. Suddenly, DH began to exclaim: "Why the bloody hell isn't this working? It was fine just now!"[6] It was observed that the application was no longer responding to input from the mouse. On further investigation it became evident that DH had employed the Selection Tool (rectangle option) to define an active area on one layer of the image. With PSP, the act of selection effectively constitutes a change in modality; user input is subsequently restricted to that area of the virtual canvas delineated by an active selection marquee, which persists until cancelled by the user. DH had attempted to work elsewhere in the image (on that layer or another) without cancelling his selection; consequently the mouse-clicks had no effect as the cursor was not located within the active area.

Problems with selection persistence became evident as participants progressed to increasingly complex tasks involving multilayer images[7] in order to create animation frames (see below) or combine vector and raster graphics within a single image. In such tasks, a selection marquee on the currently active layer was often difficult to discern among the multiple graphical elements visible on other layers. In several cases of breakdown users had also "zoomed in" in order to work on a detail – the zooming operation being accomplished by simply rolling the scroll wheel on the mouse - made their selection, and then returned to a normal view to continue working at a larger scale. Consequently, in the restored view the selection marquee was often smaller than the cursor and thus difficult to discern. Although PSP supports selection cancellation via right-mouse-click when in selection tool mode, typically, breakdown was precipitated by the users' attempt to use a new tool, such as the paintbrush, in which that option was no longer available. The alternative solution provided by PSP is to use the Selections pull-down menu to choose the command 'Select None'. However, apart from the animated selection marquee, the PSP UI offered no other feedback to indicate that a selection was in force. Thus, in many of the observed situations,

users were unaware that this was the case and so were not prompted to recall or employ appropriate recovery strategies.

6.2.1.4 Case Study: Painting with the Picture Tube

One feature of PSP that proved highly attractive to participants was the Picture Tube tool. This is a "clip art" tool that allows the insertion of high-quality raster images onto the image canvas, where they function as editable picture elements. The tool options palette for the Picture Tube, shown in Fig. 6.2 (4, 5), provides a library of images which includes animals, plants, trees, insects, cars, boats, planes, food items, geometric solids, and clouds. All are photo-realistic and many include perspective and/or shadow effects, making it possible for users to rapidly create sophisticated images. Each image has multiple variations[8] and users are able to control many of its parameters, including size, mode of placement, *etc.* The Picture Tube was first introduced to the course in Session 2 (11th September 2000) during a whole-group demonstration of PSP functions by tutor/researcher SRH. Participant learners immediately began to experiment with the tool, and over following sessions produced increasingly complex images with it.
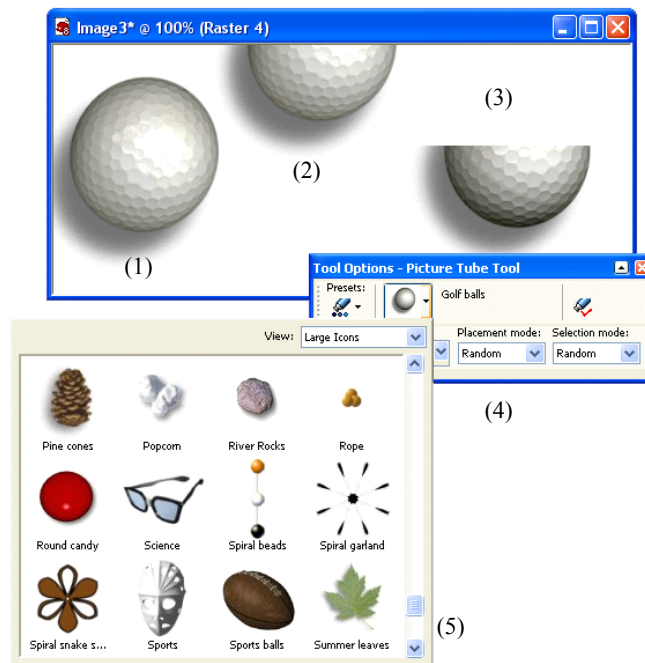
Figure 6.2: The PSP Picture Tube Tool. Image canvas (top, l-r) shows (1) a photo-realistic image; (2) image occlusion when dragged to margin; and (3) results of inserting image at margin then dragging to centre of canvas. Shown below (4) is the Tool Options palette with the image library (5) open.

Following the introduction of Animation Shop (AS, see §6.2.1 and Fig. 6.3 below) in Session 13 (Wednesday 4th October 2000) learners began to use the Picture Tube in animation projects. The basic technique adopted by the group was a form of the well-known "stop-motion" approach. It involves creating a backdrop – *e.g.* a landscape – on the background layer of a PSP image, then placing a Picture Tube object on one or more new layers so that it occludes part of the background. The Mover tool is then used to click and drag the overlay, so that the object sequentially occludes different sections of the backdrop. Using the 'Copy Merged' command from the Edit pull-down menu of PSP, it is possible to copy all the visible content of the image to the clipboard after each overlay move, and then paste the image content into an AS frame. Applying small increments of movement to the layers, with each step copied and pasted into a subsequent frame of an AS file, makes it possible to quickly produce an animation sequence. One participant (SM) used this technique to produce a short animation clip in which an elegant Siamese cat stalked across a field of grasses and flowers. When the sequence was completed (in Session 18, 17th October 2000) the whole group applauded the result.

The photo-realism of Picture Tube images appeared to encourage users to perceive them as consistent and persistent entities or objects; learners talked of "the cat" and "the plane" as they moved them around. This quality of "objectness" was enhanced by the fact that – as can be seen in Fig 6.2(2) - it is possible to drag picture tube images beyond the margins of the visible canvas until partially or fully occluded. Even when entirely non-visible to the user they persist in RAM and can be brought back into view on the canvas with the mouse or arrow keys. As noted, a typical aim of the animator was to create an object that appeared to traverse the frame; this often involved the object being partially 'outside' the frame at the beginning of the sequence. However, inconsistencies in the Picture Tube's functionality in this regard were observed to cause difficulties for users.

An example of these difficulties was observed to occur during the collaborative activity of learners DC and PR in Session 14 (9th October 2000; BDPF 2). In this session they used the Picture Tube to create a sequence in which a small aeroplane flew in from the top-left corner of the frame before crashing to the

ground at the bottom-right. The collaborators began by using the Picture Tube to place an "aeroplane" with only its "nosecone" visible at the extreme top-left of the canvas. However, as they began to move the 'plane into the frame, it became evident that only that part of the image which lay within the visible area of the canvas at the moment of insertion had been created; the remainder of the image was missing, as in the example shown in Fig. 6.2 (3). After some trial-and-error, DC and PR established a viable workaround - the Picture Tube image was initially placed at the centre of the canvas, and then moved to the desired starting position for the sequence. However, despite the generation of this solution, DC, PR and other learners were observed to encounter this problem again on several occasions during later course sessions, suggesting that this aspect of the behaviour of the Picture Tube was counter-intuitive for users.

6.2.2 Other Graphics Applications

During the study several learners used the MS Word drawing tools and clip art to create basic graphics; few problems were encountered. Word is discussed further in §6.2.4 below. Following the introduction of Poser (see §6.3.2) in Sessions 10-12 one learner, PC, explored the use of three other 3D graphics applications. He subsequently rejected two - Bryce and Painter3D – outright, but successfully used another, Cool3D, to produce files which were then imported to Poser. This field note entry from Session 11 (2nd October 2000), describes PC's initial encounter with Painter 3D:

> I sit with PC at a machine and we install Painter 3D. I leave him to explore it. His immediate reaction to the rather cluttered interface is 'great, this looks like something I've already got' and he fires straight in, showing me how to paint textures on a model. However, when I come back to him at the end of the session he expresses his frustration with the program, as it will not allow him to easily combine and manipulate wire frames.

Later, in Session 13 (4th October 2000):

> I ask PC why he rejected Painter3D, and he says 'It was rubbish; I just couldn't do what I wanted to do with it – join together some shapes and then render them. But Poser is alright'.

This suggests that PC was looking for some specific, previously encountered or envisaged functionality that would allow him to use already established

repertoires of action (see §6.2.1.1 above), and that this functionality either did not exist, or was not readily apparent, in the rejected packages.

6.3 Animation

6.3.1 Animation Shop

The main animation application used in the study was Jasc Animation Shop, (AS), a basic package initially designed for the production of small animations for use on Web pages or in presentations. AS is bundled with PSP, with which it is tightly integrated. The AS interface, which is shown in Fig. 6.3, is similar to, but less complex than, that of PSP, consisting of a 'workspace' surrounded by pull-down menus and various (docked as default) toolbars, palettes, and panels. Animation sequences are created and played back in the workspace, using the Frames View and Play View windows respectively. Generally, AS proved easy for study participants to learn and use, and was adopted for, and adapted to, a wide variety of projects during the course.
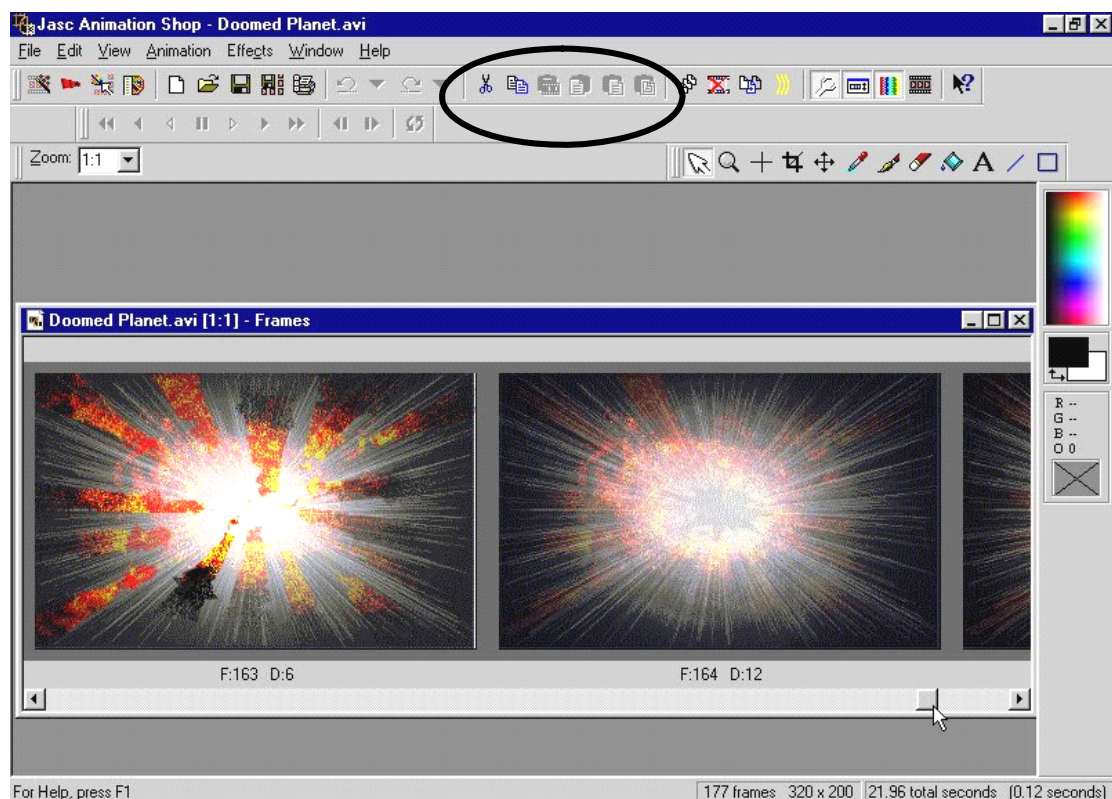
Figure 6.3: The Animation Shop 3 UI, showing frames from an animation sequence displayed in the Frames View window. A superimposed black ellipse indicates the Cut, Copy & Paste icon cluster.

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6.3.1.1 Problems with Paste and Insert Operations

During the study several learners became highly skilled in using AS in conjunction with PSP. In one frequently-used technique (described in §6.2.1.4 above) multi-layer source images generated in PSP were copied and pasted sequentially into consecutive frames of the AS. Users employing this technique frequently encountered problems with the cluster of AS toolbar icons used to invoke cut, copy and paste functions. Difficulties in distinguishing between the icons in this cluster (indicated by a superimposed black ellipse in Fig. 6.3) frequently led users to choose the wrong command, slowing interaction and producing frustration. An associated problem was that when inserting additional frames into an animation sequence in the Frames View window, the new frames were placed by default "before" (that is, to the left of) the currently active frame. This contradiction of the AS UI's visual syntax, in which the temporal succession of frames is "read" left-to-right, caused confusion for users throughout the study, and apparently remained counterintuitive throughout repeated encounters.

6.3.1.2 Problems with Inter-application Operations

On 4th April 2001 (Session 69, BDPFS 58, 59) participant learners CR and KY were observed to encounter catastrophic breakdown during their collaborative creation of two short animation clips using PSP and AS on one machine (Mill54). Both application windows were visible on the desktop. The AS window was in the foreground and apparently active, but unresponsive to user input and thus appeared (to CR & KY) to have crashed. Upon investigation by the researcher it became apparent that the learners had been using PSP to edit individual AS frames, having invoked the "Export Frames: To Paint Shop Pro" command from the File menu of AS. This command takes the content of any selected frames in AS and exports them to PSP as editable image files, starting up the application if it isn't already running. Invoking the command effectively locks AS until the PSP files are closed; when they are, AS becomes active again and the corresponding animation frames are updated to reflect changes made in the graphics editor. In this instance, a frame remained open in PSP, and thus AS was inactive. Whereas this type of seamless (that is, transparent to the user) inter-application integration might be assumed to facilitate the ICT-enabled work

process, in this case the lack of clear feedback as to the modal change in application status produced an opposite effect. This observation appears to lend support to arguments by Bødker (in *e.g.* Bødker, 1991, 1999a) and Bærentsen (2000) that removing the necessity for user intervention into, or diminishing the visibility of, transitions between application states may inhibit learning-in-use and provoke contradictions between user perceptions and the actual status of the work process.

6.3.2 Poser

A 3D graphics and animation tool, Poser, was used at least once during the study by most learners, in a series of small-group introductory sessions led by SRH (beginning in Session 19, 18th October 2000). One learner, PC, continued to use the application for the remainder of the course, developing significant expertise. Poser supports the generation and manipulation of three-dimensional representations of human and animal body forms. 2D and 3D images created in other graphics packages can be imported to Poser and used as backgrounds to the "stage". The application also has inbuilt animation functions; successive poses are recorded as a sequence of frames, animation sequences (in the form of AVI files) are automatically generated by "tweening",[9] using the recorded images as keyframes. Poser also includes other ingenious features, such as the ability to automatically generate walking motions around "paths" drawn onto the x-axis plane of the "stage" using inbuilt vector graphics tools. In general, learners found the application attractive, very quickly learnable, and usable; in interviews, many commented on how enjoyable they found working with it.

Figure 6.4 shows the Poser UI, which is of a non-standard design. Interactive controls in the form of "buttons", "indicator lights" and "wheels" surround a central "stage". Each component of the body models can be individually manipulated using the controls and various tools; groups of enchained elements (feet, ankles, legs, hips *etc.*) can be moved together with or without simulation of actual physical constraints. Feedback is in real-time; with no discernible processing lag on the hardware platforms in use. Despite Poser's complex functionality, participants were usually able to produce interesting results

rapidly, suggesting that its distinctive UI design was highly effective in supporting learning-in-use.
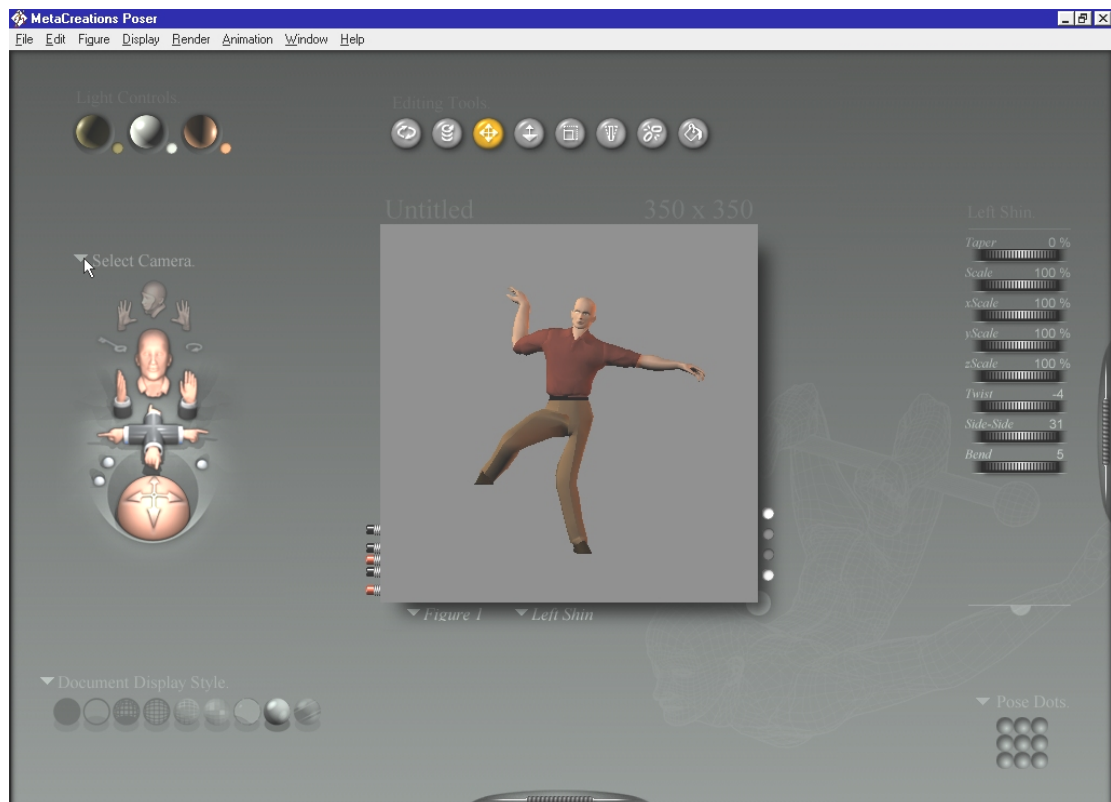
Figure 6.4: The Poser UI, showing a 3D model being manipulated with the Mover tool.

6.4 Audio Capture & Editing

The main application used for audio capture and editing was the digital multi-track[10] recording package Cool Edit Pro (CEP). CEP generally proved easy to use for editing and output operations, although - as with other applications in the study such as ScanJet, ATI VCR and UVS, see below - its initial setup (*e.g.* setting parameters for sample rate, bit depth *etc.*) required, and appeared to assume, additional background knowledge (in this case, of digital audio formats). During the study all initial setup operations with CEP were carried out by the tutors. The principal difficulties encountered with the application in operation were connected with the hardware/software interface. Interaction breakdown frequently occurred when attempting to enable audio input from a microphone and set appropriate recording levels. Although the version of CEP used during *Computer Creative* has input "meters" for use during recording, it does not provide any means of directly controlling audio input sources or levels. This task is handled by the Windows OS volume control (a utility invoked by double- or

right-clicking a loudspeaker icon in the Windows 98 system tray) which is discussed in §6.6.2 below.

In Session 29 (22nd November 2000) participant learner BD, an amateur musician, brought in and installed another audio recording/editing application, Cakewalk. This is a semi-professional software package with complex multi-track recording and editing functionality. Researcher/tutor SRH experienced catastrophic breakdown in attempting to learn and use the application, and was unable to either capture or edit audio. BD, who was accustomed to using Cakewalk at home to produce MIDI[11] files, was unable to assist SRH, finding that he could not employ his existing repertoire of actions and operations with the tool in the context of unfamiliar audio tasks. Use of the application was abandoned.

On several occasions during the study (*e.g.* in Sessions 29, 30, 31, November 2000), participant learners also explored the use of the Windows Sound Recorder, one of the OS accessories. Although learners found the application easy to learn and use, its functionality was too limited to be of practical use. Using Sound Recorder also involved the recording setup difficulties mentioned above.

6.5 Video Capture & Editing

6.5.1 ATI Multimedia Centre

During *Computer Creative* an analogue VHS camera (§4.4.1.3) was used by course participants for real-time and stop-motion[12] filming; its output was digitized through a capture card installed on PC Mill55. Interaction with the card was handled by a suite of bundled software which included ATI TV, used to tune to the camera signal, and ATI VCR, a DV recording tool.[13] No serious difficulties were encountered with either application. In the case of ATI VCR basic capture setup options (frame size *etc.*) were presented on the UI as choices (via radio button) from a small set of preset values. Although it was also possible to configure custom settings via an advanced setup mode, the presets proved adequate to requirements, as participant learners quickly established which were most suitable through trial-and-error.

One problem encountered with the digitization process was that the capture card utilized hardware (onboard) compression. This meant that captured video files, although ostensibly in a universal format such as AVI (as indicated by their file extension) could only be played back using an identical hardware configuration. In order to become machine-independent, the raw files produced by the conversion process required re-compression using an external (to the ATI suite) editing application. The ATI capture software UI gave no indication of this requirement, and the online help did not provide any relevant information. An assumption either that users would always capture, edit and playback on the same machine or have the appropriate background knowledge to deal with the technical issues involved thus appeared to be effectively designed into the ATI hardware-software ensemble.

6.5.2 Ulead Video Studio

All video editing during the longitudinal study was carried out using Ulead Video Studio (UVS). At this time (2000) UVS was being marketed to the then-emerging home DV market as a low-cost "pioneering video editor designed especially for beginners" which "Unlike other software ...features an intuitive step-based interface that helps users get started right away. By following the steps, from Start to Finish, you will be creating video masterpieces before you know it." (Ulead Systems Inc., 1999). On initial inspection the interface (see Fig. 6.5) appeared simple and similar to other applications already familiar to participants (*e.g.* Animation Shop). Learners involved in video projects, having invested substantial effort in planning, preparing and filming their projects, were strongly motivated to edit, and thus complete their work. However, despite learners' enthusiasm, in practice UVS proved difficult for them to learn and use, prompted multiple breakdowns, and often evoked strong negative emotional reactions from users. Those aspects of UVS's design and functionality which appeared to contribute to this situation are discussed below.

Figure 6.5: Ulead Video Studio in use during the longitudinal study, showing (top) the menu bar with selector/indicators of editing modes or stages, here with the Finish stage selected; and (middle, l-r) the Options panel, Preview window, and Library panel. The Timeline area is at the bottom of the screenshot, showing (top to bottom) the video, title, voice and music tracks.

6.5.2.1 Software/Hardware Issues

The basic DV editing process is based on a iterative cycle of composition (assembling media clips into sub-sequences, and sub-sequences into a whole movie), processing (*a.k.a.* rendering), and reviewing; projects may repeat this cycle many times before reaching the final output stage in which the whole movie is compressed and rendered into a standard DV file format. Many of the interaction problems encountered with UVS were exacerbated by the limitations of the hardware platforms available in Workshop 3 (see §4.2.3.2 & 6.2.1). Processing delays of unpredictable duration when rendering sub-sequences and movies for preview (always a minimum of 5 minutes and often in excess of 90 minutes as projects neared completion), plus frequent system crashes, made editing tasks tedious and emotionally stressful for some participants.[14] For example, in Session 46 (5th February 2001, BDPF 23, 24) participant learners BD, WE and SM repeatedly encountered problems while attempting the final render of a movie project containing multiple video clips, titles and a soundtrack incorporating both music and dialogue. As the session progressed they grew

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increasingly frustrated as (following a processing period of about 12 minutes) each preview did not match their expectations. The field notes record:

> Sections of video were too short or too long; music and voices occurred in the wrong places or sometimes not at all; titles either flashed by in an instant or crawled agonisingly slowly across the screen. SM was in despair, telling anyone who would listen that she'd have to "throw it all away and start again". BD was becoming angry, with himself, the computer and his companions. WE just looked on helplessly.

It was observed on this and several other occasions that users appeared to blame their own (or collaborators') lack of skill or understanding for the problems encountered, rather than the hardware/software configuration. In several cases the participant researcher (SRH) found it necessary to take on the responsibility for re-editing and rendering learners' DV projects outside of session hours in order that they might be successfully completed before the end of the course.[15]

6.5.2.2 Parameter-setting Problems

As was the case with several of the applications used in the study, successful operation of UVS appeared to hinge upon users' possession of technical knowledge not directly provided by the application itself. For example, initiating a new editing project requires the user to select a "template" from a dialogue box presenting around 25 different pre-set combinations of file format, frame size, frame rate, and codec.[16] Apart from a note that the presets result in either "high", "medium" or "low" quality results, no information is offered to indicate which might be the appropriate choice in any given circumstances; the online help simply states: "Select a template that matches your requirements" (Ulead Systems Inc., 1999). However, as the selected template determines both the time taken to process sequences for preview or final output and the viewing quality of the finished movie, the choice of an appropriate template is arguably of critical importance for the overall user experience. During the study workable settings were arrived at by the researcher and participant learners BD and LR through a series of discussions and trials-and-errors carried out over Sessions 26-34 (November & December 2000). For convenience, all new projects were subsequently based on these settings, although it was never established whether they were in any sense optimal. Project parameter setting continued to be a problem in subsequent video-based courses at the OLC (see Shelswell, 2005).

6.5.2.3 Problems with the Library

During a UVS editing project all materials (video, audio and title clips) are stored locally in the application database. Assets in the database are represented by thumbnails and icons displayed in the Library, a tabbed panel on the right-hand side of the UVS interface (Fig. 6.5). The basic composition process involves dragging thumbnails or icons onto the appropriate track in the project timeline, then adjusting their various attributes (duration, volume, *etc.*) as required. It was observed that some idiosyncratic design features introduced additional complexity into this process. For example, following each rendering and preview of a project a new video clip (an audio/video composite of the materials assembled into the previewed sub-sequence) was automatically created and stored in the database, and its corresponding thumbnail added to the video tab of the library. Thus, assets appeared in the library without the direct intervention of the user, who was otherwise required to deliberately import or capture project materials to the database. The unexpected appearance of these video clips – represented by thumbnails identical to the first video clip making up their sequence, which was already on display in the library – was a cause of considerable confusion for study participants working on UVS projects.

Additional problems were linked to the fact that UVS library assets are not uniquely associated with specific projects. Initiating a new editing project does not clear the library; rather, unwanted assets must be manually removed from the display by users. Furthermore, deleting an asset from a project requires users to choose (via an onscreen dialogue) whether to simply delete the thumbnail/icon from view in the Library panel, or actually delete the asset itself from the UVS database. If all unwanted thumbnails/icons were not removed – as was often the case with large collections of clips which required scrolling down the library panel to view in their entirety – they persisted among the assets associated with a project. These features of the asset management process appeared to greatly complicate the authoring process, as at each step of compiling a video sequence users were required to carefully consider whether the appropriate clip had been chosen. This often required users to repeatedly preview individual clips.

6.5.2.4 Metaphor & Modality

As its name implies, the basic metaphor underlying the design of UVS appeared to be based on the production stages of traditional film-making. Basing the UI design on this step-by-step approach imposes a *de facto* functional modality in the application; different steps or modes of the video editing process – as indicated by the "tabs" at the top of the UI (Fig. 6.5) – present the user with different configurations of application functionality. For example, when in soundtrack mode it is not possible to perform actions on video clips; when in storyboard mode, it is not possible to render or save a version of a sequence. In some modes, even basic operations such as saving the project file are unavailable.

During the study it was observed that these changes in modality were often not readily apparent to users. As noted, the main method of selecting and distinguishing between steps in the editing process is the highlighting of a "tab" or label at the top of the interface screen; other differences in the UI appearance were often subtle and difficult to distinguish (compare Figs 6.5 & 6.6). Thus, users frequently attempted to perform editing operations with the application in an inappropriate mode, such attempts resulting in the presentation of error messages and system alerts which users found difficult to interpret. Furthermore, changes in modality were usually only partially reflected by the UI, often in an inconsistent manner. While the transition from one stage to another (*e.g.* from the Title to Voice stage) was represented by an alteration in the range of functions and choices available in the Options panel, changing the Library panel to display the appropriate selection of (graphical or audio) assets required user intervention. The modal nature of the interface also meant that the work in progress (visible on the Timeline and in the Preview window) could be represented by a number of differing views; sometimes the results of operations carried out in one stage would not be discernible in another.

6.5.2.5 Problems with the Timeline

In UVS clips are clustered, sequenced, trimmed and otherwise adjusted on the project timeline (Figs 6.5, 6.6). The main problems observed during interaction with the Timeline were associated with the need to view clip sequences at differing scales. During editing users were required to "zoom in" to locate

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specific frames or frame-sequences within a clip, or to accurately locate junctions between clips. They then had to "zoom out" in order to see all or part of a whole movie in terms of successive sequences. In order to facilitate these different viewing needs, the Timeline offers two basic viewing modes. In Timeline mode (Fig. 6.5), video clips are shown as sequences of frames and in which all four tracks (video, title, voice and music) are visible and the Zoom facility is available. In Storyboard mode (Fig. 6.6), only video clips are shown, with each instantiation of a whole clip represented by a thumbnail of its first frame.

During the study it was observed that breakdowns with UVS increased as groups entered into the final stages of editing their projects. This appeared to be at least partly due to the increased complexity of the editing process, one significant aspect of which was the necessity – once projects had reached a certain length (duration) - to repeatedly transit between the different scales and modes of representation on the Timeline. Although participant learners were familiar with a frame-based, right-to-left timeline representation from working with AS (§6.3.1), they were observed to repeatedly encounter difficulties in interpreting the UVS Timeline in Timeline mode, especially when viewed at a scale where all the individual frames in a clip could not be displayed. Users appeared to lose their orientation within the timeline, frequently deleting or moving clips in error. Several informants reported experiencing difficulty in distinguishing between frames, clips, or sequences when seeking the appropriate object to manipulate.

6.5.2.6 The Guide

Previous sections have outlined some problems associated with the use of UVS, many which reflect the complex nature of the DV production process itself. One of the ways in which the UVS design attempted to support users in negotiating this complexity was through the provision of an on-screen Guide (Figure 6.6), a Help screen presenting relevant information which is invoked each time the application enters a new stage of the editing process. As can be seen from Figure 6.6, the Guide occupied a considerable amount of screen real-estate, in its default position completely occluding the Library panel until moved, minimised or closed by the user.

Fig 6.6: The UVS UI at the Storyboard stage (third "tab", reading l-r), showing the Guide in its default position and the Timeline in Storyboard mode, where only the first frame of each clip is shown.

In the longitudinal study users were observed to consistently react to the appearance of the Guide as an unwelcome intrusion on the work process, and usually immediately closed the window without reading its contents. During the second session in which UVS was introduced to the group (Session 22, 1st November 2000), learners CP and VB requested permission from the researcher to permanently disable the Guide so it would not appear again, a choice available from the Global section of the Options panel. Once this had been accomplished they informed other group members as to the steps of the disabling procedure. By the end of the following session (23) the Guide had been disabled on all Workshop 3 machines without any explicit intervention by the tutors, a striking example of the role played by the exchange of "episodic knowledge" (Bærentsen, 1996) in appropriating technology. Later that month (Sessions 32 & 33) it became necessary to reinstall UVS on a number of the workshop PCs following a hardware upgrade (in which additional RAM and CD-R drives were installed on some machines); over the next few sessions the Guide was again disabled by participant learners.

6.6 Software Utilities

6.6.1 Windows Explorer/My Computer/Network Neighbourhood

During the study the viewing and manipulation of locally stored and networked files and folders was mediated by the file management utility Windows Explorer (WE). *My Computer* and *Network Neighbourhood* are specific versions or instantiations of WE represented by desktop icons on the Microsoft Windows 98 OS UI desktop.[17] A double-click on either icon launches a window presenting a navigable overview of disk drives and selected folders installed locally (in the case of My Computer) or (with Network Neighbourhood) on other machines in the LAN. Throughout the study users were observed encountering breakdowns with these utilities; for example, incidents are recorded in field note entries for Sessions 14, 31, 37, 38, 47, 57, & 50 and BDPFs 7, 10, 16, 26, 44, 49 & 60. These difficulties – which were also informally observed in previous work at the OLC, see §1.2.1.1 – included problems with specific UI representations (*e.g.* folder views) and general functionality (*e.g.* window behaviour). As discussed previously, some aspects of these problems appeared to stem from users' lack of underlying concepts and background knowledge assumed, but not made explicit, by the application's design.

6.6.1.1 Conceptualizing Hierarchical Organization

Following discussions between the researcher and participant tutor (T) on the persistent recurrence of problems with file and folder operations in the early part of the course, it was decided to undertake a series of observations and interventions in order to elicit further information as to possible causes and solutions. Accordingly, from Session 28 (21st November 2000) onwards particular attention was paid to problems with moving, copying, opening and saving files, and extra efforts made to elicit information from learners as such incidents occurred. The tentative hypothesis which emerged was that, due to their educational background, participant learners may have never received specific instruction concerning the principle of hierarchical organization embodied in UI representations of PC storage systems, and had thus not acquired the "scientific" (in the Vygotskian sense, see §2.3.3) concept of "tree hierarchies". The absence of this concept (and thus a corresponding inability to visualize file and folder

operations in such terms) was seen as a possible special case of the "missing but assumed background knowledge" which emerged as a common factor in many of the interaction problems observed during the study.

In order to test this supposition a whole-group teaching intervention was organized (in Session 60, 14th March 2001) during which explicit instruction in the concept of tree hierarchies was given. This was accomplished through the creation of diagrams on the whiteboard, gradually built up through a dialogic interaction between the tutors and participant learners based on relevant real-world examples such as the organization of warehouses. At the beginning of the session only two of the group (DC and WE, both assessed as having Level 4 literacy skills, see Fig. 5.2) were willing to attempt define the word "hierarchy", while several members said they had not heard it before. Only three group members (BD, MM and LR, all male) claimed some understanding of the organization of a PC's storage structure. In the event, the nature of the study meant that no firm conclusions were able to be drawn as to the results of this intervention. However, the notion of identifying and attempting to teach "missing" concepts was considered sufficiently useful by the tutors involved to become incorporated into subsequent ICT/ABE courses at the OLC.[18]

6.6.1.2 Case Study: From Viewing to Doing with WE

In Session 25 (14th November 2000) learners DC and PR were working on their animated movie *Doomed Planet*. During this long-running project (October 2000 - May 2001; timeline 3 in Fig. 5.3b) the collaborators employed PSP and AS to produce several dozen digital graphics and animation files, using various Workshop 3 machines as circumstances dictated. As their skills improved, DC and PR developed the practice of transferring copies of their work-in-progress to an archive located in the HDD of their "base" machine (Mill50, Fig. 4.1). This procedure had been carried out at the end of the previous day's session (24), during which DC and PR had scanned a series of watercolours painted for the project. Resizing and cropping of the digitized images had been carried out on the machine to which the scanner was physically connected (Mill57, Fig. 4.1).

At the beginning of Session 25, DC and PR were unable to locate some of the files on either Mill57 or Mill50, and faced the prospect of having to redo several

hours' work. This was not untypical; DC and PR had encountered similar difficulties on several earlier occasions, and the problem of "lost" files was also frequently encountered by other participant learners involved in *Computer Creative*. While in many cases learners could clearly visualize and describe the content of a file, they often could not recall its name, location, or file format. From an activity-theoretical point of view, it can be speculated that the automatized or semi-automatized - and therefore mainly unconscious, see §2.4.1.2, 3.3.13 - nature of the operations involved in "clicking through" the Save As dialogues might preclude sufficient conscious attention being paid to the information in the *Save in* and *File name* fields of the dialogue box.[19]

The researcher aided DC and PR in locating their missing files by using the Windows search facility. However, during the retrieval process the collaborators decided that - with the aim of preventing a recurrence of the problem - they would like to set up a better-organized file structure, using more descriptive file names. In order to achieve this end DC and PR (with SRH looking on) worked together at Mill50, with PR operating the mouse and keyboard. PR double-clicked on the My Computer icon on the desktop, launching a window representing the PC's file storage hierarchy. She then selected the C: // drive icon from the display, causing the content of the window to change to a representation of the file system on the local hard drive. She then selected (or, in her words, "went into", *cf.* Bærentsen, 2000) the folder for her group, and then a folder labelled with her name. Throughout this process, only one window was open, its display content changing to represent navigation through the local storage hierarchy. Once the contents of "her" folder were visible, PR used the WE File menu commands to create a number of new sub-folders nested within it, in preparation for reorganizing the project files by moving them to more clearly labelled storage "locations".

At this point, breakdown occurred. PR desired to see all the relevant files simultaneously, and to simply drag and drop them from one folder to another. However the current WE UI configuration did not support this view. Whereas at this stage of the task PR required, and apparently expected a *new* window to open each time she clicked into a folder, the actual behaviour remained as before; with each double-click on a folder icon the window's contents were

updated, and the name on the title bar changed. The field notes record that "PR threw her hands up in despair, and DC began to complain about how 'stupid' the whole thing was, saying 'it's no wonder we can never find our files'". At this point, the two learners abandoned the file reorganization task. In the following session (26, 15th November 2000) SRH reconfigured the WE interface on Mill50 so that all folders opened in new, separate windows. Once this had been accomplished, PR and DC resumed the task, and carried on "getting organized" until the end of the session, opening folders, renaming files, and dragging and dropping files to their new locations. Again, PR operated the application while DC leaned on the back of her chair, offering support by continually reminding PR of the sequence of steps to be carried out.

The interactions with WE described here, which illustrate some limitations of its UI design, might also be thought to point to some of the strengths and weaknesses of the direct manipulation (DM) interaction model (Shneiderman, 1983, 1998) with regard to supporting users' goal-oriented activity. In this case it is clear that as the conscious goal of action changed from navigation, to folder creation, to file manipulation, the users' requirements of the interface representation – which from the point of view of the user *is* the functionality of the file management system - also changed. Initially, the default representation was adequate for navigation – an analogy can be made with the window of a moving vehicle, through which various virtual "locations" or "places" are seen. Having arrived at the "destination" (PR's personal folder), the view was also adequate to the task of creating new sub-folders in the current location. However, when the goal of the PR's action became that of moving virtual "objects" (the files) from one location to another, the UI representation proved inappropriate and breakdown occurred. The representation of both source and target location within the same window required the user to make the source location disappear in order to see the target location.[20]

Broadly speaking, DM offers two possible solutions to the problems with WE described above. Firstly, the application can be reconfigured to support the changing requirements of the user, by altering the folder view options so that each folder appears in a new window. However, such an intervention requires the user to consciously anticipate their need and either make the change before

beginning their task or interrupt the flow of activity during task performance to make the required adjustments. It should be noted that in the case of WE these adjustments are non-trivial, inasmuch as they require the identification and selection of appropriate options from both a pull-down menu and a tabbed dialogue box. Thus, while navigating through folders and dragging and dropping files in the default single-window view can be achieved through direct manipulation calling on established largely automatized operational repertoires, the operations involved in altering folder views require various conscious decision-making actions. This requirement to switch "levels" of activity arguably increases the complexity of the task; it may also be linked (as in the example given) to users perceiving an increase in task difficulty. If this is the case, and the task-in-hand is of insufficient significance for the user it may, as here, be abandoned. The other possibility available to the user is to launch another instantiation of the application. The user will then be able to drag and drop between windows, while each window maintains the default "new folder, new view" functionality. However, it was observed that users rarely chose to employ opening more than one instantiation of an application; moreover, in those cases where the use of multiple application windows was part of the task-solving strategy, breakdowns were observed to occur frequently. This issue is discussed further in the following chapter (§7.2).

6.6.2 The Windows Volume Control

Figure 6.7 shows various interface features of the Windows Volume Control, an OS audio control utility implicated in a number of breakdowns observed during audio capture and editing tasks (§6.5). In use, this tool requires users to switch between recording setup and playback modes according to the type or stage of audio task underway. Switching between modes, and enabling or disabling audio inputs and outputs (including making slider controls visible for user manipulation) is achieved using radio buttons and checkboxes in a properties dialogue box (Fig. 6.7b), invoked from the Options pull-down menu in the Volume Control UI. In both modes audio input and output levels are set using slider controls. In recording mode, checkboxes below the slider must be checked to *enable* (select) the channel and sliders; in playback mode the checkboxes *disable* (*i.e.* mute) the channel and its controls. This contradictory aspect of the

UI design was consistently confusing for users; often many trials-and-errors were required before the correct configuration for recording was achieved. In some cases further complexity was added to the recording setup process by the additional need to manipulate physical playback volume controls on PC monitors or speakers.
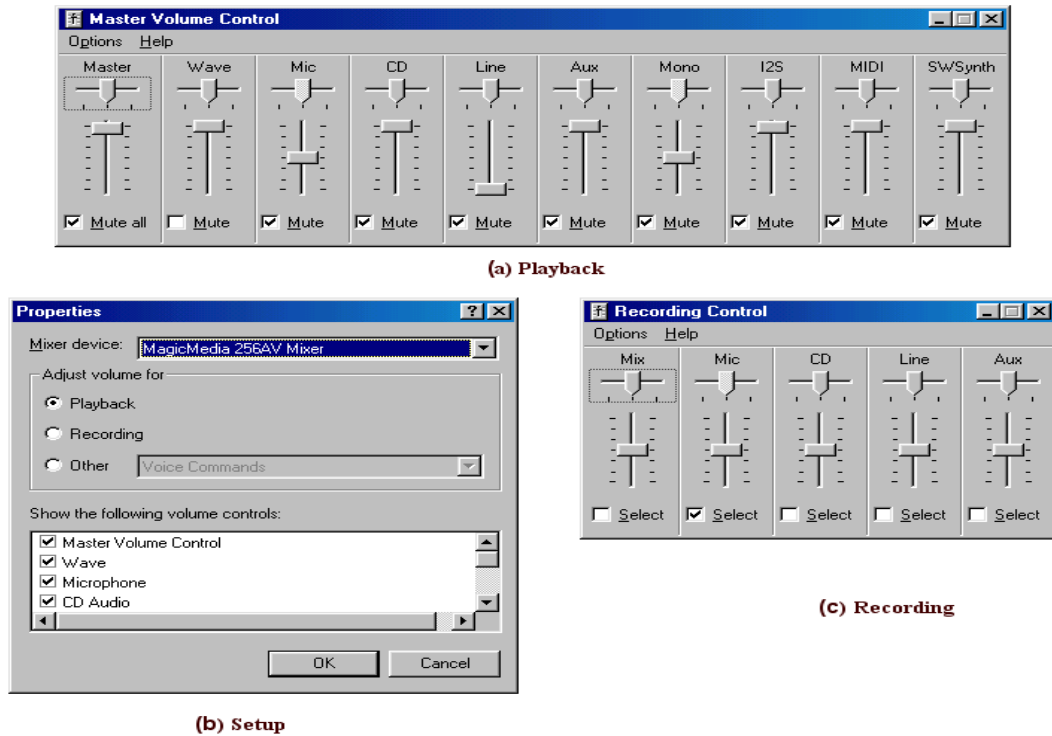
Figure 6.7: The Windows Volume Control, showing (a) playback control mode, (b) the properties dialogue box, and (c) recording control mode.

6.6.3 Nero Burning Rom

CD-write/rewrite drives were installed on Workshop 3 machines during the longitudinal study. The software supplied with these drives, Nero Burning Rom, proved to be almost completely unusable by both tutors and learners.[21] The field notes record numerous breakdowns during CD-writing (*e.g.* sessions 32, 39, & 61; BDPF 6, 15, 51); repeated attempts to develop better working practices with Nero were unsuccessful. The CD writing process was controlled through a wizard, each step of which required users to select from a variety of options. Differentiating these options required considerable background knowledge of the properties and design of CD-R and CD-RW disks. Little guidance was provided by the UI as to which options were optimal; once choices had been made, it was often not possible to judge if they were appropriate until the burn process had

completed. There was insufficient feedback to the user during the burn process, which, on the hardware available, was often extremely slow (up to 45 minutes) and frequently resulted in unusable disks. Nor was it advisable to use the machine for other operations during the burn process, for fear of system crashes. Thus, the problems with Nero's UI design were exacerbated by hardware limitations, and the CD-writing process was perceived by participant learners as frustrating and difficult. It was avoided whenever possible. Consequently, most of the data archiving to disk was done by SRH, post-session.

6.7 Web Browsing, Searching, & Authoring

6.7.1 Web Browsing

The Microsoft Web browser, Internet Explorer, (IE, version 5) was used for viewing Hypertext Mark-up Language (HTML) files and other media downloaded from the World Wide Web (WWW). Learners encountered few major problems; minor difficulties mainly involved users' following "dead" hyperlinks from the Google results pages (see below) and thus triggering IE error messages indicating that the file could not be retrieved. The unexpected appearance of "pop-ups" – small, automatically-launched browser windows displaying advertising materials - was also an occasional source of concern, as some emulated the appearance of Windows OS interface elements such as alert boxes, often displaying a false warning of virus infection. Participant learners found these alerts confusing and worrying.[22] IE was also used during Web authoring to view HTML pages created with Notepad (see below) and stored locally. Here, problems were observed to occur when using multiple IE windows (see below and §7.2).

6.7.2 Searching & Webmail

During the research stage of many projects IE was used to access online search engines, the most popular being Google (http://www.google.com/). Participant learners found Google's dedicated image search facility especially attractive and useful. Several learners (mainly BD, DC, DH, DK and MM) also used IE to interact with Web-based email services such as Yahoo! Mail (http://mail.yahoo.com).

6.7.3 Web Authoring

The main application used for HTML authoring was Notepad, a basic ASCII[23] text editor bundled as an accessory with the Windows OS. Notepad was introduced to the class through a series of small-group teaching sessions (numbers 46 – 52) in February 2001. Few difficulties were encountered with Notepad *per se*, but when used in combination with IE and other applications, the opening of multiple instantiations of the program contributed to some breakdown incidents. One of these is discussed in detail in §7.2.

In two sessions in June 2001 (not numbered; see §5.2.1) participants BD and DH attempted to use a WYSIWYG HTML editor, Macromedia Dreamweaver, to create Web pages. Their engagement with the application was not extensive enough to draw any firm conclusions as to its usability; the main difficulties observed were connected with DW's inbuilt File Transfer Protocol (FTP) utility, and appeared to stem from users lack of appropriate background and technical knowledge. In other course sessions during June and July 2001 a Web-based authoring application, Blogger (http://www.blogger.com/), was used by learners BD and DH (via the IE browser) to create a group Weblog.[24] No breakdowns were observed.

6.8 Miscellaneous Software

6.8.1 MS Word

As the design of *Computer Creative* (§5.1.1) focused on supporting situated "literacy events" (Barton *et al.*, 2000) rather than specific instruction in reading and writing, text creation was not a central activity of the course. However, on several occasions Microsoft Word 98 (Word) was used by participant learners to word-process written pieces such as movie synopses, scenarios, and scripts. At the beginning of the course a majority of the learners (19/23) reported some prior experience with Word; however, the extent of this experience was found to vary greatly between individuals (Fig. 5.2). It was noted in §5.4.2 that in most of the collaborative activities observed an informal division of labour was negotiated. In the case of word-processing tasks the more experienced persons in the group would generally volunteer to operate the software whilst other members prepared

hand-written drafts and/or gave dictation. Breakdowns with Word were mainly connected with the use of pull-down menus; even the more experienced learners appeared to find it difficult to remember the location of specific menu commands.[25]

During the study Word was also occasionally employed as a graphics editor, making use of the application's inbuilt Drawing tools and ClipArt library[26]. In session 49 (12th February 2001; BDPF 29) learner JH experienced catastrophic breakdown when attempting to cut and paste an image from Word to PSP in order to access editing functions not provided by Word. The breakdown was due to incompatibilities between the file formats in use; JH had assumed inter-application compatibility on the basis of work with PSP and AS and evidenced surprise and frustration when the operation repeatedly failed to produce the results he had anticipated. Recovery was impossible without engaging in file-conversion processes requiring some background knowledge of computer graphics formats; DH abandoned his attempt to use PSP and began a new graphics task solely using Word.

6.8.2 Logo

From session 42 (24th January 2001) onward several participant learners (principally CP, LR, SC, and SM) undertook introductory programming exercises using Mach Turtles Logo Learning Edition, a commercial version of the Logo programming environment developed for use in schools (Papert, 1980, Goodyear, 1984, Papert, 1993, and see Notes 1 & 3, Chapter 1). In general the application proved highly learnable and usable. However, one interaction problem observed appeared to stem from differences between Logo's functionality and that of other packages which accept text input (*e.g.* Notepad, Word) with which learners were already familiar. The field note entry for Session 55 (5th March 2001) records user LR encountering breakdown when wishing to save (and subsequently print) the code he had been typing into the Logo UI:

> …what he wanted to do was save the file, however, when he went to the file menu the save and save as options were dimmed. I discover that LR is using the "listener" section of the interface - the command line prompt.

LR had anticipated that the command-line input section of the Logo UI would function in the same way as a text editor. Further investigation of this incident revealed that LR and his collaborator on the Logo project, CP, had encountered this problem at least once before, and recovered by making use of an inbuilt Logo function which allows the capture (as graphics) and printing of the contents of all active application screens. However, in this case LR had not immediately recalled this prior experience; he apparently attempted to utilise a series (or "repertoire") of routine operations automatized during his previous use of Word and Notepad.

An interpretation of this lapse in activity-theoretical terms is based on the observation that immediately prior to the breakdown incident LR and CP's efforts (to print the code) were guided not by the immediate goals of the programming task in hand but rather by the supervening task-goal of collecting materials for their accreditation portfolios. These cognitive conditions might be said to have "triggered" an operational repertoire usually appropriate to the printing task, but unsuitable for the specific tool actually in use. This emphasizes the need to consider the broader context of work when analysing any isolated interaction incident. The users' prior development of an effective workaround – which was subsequently recalled and used to achieve the task-goal in the instance reported here - also illustrates the role breakdowns play in processes of technology appropriation (§3.5.1.3) through experiential learning.

As was noted in §5.5.1, the use of Logo prompted some of the few instances in the study in which participant learners made any use of support materials. Following guidance from the tutors, learners SC, LR, CP and BD printed out *Starting with Logo* instructions from the online help system and used them as a guide when programming. On inspection the materials were found to be brief, simple, clearly written, reliable, accurate and useful, as might be expected from Logo's functionality and history. Logo support materials were specifically designed for pedagogy, and have been refined through the sharing of considerable practical classroom experience among a network of enthusiastic education professionals (see Notes 1 & 3, Chapter 1). When working with Logo users carry out all basic tasks within a consistent environment, designed for novice programmers and computer users, and which requires very little

underpinning knowledge or previous experience for successful operation. This results in a close correlation between the documentation and the actual actions required, and between the predicted and actual outcomes of user actions.

6.8.3 PowerPoint

Toward the end of the course (in sessions during July 2001 not recorded in the field notes but represented by other data sources; see §5.2.1) a number of participant learners developed presentations with the MS Office application PowerPoint 98 and delivered them to the whole learning group. PowerPoint is a presentation graphics program which allows the combination of media files (graphics, video, audio) with text and hyperlinks into sequences of individual frames or slides, and their subsequent playback (automatic or manually triggered) as a "slideshow". At this stage of the course, with all participant learners having developed their ICT skills to some degree, PowerPoint was quickly adopted. The application provides a wide array of basic slide templates with text and image input areas which can be quickly and easily customised by users. Only minimal introduction by the tutor or a peer was required before learners were able to produce acceptable results by adapting a template. In end-of-study interviews, participants reported finding PowerPoint to be one of the most attractive, easily learned and used, and useful packages encountered during the course.

6.8.4 The VR Worx

In the closing months of the study two learners (CP & MM) experimented with The VR Worx, a package which enables the creation of QuickTime VR panoramas, interactive graphic images that simulate a 360º view of an environment. There were contrasting results: while CP found the package difficult to learn and rejected it, MM, found it attractive and easy to learn and use. Interview data suggested that these reactions were linked to the learners' differing expectations of the speed with which results should be obtained; CP reported hoping for quick results and being dismayed when unable to achieve them in the first hours of interaction with the package. MM said he was prepared to work more slowly, and considered the anticipated outcome worth some sustained effort to achieve. These variations in expectation may have been

connected with their previous experiences on the course, MM having worked with a wider variety of software. However, after discussions with the participant tutor and other OLC staff the researcher concluded that sociocultural factors were more relevant to explaining these observed differences in behaviour. At the time of the experiments, CP was involved in one of the "legitimation conflicts" referred to in §5.1.2. She reported feeling somewhat marginal to the learning group and its activities, and it was observed that this had the effect of lessening her motivation with regard to engaging in course tasks. As noted in §5.4.1 & 6.6.1.2, tasks perceived as difficult are less likely to be undertaken or completed by users for whom they have little significance; CP apparently lacked sufficient motivation to sustain engagement with the multiple-stage panorama-building task. It is unclear to what extent the UI design of The VR Worx might have contributed to this situation, although it might be speculated that interactive feedback as to the extent to which the task was near completion might have proven helpful in ameliorating this problem.

6.8.5 Multimedia Builder
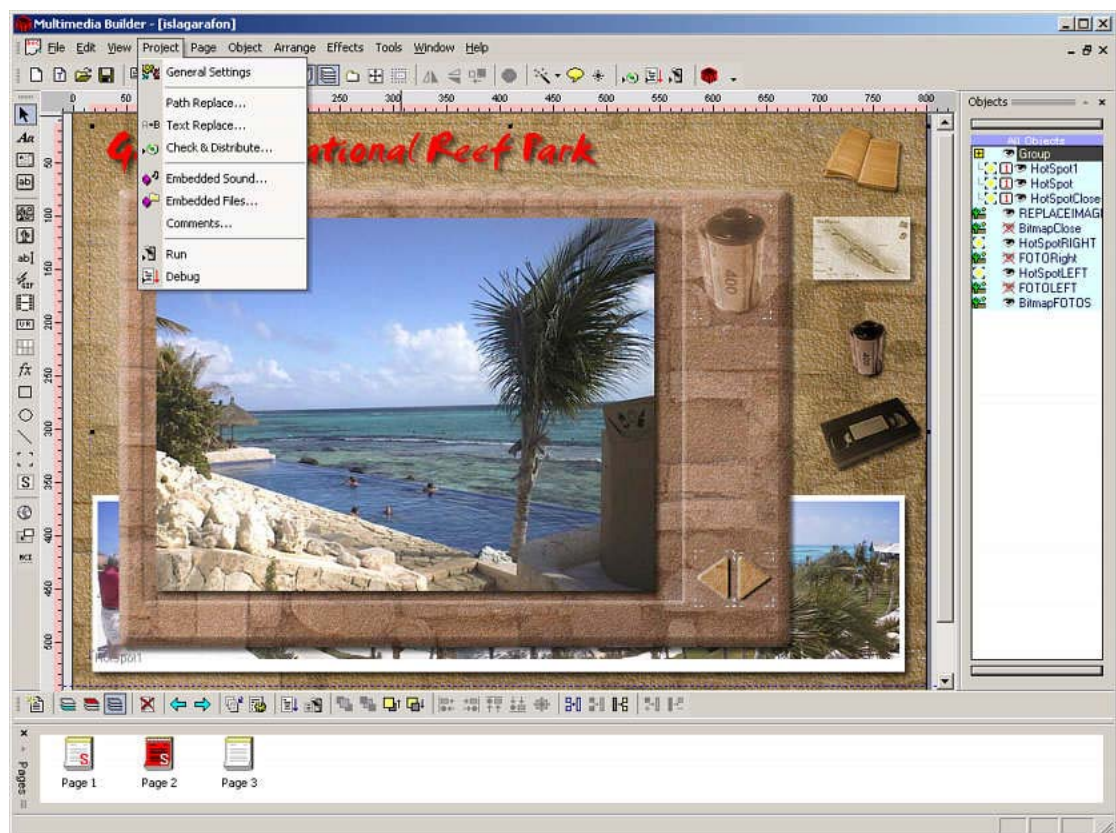
Figure 6.8: Multimedia Builder.

In the latter half of the study learners MM and PR made extensive use of a multimedia authoring application, Multimedia Builder, which MM downloaded from the WWW[27] and installed during Session 54 (28th February 2001). This shareware tool supports the creation of stand-alone multimedia applications such as tutorials, interactive kiosks, and autorun CD browsers. The application UI (Fig. 6.7) makes use of many standard Windows and MS Office elements and is also similar to that of PSP. The creation of interactivity is based on the use of "objects" placed on a virtual canvas and their hierarchical ordering and temporal sequencing is achieved using a "pages" metaphor. The two learners found this design highly learnable and usable for authoring, readily transferring their established skills. Both successfully completed several small projects. However, some system crashes were experienced by MM when attempting to autorun executable files produced in the final output stage of the authoring process. Investigation by the researcher revealed that this was due to inappropriate parameter settings being applied by default during the executable creation process. As was often observed during the study in connection with other applications, MM simply clicked "OK" to accept the default settings offered in a series of dialogue boxes during the executable creation process, without questioning their suitability.

6.8.6 Other Packages & Utilities

During Session 51, in February 2001, the whole group interacted with a ChatBot application, WinAlice.[28] Learners typed input and read output, with all interactions recorded in log files for later analysis.[29] No operational difficulties were encountered, and learners found the program attractive and enjoyable to use. HP ScanJet, a scanning/OCR utility bundled with the workshop scanner and installed on the machine to which the scanner was connected, proved, for the most part, trouble free in operation. However, it was observed that - possibly due to a lack of appropriate background knowledge - users avoided altering the default settings, with the consequence that scanner output was not always appropriate to project needs and often required further processing in a graphics editor.

6.9 Summary

Twenty-six software packages with differing processing and storage requirements were observed in use during Phase 1. Participant learners found many of the applications attractive and easy to learn and use; however, some consistently presented greater difficulties, and a few were rejected outright as being unusable and/or not meeting expectations. The majority of breakdowns noted by the researcher were associated with the more complex applications and tasks; most breakdowns linked to specific user interface (UI) design features involved modes, dialogues and alerts, menus, and the use of multiple windows. Changes to familiar UI designs also appeared to prompt some breakdowns.

Many of the users in the study achieved highly skilled operation with the 2D graphics application Paint Shop Pro (PSP); however, problems were encountered with the transfer of existing skills, the "instability" of the PSP UI, with layers, modality, and selection persistence, and with contradictions and inconsistencies in the functionality of the Picture Tube Tool. Several other 2D & 3D graphics applications were employed during the study with varying degrees of success. Animation Shop (AS) generally proved easy for study participants to learn and use; some problems were encountered when pasting and inserting frames and during inter-application operations. The 3D package Poser was found by most users to be attractive, learnable, and usable; its non-standard UI design appeared particularly effective in supporting learning-in-use. Numerous problems were encountered during audio recording and editing, particularly with configuring the hardware/software interface, a task made more difficult by the UI of the OS audio utility Windows Volume Control. Most users experienced difficulties when using Ulead Video Studio (UVS), encountering problems with software/hardware issues; parameter-setting operations; the Library; metaphor and modality; the Timeline; and the online help system. Some operations with packages such as Nero Burning Rom appeared to require additional technical background knowledge not provided through the UI of the applications themselves; a case study of Windows Explorer highlighted the way in which its design appears to assume that users have acquired a conceptual understanding of tree hierarchies.

Notes to Chapter 6

[1] Some tools also fulfilled supplementary roles, *e.g.* MS Word, used for both word-processing and graphics creation.

[2] The components of the basic MS Office application bundle are Word, Publisher, PowerPoint, Excel (spreadsheet), and Access (database). Excel and Access were not used during *Computer Creative*.

[3] Pre-course the PSP/AS bundle was selected by tutors as a more cost-effective and user-friendly option than using Adobe PhotoShop (the industry standard, known for its complex UI) and a stand-alone animation package.

[4] Manufactured by the Corel Corporation, http://www.corel.com.

[5] Following a period of infrequent attendance (Sessions 8-13) WH dropped out of the course in November 2000. At the time, interpersonal relationships within the group were seen by tutors as the main factor behind this decision; in retrospect it became clear that WH's inability to master PSP while others were becoming skilled in using the application contributed toward his increasing marginalization within the emerging community of practice (for a related discussion of issues of "illegitimate peripherality" in *Computer Creative* see Harris and Shelswell, 2005).

[6] Once the *Computer Creative* community of practice was fully established, cases where breakdown was sudden and the cause not readily apparent to the user frequently gave rise to demonstrative vocal reactions, which the group came to consider a normal and appropriate way to signal breakdown and the need for help. This is an example of the non-material objectification of praxis (see §2.3.1, 3.5.1.1).

[7] By default, the background layer in a PSP image is created as a raster layer (*i.e.* a grid of pixels); the operation of creating a vector object (*i.e.* a set of point and direction values) automatically inserts a new vector layer "on top" of, and initially linked to, any currently active raster layer. Changing between active raster and vector layers invokes various UI changes including the "greying out" of a number of tool icons.

[8] Picture Tube source files can be visualized as an array of raster image variations arranged in rows and columns of cells. As users paint with the tool, one cell after another is placed, either in a linear progression through the array or randomly according to the options selected. Some Picture Tube files consist of series of discrete images, while others create the effect of one continuous image.

[9] A computational technique which calculates the incremental changes required to transform the pixels of one "key" frame to those of the next, allowing the automatic interpolation of a series of computer-generated images between the key frames to produce a smooth animation sequence.

[10] In the sense that it supports the recording and playback of four separate audio data streams simultaneously.

[11] Musical Instrument Digital Interface.

[12] An animation technique which involves using the film or video camera for "frame-by-frame" composition of an animation sequence. The technique is generally used to animate models or puppets. A single image is captured; several elements of the scene are slightly repositioned; another image is photographed; and so on, with between 15 and 30 frames created for each second of animation.

[13] A basic video editing application was also included with the ATI software, but was not used in the study as the more fully functional Ulead Video Studio package was also bundled with the card.

[14] Readers are reminded that the Workshop 3 machines (whose specifications are set out in §4.2.3.2), were purchased and installed in 1998, since when there have been large increases in PC processing power (according to Moore's Law, Note 12, Chapter 1) and storage capability.

[15] These interventions by the researcher exemplify the ethical challenges involved in participatory action research (see also §5.2.1). Here, it was clear that supporting participant learners' success in the activity should be prioritised over the possible design-oriented insights to be gained from observing the process of project failure.

[16] COmpression/DECompresssion algorithm.

[17] WE, My Computer and Network Neighbourhood are treated as one application for the purposes of the discussions that follow.

[18] *CyberLab*, an experimental ICT/ABE course developed delivered by the researcher in 2003-4 (described in Harris, 2005b) was based on facilitating learners' acquisition of a series of such "scientific" concepts through various instructional strategies and constructivist activities with computer artifacts. This work drew on Gal'perin's stage-by-stage theory of learning (Gal'perin, 1969, Haenen, 1996, Haenen *et al.*, 2003), and mainly focused on strategies for providing an "orienting basis" for goal-oriented computer-mediated learning activity.

[19] Another useful discussion of this kind of problem from an activity-theoretical viewpoint can be found in (Raeithel and Velichkovsky, 1996).

[20] Related critiques of DM can be found in (Beaudouin-Lafon, 2000, Beaudouin-Lafon and Mackay, 2000). Proposals for UIs designed to represent "moving" from one virtual "place" to another in ways that accord with human perceptual capabilities can be found in (Bærentsen, 2000). *Cf.* the passage and the papers cited above with the discussion of "co-ordination by tightly-coupled windows" in (Shneiderman, 1998, pp. 458-462).

[21] The difficulties discussed in this section partly stem from the relative immaturity of CD-R/RW technology on the PC platform at the time of the longitudinal study. Significant improvements have been made since 2001, and CD writing is now fully integrated into the Windows XP OS. Current versions of Nero feature a highly simplified and effective wizard. It should also be noted that the cost of blank CD-R discs in the UK is now around 10% of 2001prices.

[22] While this once-common problem has been addressed in later versions of IE and Google, which now block pop-ups, since the time of the study there has been a huge increase in the amount of such malicious material ("malware") on the Web.

[23] ASCII: American Standard Code for Information Interchange. A standardized character set and method of encoding text using 256 combinations of 7-bit or 8-bit binary numbers.

[24] A Web-based diary or journal for which users create posts containing text, images and hyperlinks using an online WYSIWYG HTML authoring environment.

[25] It should be noted that the software in use here was MS Office 98, which employed static pull-down menus. In later studies (*e.g.* Harris, 2005b, Harris and Reddy, 2005) it was found that the recurrent problem of failure to locate menu commands was exacerbated by the introduction of dynamically adaptive menus with MS Office 2000.

[26] A database of copyright-free bitmap and JPEG images for use in Word documents.

[27] Available from http://mmb.mediachance.com.

[28] ChatBots are software programs which simulate natural language conversations between human and robot/computer in real time. Input sentences are analysed on the basis of decomposition rules triggered by key words in the text. Responses are generated by reassembly rules associated with selected decomposition rules. Famous early examples of ChatBots include Eliza, a simulation of a Rogerian psychotherapist developed by Joseph Weizenbaum in the mid 1960s, and Parry, a simulated paranoid schizophrenic developed by Kenneth Colby in 1972. Information about current ChatBots can be found at http://www.botspot.com/. WinAlice is a variant of Alice, a generic ChatBot, see http://www.alicebot.org/. The experimental use of WinAlice described here is part of ongoing research by the author into the use of robotics in adult basic education; accounts of other interventions can be found in (Harris, 2005b) and (Harris and Reddy, 2005).

[29] Incomplete at the time of writing (autumn 2006).

7. Phase 1: Further Analysis

This chapter continues to use activity-theoretical methods to analyse the Phase 1 data for connections between interface, application, and use-setting design features and interaction breakdown. It begins by describing a general usability evaluation of the applications used in the study, discussing attempts to identify common factors underlying cases of recurrent interaction breakdown. Other work in the post-study period focused on the detailed examination of selected interaction sequences; the second section of the chapter presents a case study of breakdown and recovery during Web authoring using a combination of ATIT analysis techniques.

7.1 Use, Usability & Breakdown in the Longitudinal Study

7.1.1 The Usability Evaluation: Methods

Following the end of active data-gathering a general usability evaluation was carried out on the computer artifacts used in Phase 1 (Table 6.1). The aim was to "triangulate" (§5.2.2.1) and, if possible extend, findings on learnability and usability emerging from earlier analyses. The evaluation combined three established techniques: (1) usability *testing*, where application usability is assessed by users working on typical tasks with the tool; (2) *inquiry*, where information about users' likes, dislikes, needs, and understanding of applications is obtained through interviews and observation; and (3) *inspection*, where usability specialists (in this case, the researcher) examine usability-related aspects of the user-interface (Shneiderman, 1998, Dumas and Redish, 1999, Gould and Lewis, 1985, Nielsen, 1994). Techniques 1 and 2 (testing and enquiry) were applied during a retrospective analysis of the field data carried out by the researcher over several sessions in the period August 2001-January 2002. Usability testing was based on a close examination of descriptions and recordings of participant learners' experiences during typical tasks, with particular attention paid to the levels of *control*, *efficiency*, *helpfulness* and *learnability* described in the field note entries (§4.4.1.1) and BDPFs (§5.2.2.3). Usability enquiry involved scrutiny of the interview (§4.4.1.2) and video-recording (§4.4.1.3) transcripts, and those passages in the field notes recording

application-specific dialogues, particularly with regard to the evaluation criteria *attractiveness* and *helpfulness*. The usability inspection (technique 3) was carried out in Workshop 3 during the OLC summer recess of August 2001.[1] This principally involved a "walk-through" by the researcher of the performance of a typical task with each application (Polson *et al.*, 1992, Wharton *et al.*, 1994, Bertelsen, 2003). The aim was to identify and note at each step of the task whether: (a) the appropriate action is obvious to the user; (b) the user is able to connect the correct action with the desired outcome; and (c) whether the action will trigger appropriate feedback from the interface.[2]

Table 7.1: Usability evaluation criteria and scoring scales.

Criterion[1]	*Evaluates*[3]	*Scoring Scale*[2]
Attraction	Degree to which participants were motivated to appropriate the tool into activity.	1. Little or no interest in using the tool 2. Some showed interest in using the tool 3. Moderate interest in using the tool 4. Many showed some interest in using the tool 5. Most showed strong interest in using the tool
Control	Degree to which users, rather than the tool, set the pace and style of task activity.	1. Tool afforded very little control to user 2. Tool afforded some control to user 3. Control balanced between user and tool 4. Tool afforded good control to user 5. Users feel in complete control of tool
Efficiency	Degree of effectiveness in enabling users to achieve task goals.	1. Highly inefficient and ineffective in use 2. Poor efficiency and effectiveness 3. Reasonably efficient and effective in use 4. Good efficiency and effectiveness 5. Highly efficient and effective in use
Helpfulness	Extent to which the tool assisted and supported users to achieve task goals.	1. No help or support offered for use activity 2. Poor help and support for use activity 3. Moderate help and support for use activity 4. Good help and support for use activity 5. High level of help and support for use activity
Learnability	Ease of initial use, and learning and employment of more features of tool as activity unfolds.	1. Each use as difficult as first 2. Difficult to learn, but progress possible 3. Reasonably easy to learn, reasonably easy to make progress 4. Easily learnt during first use, good ongoing learning with extended use 5. Quickly and easily learnt during first use, very easy and ongoing learning with extended use
Usability	Overall attraction, control, efficiency, helpfulness and learnability of tool	Overall rating:[3] a. 5-10 Poor usability b. 10-15 Moderate usability c. 15-20 Good usability d. 20-25 Highly usable

Notes:
1. Usability criteria derived from ISO 924-11.
2. Scoring scales based on BASELINE user validation project materials from http://www.ucc.ie/hfrg/baseline/.
3. Criterion descriptor & overall ratings scale developed by the author.

Practically, this involved the compilation of a minimum of three usability checklists for each of the 26 tools evaluated. Applications were allocated scores (of 1-5 in whole-number increments) against each of five usability criteria - *attraction*, *control*, *efficiency*, *helpfulness* and *learnability* - adapted from the definition of usability set out in ISO 9241-11.[3] The scoring scales were derived from the BASELINE usability evaluation materials developed by the Human Factors Research Group at University College, Cork.[4] The usability criteria, their definitions, and the 5-point scale associated with each criterion are set out in Table 7.1. Some efforts were also made to provide additional context for the interpretation of the usability ratings. These involved (1) estimating the frequency with which applications were used during the longitudinal study, and (2) evaluating the necessity for users to employ a particular tool in order to carry out their work activity.[5]

7.1.2 The Usability Evaluation: Results

Table 7.2: Usability scores of tools used in the longitudinal study.

Tool	Attraction	Control	Efficiency	Helpfulness	Learnability	Overall Usability	
PowerPoint	5	5	5	5	5	25	
Animation Shop	5	4	4	3	5	21	
Digital cameras	5	4	5	1	5	20	High
Logo	3	4	4	4	5	20	
Paint Shop Pro	5	4	3	4	4	20	
ATI TV	3	4	4	4	3	18	
Camcorder	4	3	4	3	4	18	
Notepad	1	5	5	2	5	18	
Poser	4	3	3	3	4	17	Good
Cool Edit Pro	3	3	4	3	3	16	
Word	4	3	3	3	3	16	
HP ScanJet	4	4	4	2	2	16	
Internet Explorer	3	4	4	2	3	16	
Cool3D	2	3	3	3	3	14	
VR Worx	3	3	3	2	3	14	
WinAlice	3	1	4	3	3	14	
Dreamweaver	4	3	2	2	2	13	
Ulead Video Studio	4	3	2	3	1	13	Moderate
Windows Explorer	2	4	4	1	1	12	
Bryce	3	2	2	2	2	11	
Sound Recorder	2	3	2	1	3	11	
Printers	5	1	1	1	1	9	
Cakewalk	3	1	1	1	1	7	
Nero	1	1	2	1	1	6	Poor
Painter 3D	2	1	1	1	1	6	
Volume Control	2	1	1	1	1	6	

The usability scores were compiled into a spreadsheet and combined and averaged; total scores against each criterion were then summed to produce an overall usability rating for each application. Table 7.2 presents the results. It can be seen that the majority of tools (16/26, 61.5%) were evaluated as being of moderate or good usability, with a smaller proportion found to be of either high (5/26, 19.25%) or poor (5/26, 19.25%) usability. In general the results of the usability evaluation exercise were congruent with the informal judgements about learnability and usability made by the researcher (and recorded as comments in the field notes) during the active observation period. With a score of 25/25, the presentation software MS PowerPoint (§6.8.3) was evaluated as the most usable application overall. Other highly rated packages included Animation Shop (21/25, see §6.3.1), Paint Shop Pro (20/25, §6.2.1), and Mach Turtles Logo (20/25, §6.8.2). The Windows Volume Control (§6.6.2), Painter 3D (§6.2.2) and Nero Burning Rom (§6.6.3) were evaluated as having the lowest usability, with a rating of 6 points each.

The methods used and results of estimating tool use frequency and use necessity are presented as Appendix 5. There appeared to be some slight positive correspondence between use frequency and usability, perhaps suggesting that in general the applications chosen during the design stage of *Computer Creative* (§5.1.1) proved fit for purpose.[6] For example, the graphics editing package Paint Shop Pro (PSP, §6.2.1), the most frequently used application, was also evaluated as highly usable. This might also suggest that those infrequently used applications retrospectively evaluated as highly usable (*e.g.* PowerPoint, Logo) could have been better utilised, especially in the early stages of the course when the outcomes of users' initial encounters with ICT tools might be supposed to have an impact on their subsequent involvement. Analysing the relationship between necessity of use and use frequency supported the finding (from observation, interviews, *etc.*) that several of the most required tools in the study were among the least usable, *e.g.* the Windows Volume Control (§6.6.2) and Nero Burning Rom (§6.6.3). This suggests that either (1) a higher priority should have been given to replacing such applications once recurring problems were detected or (2) tasks should have been redesigned to avoid using the tools concerned.

7.1.3 Further Analysis of Breakdowns

The usability evaluation outlined above entailed a comprehensive review of the interaction breakdowns observed during Phase 1. As discussed in §5.2.2.3, a majority of the breakdowns observed during the study (68%) were categorised as "constructive", inasmuch as they prompted learning-in-use (through dialogue about, and exploration of, the computer artifacts mediating activity) and were followed by recovery, *i.e.* resumption of the task-in-hand. This process of breakdown, learning and recovery was associated with improvements in participants' skills and corresponding gains in confidence.

However, around 18% of the total breakdowns observed[7] resulted in either temporary or permanent abandonment of the task and/or temporary or permanent rejection of the tool in use. Furthermore, just over 8% were of a type consistently encountered by users when engaged in certain actions, operations or sub-tasks, especially in those cases where there was no substitute tool or alternative strategy available for task solution. When considering those situations in which catastrophic and/or recurrent breakdowns occurred from the point of view of contradictions analysis (§2.5.2.2, 3.3.1.3; Table 3.1) some common factors emerge. Three general types of contradiction as possible causes of catastrophic or recurrent interaction breakdown were identified in the study data: (1) contradictions between UI representations and user perceptions of task difficulty and task complexity; (2) contradictions between the assumed and actual knowledge of users; and (3) the contradiction of "adaptation operations" at the user-interface. These contradictions can be seen as complementary to conventional HCI/usability analyses of user-interface design deficits (*e.g.* lack of standardisation across UI designs, internal inconsistencies in UI design, inappropriate use of metaphor, etc.); the observations that follow are also recall the discussion of "recurring inappropriateness" in (Bødker, 1991, pp. 80-81).

7.1.3.1 Contradictory Representations of Task Difficulty

Activity theory posits a complex interrelationship between subjects' motivation, their evaluations of the personal significance of a task ("sense", which can be comprised of both "internal" and "external" aspects, *i.e.* desirability and/or necessity; see §2.4.1.3 and glossary) and their subjective perception of a task's

difficulty (Bedny and Meister, 1997, pp. 81-83). Subjects' interactions with the tools involved in the task have an effect upon, and are affected by, this dynamic relationship. Applying this concept to human-computer interaction has implications for usability; for example, it suggests that various design features of a tool may under- or over-represent actual task complexity, influencing subjective evaluations of task difficulty in ways that might affect the choice of strategies for task solution – either positively or negatively, according to the significance of the task for the user (see also §5.4.1 & Chapter 9). This suggests possible contradictions between usability criteria such as *attraction, efficiency,* and *helpfulness* in concrete use situations. For example, an application may attract a user by representing a task as relatively easy to accomplish, and then prove ineffective or insufficiently helpful in supporting the user to deal with the actual complexity of the required work-process. In the longitudinal study, the Ulead Video Studio interface appeared to achieve its initial attractiveness by under-representing task complexity, leading to some of the problems discussed in §6.5.2. Other applications (*e.g.* Windows Volume Control, §6.6.2; Nero, §6.6.3), arguably represented relatively straightforward tasks (such as adjusting the audio volume) in ways that encouraged users to perceive them as overly difficult, dissuading them from attempting, or continuing to attempt, to solve them.

7.1.3.2 Contradictions between "Assumed" and Actual Knowledge of Users

Computer applications are cultural artifacts (§3.5.1.1) which both explicitly and implicitly reflect (objectify, §3.5.1.3) the practices and understandings of their designers and developers. These objectified values may differ significantly from those of the user seeking to appropriate the tools into his or her practice (Honold, 2000, Törpel *et al.,* 2003). The previous chapter provided several examples of cases where application designs appeared to embed "assumptions" about users' conceptual and technical knowledge and concepts; contradictions with the actual state of user knowledge often emerged during parameter-setting operations which apparently required information and ideas not explicitly provided by the user-interface (see *e.g.* §6.5.2.2, 6.6.3, 6.6.1.1). The study also demonstrated that even if support materials (help systems or manuals) should provide the appropriate supplementary information, it was unlikely that users would consult

them. This implies that without specific design or training interventions (see *e.g.* §6.6.1.1) this type of contradiction is likely to prove a recurring source of interaction difficulties, hindering interaction with those applications by users who are (in ICT terms) from non-traditional backgrounds.

7.1.3.3 Contradiction of Adaptation Operations

As noted in Chapter 2, activity theory is particularly concerned with historical and developmental modes of explanation. Accordingly, the activity approach has frequently made use of evolutionary perspectives on cognition and behaviour (among the best-known examples in AT are Leont'ev, 1978, and Leont'ev, 1981b, and, elsewhere in the tradition, the work of Holzkamp).[8] Some ATIT researchers have attempted to extend this approach to application and interface design, including the cognitive psychology group associated with the Aarhus-Oslo school (*e.g.* Bærentsen, 2000, Bærentsen and Trettvik, 2002, Nørager, 2004) and researchers working on the Build-it augmented reality system (*e.g.* Fjeld *et al.*, 1999, Fjeld *et al.*, 2002, Lauche, 2005). This line of research, which also draws on Gibson's theories of perception (Gibson, 1979), uses recent findings in cognitive and evolutionary psychology to support the argument that as "…the resources behind human sensory-motor functioning are *highly specialised* to solve *specific types* of problem…" and users thus conceptualise interfaces in terms of "…real-world categories of spaces, actors, and objects" (Nørager, 2004, p. 31); for user-interfaces to be "intuitive" they must be "…shaped to conform to these categories" (*ibid.*).

Observations made during the longitudinal study lend some support to this argument. In particular, it was noted that participants' dialogues and monologues during interaction were frequently couched in terms of spaces, actors, and objects (see *e.g.* §6.2.1.4, 6.6.1.2 and *cf.* the discussions of human-computer dialogue in Tikhomirov 1999, p. 357 and Bærentsen, 2000, p. 33). During the review of data on frequent and recurrent breakdowns it was hypothesised that a contributory factor in some cases might be the presence of contradictions between the appearance and behaviour of user-interface elements and the "core knowledge systems" of users (Nørager, 2004, pp. 31-36). In order to investigate this hypothesis an additional analysis of the BDPF data was undertaken. This involved the generation of a 9-category coding scheme derived from the sources

outlined above, and the application of the scheme to the BDPF archive. Appendix 6 of the thesis presents the materials used (Appendix 6a) and results generated (6b) by this analysis. However, during application of the scheme to the data it became apparent that the coding categories were insufficiently well-developed to support meaningful testing of the hypothesis, and that considerable further research in the extensive and rather disparate primary literature would be required in order to address these methodological challenges. Such work was judged to be beyond the scope and resources of the research project. However, the general congruence of evolutionary/perceptual arguments with observations made during the longitudinal study, and the strengthening of the hypothesis by findings from subsequent empirical and theoretical work by other researchers[9] suggests that this may be a fruitful direction for future research.

7.2 Case Study: Breakdown and Recovery in Web Authoring

In response to findings from (1) the review of AT and ATIT literature (§2.6.1, 3.5.2) and (2) the iterative process of gathering, analysing and reflecting upon the data during the fieldwork (§5.2), post-study analyses of Phase 1 data focused on using activity-theoretical techniques to investigate specific cases of observed interaction breakdown and recovery. The chief objectives were:

- To elicit additional design-oriented insights from the field study data, principally through the fine-grained analysis of moment-to-moment interaction;

- To further explore and develop established and new ATIT analysis methods, evaluating their potential to get "close to the technology"(see §3.5.2.1);

- To explore ways of combining ATIT techniques and perspectives to produce holistic, detailed and design-oriented descriptions of computer-mediated activity.

7.2.1 Introduction to the Case Study

7.2.1.1 Selection of Data for Further Analysis

Interaction sequences were identified as suitable for further detailed analysis according to the following criteria:

1. The presence of breakdown incidents (§4.3.4);

2. The availability of multiple intersecting data sources to enable multi-level analysis (§2.6.1, 4.3.3) and facilitate the process of "indefinite triangulation" (§5.2.2.1);

3. The availability of a sufficiently detailed and continuous data to support the application of micro-analytical techniques (*e.g.* §3.3.1.4 & 3.3.2).

In the event, only four sequences were found to satisfy these selection criteria. This shortage of suitable material was one factor informing the decision to undertake the further field studies reported in Chapter 8.

7.2.1.2 Outline of the Case Study

The case study which follows is selected from among four sets of Phase 1 observation data identified as suitable for further detailed post-study analysis according to the criteria outlined above.[10] It examines two linked interaction sequences observed during the performance of a Web authoring task. This example was chosen as (1) the dataset for the relevant session is one of the most complete of the four, comprising field notes, video-recordings and a collection of digital artifacts and (2) although two persons were involved in communicative (subject-oriented, see Fig 2.10) activity during the sequence, the object-oriented activity was mainly carried out by a single user with small set of software tools and objects, simplifying the analysis and rendering it amenable to treatment within the space available.

The case study adopts a combinatorial, multi-method approach to activity analysis. It begins by describing the major elements of the computer-mediated work activity (Fig. 2.6). This is followed by a general contradictions analysis based on Engeström's CHAT (§2.5.2), extended through the use of the focus-shift analysis methods developed by Bødker (§3.3.1.4). Finally, an algorithmic approach to morphological (structural) activity micro-analysis (§3.3.2.1) derived

from SSAT is applied. At the time of the work reported here these three methods were at different stages of development: while contradictions and focus-shift techniques have been applied in ATIT since the early 1990s,[11] few reports of algorithmic or systemic-structural analyses were then available, of which only one (Bedny *et al.*, 2001d) dealt specifically with computer-mediated activity.[12] Also, whereas the other techniques are based on the Scandinavian cultural-historical interpretation of (Leont'ev's) general activity theory, the algorithmic method derives from the systems-cybernetic tradition (§2.4.2, 3.3.2.1).[13] This attempt to combine, compare and contrast methods and principles derived from differing traditions within AT is also reflected in the variety of graphical and symbolic representations used in the study.

7.2.2 Overview of the Web Authoring Activity

7.2.2.1 Conditions & Subjects

The activity in question was observed during Session 69 of *Computer Creative*, which took place in OLC Workshop 3 (§4.2.3) from 0900-1230 on Wednesday, 4th April 2001. The principal acting subject was male participant learner DH, assisted by the researcher/tutor SRH (see Table 5.2 and §5.3.2). At this time DH was 29 years old and had been attending the course since its inception the previous September. On entry to the course his skills were assessed as being at Entry Level 3 (E3) for literacy; E2 for numeracy; and E1 for ICT (§5.3.3 & Fig. 5.2).[14] DH attended almost every session of the course, and had previously completed several complex collaborative digital graphics, animation, and video projects. By this stage of the study he had become confident in his technical and creative abilities and generally required only minimal assistance from peers and tutors.

7.2.2.2 Activity & Tasks
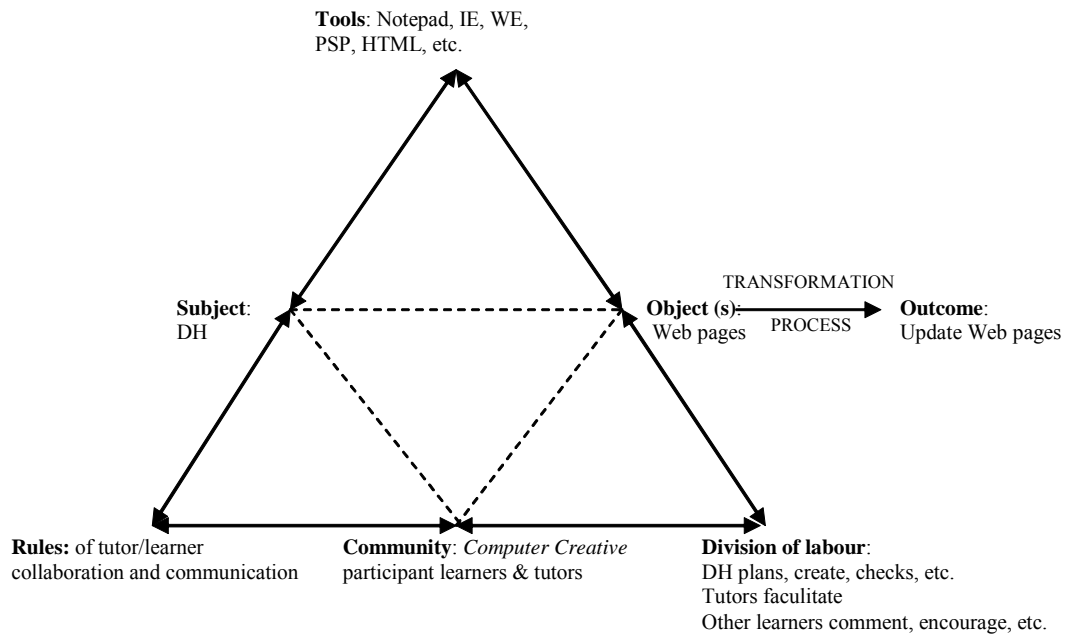
Figure 7.1: The "update Web pages" activity system.

Throughout February and March 2001 DH was engaged in creating a personal Web site (timeline 10, Fig. 5.3a).[15] By April 2001 this work had reached an advanced stage. During Session 69 DH was engaged in revisions aimed at updating and improving the site. This involved checking and correcting two pages containing lists of hyperlinks (henceforth, "the links pages") while also adding graphics to some pages. Figure 7.1 uses Engeström's graphical notation (*cf.* Fig. 2.4) to portray DH's activity as a dynamic system.

Table 7.3 lists some of the main actions, operations and tools involved in the "Update Web pages" activity, using categories based on the activity-theoretical concepts outlined in Chapters 2 & 3 (*cf.* Fig. 2.7, §4.3.3 & Table 5.1). The case study in this section focuses on two of the tasks listed: "check and update hyperlinks" (column 1) and "update graphics" (column 2). The breakdowns which occurred in both are used as starting points for analysis.

In general terms the activity analyses proceed from macro- (contradictions analysis at the level of activity and task sequences) to meso- (focus-shift analysis at the level of task and action sequences) to micro-analysis (algorithmic analysis at the level of clusters of actions & single actions). However, the analytical process also moves back and forth between these "levels" of activity (Figs. 2.2 & 3.5) according to the dominant analytical perspective (§2.5.3.3) at any juncture.

For convenience the two tasks are dealt with out of their actual temporal sequence in the account that follows.

Table 7.3: Tasks, actions, operations and tools in the "Update Web pages" activity.

Activity: why?	Update Web pages *in order to complete Web site project.*			
Tasks & Sub-tasks: What sequences of goal-oriented actions?	**Check & update hyperlinks** • Check for "dead" or incorrect hyperlinks • Delete or correct hyperlinks • Put hyperlinks into correct alphabetical sequence • Review changes	**Revise Text** • Check body text for spelling & grammatical mistakes • Review body text content • Correct or replace text • Review changes	**Update Graphics** • Adjust graphics (size, brightness, contrast, etc) • Search for graphics • Download graphics • Insert/Correct relevant HTML • Review changes	**Update File structure** • Remove unwanted folders • Remove unwanted files • Correct relevant HTML • Review changes
Actions: What exploration or transformation? What goal, object, subject?	View hyperlink anchor page	Read text	View graphics	View folders/files
	View hyperlink target page	Highlight text	Highlight graphics	Delete File
	View hyperlink source code	Enter text	Cut/Copy graphics	Copy File
	Delete hyperlink mark-up	Cut/Copy text	Paste graphics	Move File
	Enter new hyperlink mark-up	Paste text	View graphics mark-up	Check file name
	Cut/copy/paste hyperlink mark-up	Delete text	Enter new graphics mark-up	Re-name file
	Open/Save Files	Edit text mark-up (formatting)	Cut/copy/paste/delete graphics mark-up	
		Open/Save Files	Open/Save Files	
	Etc.	*Etc.*	*Etc.*	*Etc.*
Operations: How?	Mouse-clicks	Keystrokes	Cursor movements	Glance
	Gaze			*Etc.*
Tools & Instruments: With/through what? (mediators)	Internet Explorer	Notepad	PC system – hardware and OS	Speech/Gesture
	Windows Explorer		Local Area Network (Workshop 3)	Collaboration skills (turn-taking, *etc.*)
	Paint Shop Pro		Wide Area Network (College)	Literacy skills (reading, writing, *etc.*)
	Notepad	HTML	Internet	*Etc.*

7.2.2.3 Objects & Tools

Two types of digital artifact were the principal objects of DH's explorative and transformational actions during the observed activity:

1. Web pages,[16] present for the users (DH, SRH) in three forms or modes: as interactive visual displays; as editable code (text plus HTML mark-up); and as data entities within the PC's storage structure;

2. Graphics files, also presented to the users in three forms: as constituent elements of the Web pages (in this case in non-interactive form, *i.e.* not hyperlinked to external URLs); as editable files; and as data entities within the PC's storage structure.

Object-oriented actions were mediated by the computer hardware (§4.2.3.2) and four software applications. The Web pages were (1) viewed with the Internet Explorer 3 Web browser (IE, §6.7.1); (2) edited using Notepad (§6.7.3); and (3) manipulated as data entities using the Windows Explorer file management utility (WE, §6.6.1). Graphics files were (1) viewed with IE, (2) viewed and edited with Paint Shop Pro (PSP, §6.2.1) and (3) manipulated as data entities using WE. IE, Notepad and WE were all run continuously and concurrently on PC Mill57 (Figs. 4.1, 4.2h) throughout the activity. PSP was launched and quit as required. Not being present in any external form, the work objects were only encountered by the user "in" the interface (Fig. 3.1a) while being handled through the computer artifacts in use.

7.2.3 Analysing the "Update Graphics" Task

While engaged in the "check and update hyperlinks" task (which is analysed in §7.2.4 below) DH used IE to view pages on destination Web sites.[17] Whilst browsing DH identified several graphics that he considered would enhance his own site, and formulated the task-goal of adding the images to his own pages. Solving this "update graphics" task (column 4, Table 7.3) involved DH performing sequences of actions oriented by a set of hierarchically related goals. The overall task can be described as comprising four main stages, each stage or sub-task consisting of several sequences of goal-oriented actions organized around intermediate goals:

- Stage 1, a "download graphics" sub-task involving locating suitable graphics and saving copies to an appropriate folder in the local Web site directory; [18]

- Stage 2, an "adjust/edit graphics" sub-task involving editing the downloaded files with PSP (mainly in order to resize them to dimensions appropriate to the envisaged Web page design), the files subsequently being re-saved;

- Stage 3, an "insert/correct relevant HTML" sub-task, using Notepad to make and save changes to the mark-up of Web pages to which the graphics are added;

- Stage 4, a "review changes" sub-task in which the altered pages (and newly embedded graphics) are viewed using IE and evaluated.

The work process was iterative; if the need for further changes was identified at stage 4 then earlier stages were revisited. As shown in Table 7.3, each (more-or-less) conscious action carried out on the objects (cut, copy, paste, move, *etc.*) was accomplished through a series of (mainly) unconscious operations (mouse-clicks, keystrokes, *etc.*).[19] During the interaction sequence these operational aspects of the performed actions mainly involved user interaction with a series of dialogue boxes, which from a tool perspective (§3.3.1.1, Table 3.2) can be seen as providing the main technical conditions shaping the flow of activity.

7.2.3.1 Breakdown in the "Update Graphics" Task

Figure 7.2 shows some of the UI elements involved in the graphics breakdown. Task performance began with the graphics files being viewed as part of a Web page visible in the display pane of the Web browser. DH used the mouse to move the cursor over the target graphic and - by right-clicking - invoked a context-sensitive menu. He then moved the cursor over the menu and left-clicked to choose the option *Save Picture As* (see Fig. 7.2a). This resulted in the appearance on the desktop of the IE 'Save Picture' dialogue (Fig. 7.2b). DH then navigated through a pull-down list (invoked by left-clicking the folder icon displayed on the *Save in* field of the menu) to locate the appropriate folder in his local Web site directory structure on the C: // drive. Once this was accomplished, his only further input was to left-click the *Save* button of the 'Save Picture' dialogue. The dialogue box then immediately closed.
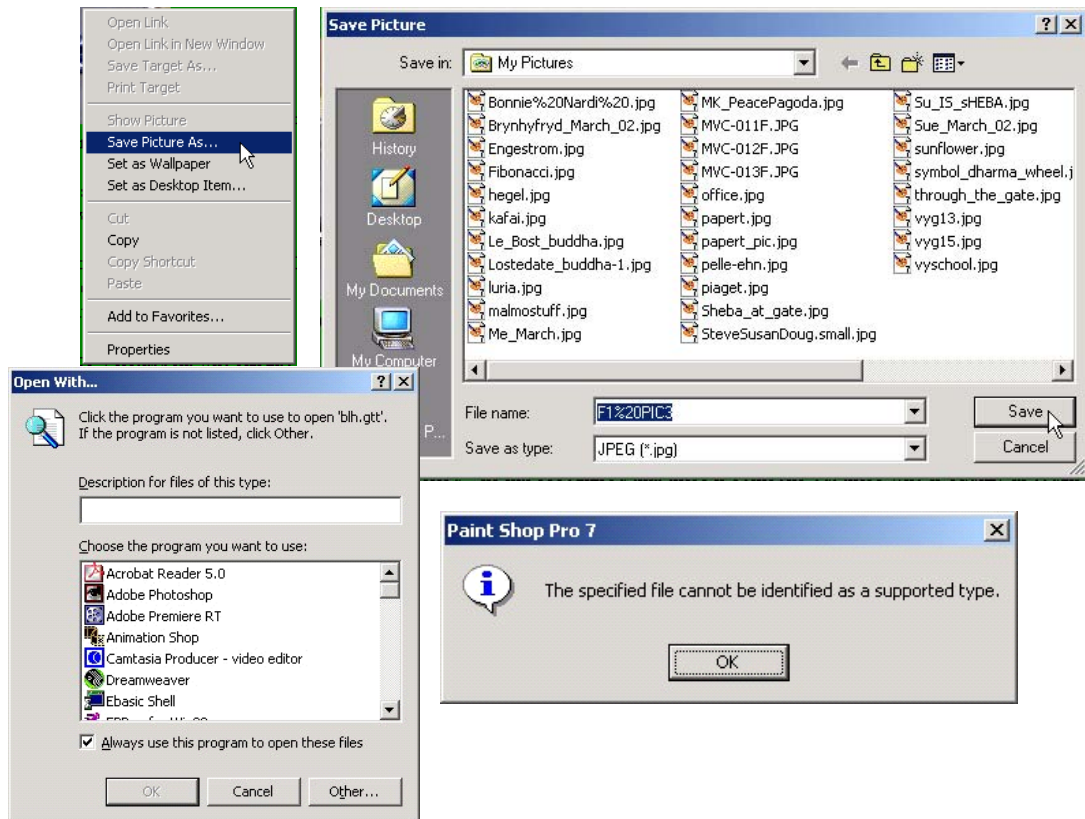
Figure 7.2: Some interface elements involved in the graphics breakdown. Clockwise from top left: (a) IE Context Menu (b) IE Save Picture Dialogue; (c) PSP Alert Box; (d) Windows OS 'Open With' Dialogue Box. Items not to scale.

Breakdown occurred at the second stage of task performance ("adjust/edit graphics"). Proceeding on the assumption that he had successfully copied the graphics, DH launched Paint Shop Pro (PSP) by left-clicking an icon on the Windows taskbar, with the intention of using the application to alter the display size of the graphics files. Once a PSP window was open, DH left-clicked the *Open* icon on the PSP standard toolbar (Fig. 6.1) to invoke the 'Open' dialogue box. He used the *Look in* field and folder icons to locate the files, and with a keystroke-mouse combination (position cursor, left-click, shift-key, reposition cursor, left-click) highlighted the file names in the main pane of the dialogue. He then left-clicked the dialogue's *Open* button. This resulted in the display of an alert box in the centre of the PSP window (Fig. 7.2c), signifying a breakdown (in the form of a disruption to the expected sequence of events). The alert carried the message: *The specified file cannot be identified as a supported type*. DH left-clicked the *OK* button on the alert box to cancel it. He then called out to SRH, who responded by crossing the room and sitting beside him at the PC. The transcript extract shown in Figure 7.3 illustrates what followed:

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56. DH: Yep. Erm (.) These two files here, F1 pic 1 and F1 pic 2 {*points to WI window*}
57. SRH: Yeah
58. DH: I'm trying to stick em in erm my Formula 1 web page, I can't do so because they're not gifs, sorry they're not jpeg pictures
59. SRH: right
60. DH: erm, I wanted to transfor em, trans(.)fer em into Paint Shop Pro so I could resave as, er
61. SRH: jpeg
62. DH: A jpeg, and I can't, they won't open.
63. SRH: They won't open?
64. DH: Not in Paint Shop Pro.
65. SRH: Is that a Paint Shop Pro open dialogue box at the moment? Yeah? {*focus shifts to PSP dialogue box*}
66. DH: Yeah
67. SRH: So, click on one of them and let me see what it says {*unable to open message appears on screen*}
68. SRH: OK, so what kind of files were they then?
69. DH: I haven't got a clue.
70. SRH: Not, obviously, not picture files?
71. DH: {*using explorer*} Erm, there they are, those two. {*focus shifts to WE window*}
72. SRH: {*Takes control of mouse, double-clicks file icons in WE*} What happens if you double-click them, in there, if you double-click them - it doesn't know what to open them... {*Windows 'what application' dialogue box appears*}
73. SRH: have you still got the website that you saved them from?
74. DH: No, I don't think so.
75. DH: Erm, if I went to... {*foregrounds IE3 window, not displaying appropriate source page*}
76. SRH: They must not be, picture files for some reason. If you go into your history on your browser
77. DH: Yerss {*opens history files in Internet Explorer*}
78. SRH: Look at the history.. Formula 1 com, was it any of that?
79. DH: Yeh
80. SRH: If you go down, we'll open... {*DH loads the WWW page and identifies the pictures he seeks*}
81. SRH: They're in it?
82. DH: Yeah
83. SRH: We can have a look at what they - what it is, they're obviously not supported file types, so they must have been - you must have accidentally downloaded something that wasn't actually a picture, that was something else - maybe a bit of video or something, who knows, we'll have a look at them now

Figure 7.3: Transcript extract for the graphics breakdown. From Transcript *tape1_07_01* for Series CC, Episode tape1_07. Excerpt begins 00:02:31.1, line 56 in transcript. Video-recording transcription methods are described in Chapter 8.

At lines 65-7 SRH intervened to recreate the breakdown with PSP. At lines 71-2 a further breakdown occurred as SRH attempted to open the files by double-clicking their icons in an (already open) Windows Explorer window. This action resulted in the appearance of the Windows OS 'Open with' Dialogue Box (shown in Fig. 7.2d). SRH deduced from this result that the files had been saved in a format inappropriate for use by PSP (line 76), and concluded that DH did not pay adequate attention to the *File name* or *Save as type* fields of the 'Save Picture' dialogue – a diagnosis consistent with DH's mainly operational (*i.e.* unconscious) interaction at that juncture of the file-saving procedure. Recovery was eventually achieved by DH and SRH jointly recapitulating stage 1 of the task sequence (from line 76 to the end of the extract; for brevity, the remainder of transcript dealing with the reiteration of stage 1 is not shown).

7.2.3.2 Contradictions in the Activity System
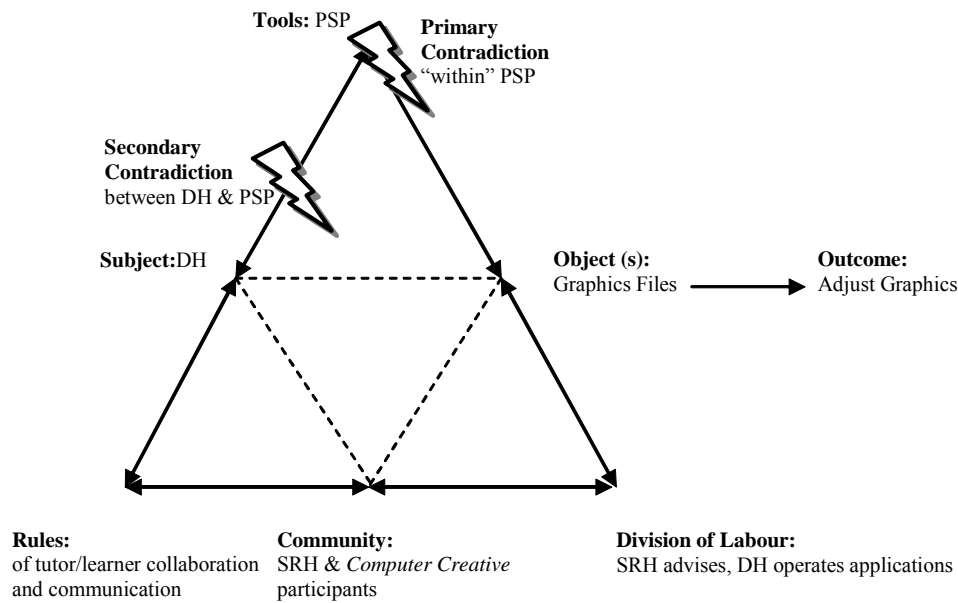
Figure 7.4: Contradictions in the "update graphics" task.

Figure 7.4 illustrates a contradictions analysis of breakdowns in the "Update Graphics" task based on Engeström's cultural-historical activity theory (CHAT, §2.5.2). In CHAT terms, at the point of breakdown PSP was the *primary artifact* mediating DH's actions toward the graphics files (see Table 2.2). Using CHAT's typology of contradictions (Table 2.1), it might be said that a *primary contradiction* developed "within" the tool component of the activity system, in this case between PSP's functionality and the actual conditions of operation (the files being of a type unsupported by the package). This conflict produced a *secondary contradiction* between subject and tool, as DH's existing repertoire of operations with PSP proved inadequate, forcing the conscious focus of his actions to shift from the graphics files themselves toward the tool, PSP, which he had planned to use to edit them.

These events are shown taking place within a wider cultural-historical context: the *Computer Creative* community of practice with its own rules, norms, and divisions of labour. The instability within and between components of the activity system caused by contradictions and evidenced by breakdowns drives changes throughout the system; for example, the problems encountered with PSP result in both individual and communal learning, subtly changing the whole practice. The range of possible interventions suggested by this analysis similarly

span various levels of the activity and, if implemented, will affect all its components. They include altering IE's 'Save Picture' routine to warn the user of possible problems; extending PSP's functionality to automatically convert the files to a usable format; providing training to DH; changing the rules or division of labour within the community so DH would not undertake such a task alone; or even altering the community to include more members expert in the manipulation of Web graphics. Further developments in the activity system resulting from these and other changes might be tracked through subsequent field studies, perhaps with – as in the DWR approach, §2.5.2.4 – attempts being made to encourage "expansive learning" (*i.e.* the further development of ICT and other skills) through PAR means such as feeding-back the research findings to participants.

7.2.3.3 Focus-Shifts in the Collaborative Activity

Figure 7.5 presents a complementary approach to analysing the "Update Graphics" task using focus-shift techniques (§3.3.1.4). The left-hand side of the figure provides a narrative description of the interaction as it unfolds over time, supplemented by lines of dialogue selected from the video transcript extract (Fig. 7.3). The right-hand side of the figure plots major focus shifts, breakdowns and the direction of joint attention toward applications and interface elements. The focus-shift markers (•) are consecutively numbered and range horizontally across columns representing the applications and interface elements involved as tools and objects of actions. Initials and arrows represent the subject-oriented (communicative and collaborative) aspects of the focus-shifts, indicating junctures where one participant guides the focus of joint attention onto a particular application interface element (*cf.* similar analytical approaches in Raeithel, 1992, Raeithel and Velichkovsky, 1996).

T

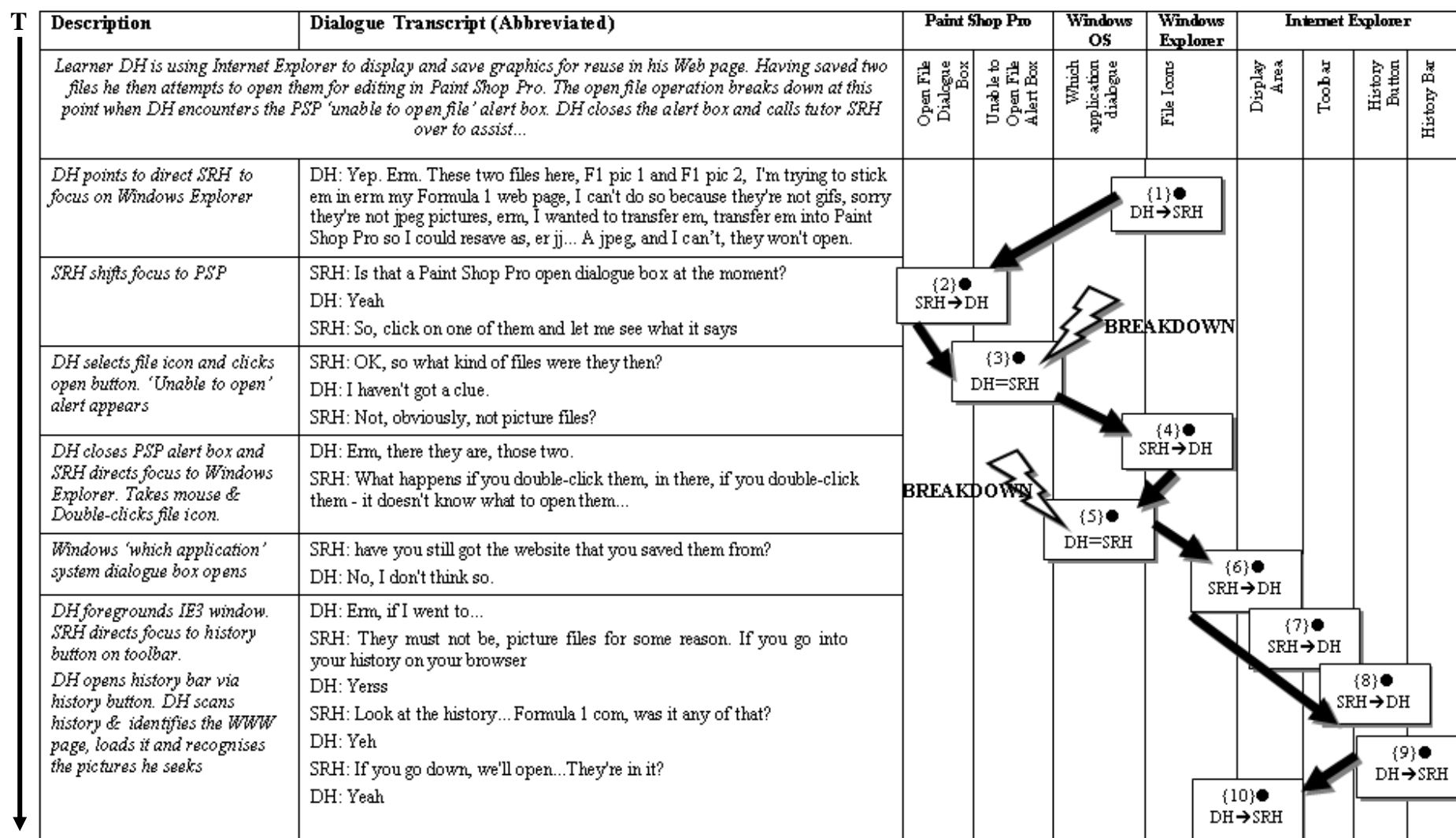| Description	Dialogue Transcript (Abbreviated)	Paint Shop Pro		Windows OS	Windows Explorer	Internet Explorer			
		Open File Dialogue Box	Unable to Open File Alert Box	Which application dialogue	File Icons	Display Area	Toolbar	History Button	History Bar
Learner DH is using Internet Explorer to display and save graphics for reuse in his Web page. Having saved two files he then attempts to open them for editing in Paint Shop Pro. The open file operation breaks down at this point when DH encounters the PSP 'unable to open file' alert box. DH closes the alert box and calls tutor SRH over to assist...									
DH points to direct SRH to focus on Windows Explorer	DH: Yep. Erm. These two files here, F1 pic 1 and F1 pic 2, I'm trying to stick em in erm my Formula 1 web page, I can't do so because they're not gifs, sorry they're not jpeg pictures, erm, I wanted to transfer em, transfer em into Paint Shop Pro so I could resave as, er jj... A jpeg, and I can't, they won't open.			{1}● DH→SRH					
SRH shifts focus to PSP	SRH: Is that a Paint Shop Pro open dialogue box at the moment? DH: Yeah SRH: So, click on one of them and let me see what it says	{2}● SRH→DH		BREAKDOWN					
DH selects file icon and clicks open button. 'Unable to open' alert appears	SRH: OK, so what kind of files were they then? DH: I haven't got a clue. SRH: Not, obviously, not picture files?		{3}● DH=SRH		{4}● SRH→DH				
DH closes PSP alert box and SRH directs focus to Windows Explorer. Takes mouse & Double-clicks file icon.	DH: Erm, there they are, those two. SRH: What happens if you double-click them, in there, if you double-click them - it doesn't know what to open them...	BREAKDOWN		{5}● DH=SRH					
Windows 'which application' system dialogue box opens	SRH: have you still got the website that you saved them from? DH: No, I don't think so.				{6}● SRH→DH				
DH foregrounds IE3 window. SRH directs focus to history button on toolbar. *DH opens history bar via history button. DH scans history & identifies the WWW page, loads it and recognises the pictures he seeks*	DH: Erm, if I went to... SRH: They must not be, picture files for some reason. If you go into your history on your browser DH: Yerss SRH: Look at the history... Formula 1 com, was it any of that? DH: Yeh SRH: If you go down, we'll open... They're in it? DH: Yeah					{7}● SRH→DH {10}● DH→SRH	{8}● SRH→DH	{9}● DH→SRH	

Figure 7.5: Tracing focus shifts, breakdowns, and the direction of joint attention in the "update graphics" task. *Cf.* Figs. 3.3 & 3.4.

It can be seen from Fig. 7.5 that at {1} DH begins his interaction with SRH by directing their joint attention toward the file icons displayed by WE. At {2} SRH shifts the focus of attention back toward the PSP *Open* dialogue box that remains onscreen following DH's dismissal of the PSP alert. At {3} breakdown reoccurs and the collaborators' joint attention is forced to shift to the PSP alert box; PSP's role in the system of activity then changes from that of mediating tool to object of action (*cf.* Fig. 3.2). At {4} SRH redirects attention to WE. DH then attempts to open the files by double-clicking their icons in the WE UI; at this point, WE mediates DH's actions, with the icons as objects. At {5} breakdown again occurs and the joint focus is forced to shift to the Windows OS *Open with* dialogue. This second breakdown triggers learning-in-use, and it becomes apparent to both participants that a new approach is required; at {6} SRH redirects DH's attention toward IE as a means of further investigating the causes of the current problem. At {7, 8, and 9} DH is guided by SRH through a series of focus shifts as he uses the history functions of the browser. At {7, 8} IE is the object of actions, then at {9, 10} it becomes the tool through which actions are carried out. The sequence ends as DH recognises the original graphics files that precipitated the initial breakdown.

This more detailed analysis of the breakdown and recovery process discussed in §7.2.3.1-2 illustrates some general points which might provide a basis for suggesting possible design interventions. Firstly, it is clear from the recreation of the breakdown at {3} that the primary contradiction within PSP arises as a result of antecedent operations performed with a different tool, IE, and is eventually resolved (from {10} and onwards) using yet another tool, WE. This may be seen as in some ways typical of the kind of computer-mediated activity associated with the new digital media, where the objects under transformation may be sequentially manipulated using multiple applications before the work process is completed. It also raises larger cultural-historical issues pertaining to the limited interoperability of commercially competing software packages running on the same platform. These considerations suggest that the situation could not easily be resolved through user intervention based on the support materials (manual, help system) offered by any single one of the individual packages involved, reinforcing the suggestion that automated conversion of the files to an

appropriate format would be an effective technological solution. An alternative approach might be to modify the PSP alert box which appears at {3} (Fig. 7.2c) so that rather than simply stating the cause of the breakdown it also provides advice as to how to proceed (*e.g.* "please convert the file to a suitable format").

As in similar exercises by other researchers (*e.g.* Bødker, 1996a, Raeithel and Velichkovsky, 1996), close analysis makes evident the continual transformations that occur between object- and subject oriented actions (§2.5.3.3, Fig. 2.10) in collaborative computer-mediated activity. The participants' self- and mutual regulation through communicative actions is central to the recovery process; it should be noted that at {4} (line 72 in Fig. 7.3) the dialogue provides SRH with an appropriate context for regulating his sense-making and learning activity through self-directed speech (see also §2.3.2 & 2.5.1.1). The participants' communicative interaction might be said to amount to the co-creation of a "zone of proximal development" (§2.3.3) in which learning takes place, in this case an "expansive learning" through which both DH and SRH further develop their understanding of the work-process. This observation emphasizes the support offered for learning-in-use by physical co-location in a use-setting which favours communicative interaction. It is difficult to envisage technical solutions which might offer similar support for the recovery processes as that provided by the communicative interaction of the two co-located participants in the observed activity. One suggestion might be a "Global History Browser" OS utility which would allow users to scroll back not just through actions with single applications (a facility currently available with many packages, including both PSP and IE) but through *all* actions involving the PC as a means of work which have contributed to the current state of the work-process.

7.2.4 Analysing the "Check & Update Hyperlinks" Task

This part of the chapter continues to discuss the application of AT-based methods to the detailed analysis of HCI tasks, in this case the "check & update hyperlinks" task introduced in §7.2.2.2 and shown in column 1 of Table 7.6.[20] The analysis utilises methods derived from the systems-cybernetic, rather than cultural-historical strand of activity theory (§2.4), namely the first two stages of a morphological analysis using SSAT principles: (1) qualitative descriptive

analysis; and (2) algorithmic analysis (§3.3.2.1 and Bedny and Meister, 1997, pp.236-7). As previous chapters and sections have described the cultural-historical context of the Web authoring activity, the main descriptive focus in following sections is on the objectively-logical and individual-psychological aspects of the interaction sequence (see §2.5.3.3 on the three analytical perspectives of AT).

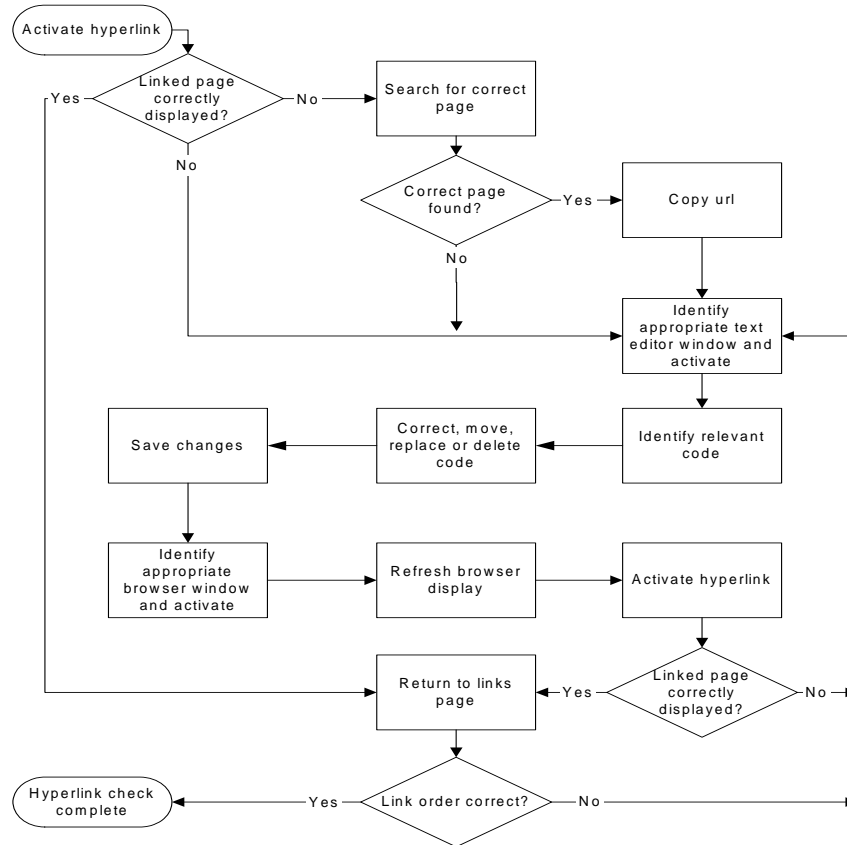### 7.2.4.1 Breakdown in the "Check & Update Hyperlinks" Task
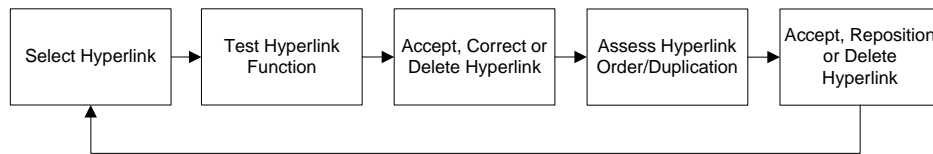
Figure 7.6: Schematic of the "check & update hyperlinks" task.

Description & Classification of the "Check & Update Hyperlinks" Task

DH's activity during the "check & update hyperlinks" task was aimed at transforming two Web pages, each containing an unordered list[21] of around 160 separate hyperlinks (henceforth, "the links pages"). The sub-tasks involved included using the browser to check for "dead" or inappropriately targeted hyperlinks on the pages; using Notepad to delete or amend any HTML mark-up found to be incorrect; putting the hyperlink lists into alphabetical sequence, using Notepad and IE; and reviewing the changes made using IE. Figure 7.6 presents a simplified schematic of DH's task as a recursive, 5-step process which continues until all hyperlinks have been checked (*cf.* Fig. 2.8). Figure 7.7 presents a more detailed picture of the task, using a flowchart to indicate the major decision points in the work process.

As noted in §3.3.2, a usual initial step in any SSAAD analysis is to classify the task under study. Such classifications can be made according to various criteria (Bedny *et al.*, 2005a), but generally involve evaluating the degree of freedom of performance associated with the task (Bedny and Harris, 2006a).[22] Tasks which are highly structured by the artifacts in use are considered as predominantly *deterministic*, or *deterministic-algorithmic*; that is, they require a standardized sequence of actions to be performed if they are to be successfully completed. *Probabilistic-algorithmic* tasks are those which involve some element of choice

or problem-solving at some stages of their performance. Where the content and sequence of actions to be performed are even more uncertain, tasks are categorized as *heuristic* or *semi-heuristic*, according to the extent to which the task presents an undefined field of solution.[24]

Fig 7.7: Flowchart of the "check & update hyperlinks" task showing major decision points.

The flowchart in Fig. 7.7 shows that each iteration of the work process mainly involved step-by-step procedures but also required at least four decision-making actions. Thus, in systemic-structural terms the process of checking and updating the hyperlinks is best described as a probabilistic-algorithmic task. The field data suggest that DH indeed viewed updating his links pages in this way, as a relatively straightforward process requiring only a few well-known interaction routines (repertoires of action, strategies of performance) and simple choices.

Breakdown in the "Check & Update Hyperlinks" Task

DH's subjective perception of the level of task difficulty appeared to be reflected in his approach to task solution: he decided it would be more efficient to review and update the two links pages simultaneously. Under the conditions obtaining this decision greatly increased the actual complexity of the task, as it involved

making use of at least two instantiations of Notepad, 2-4 browser windows, at least one instantiation of Windows Explorer, and on occasion also a PSP window.
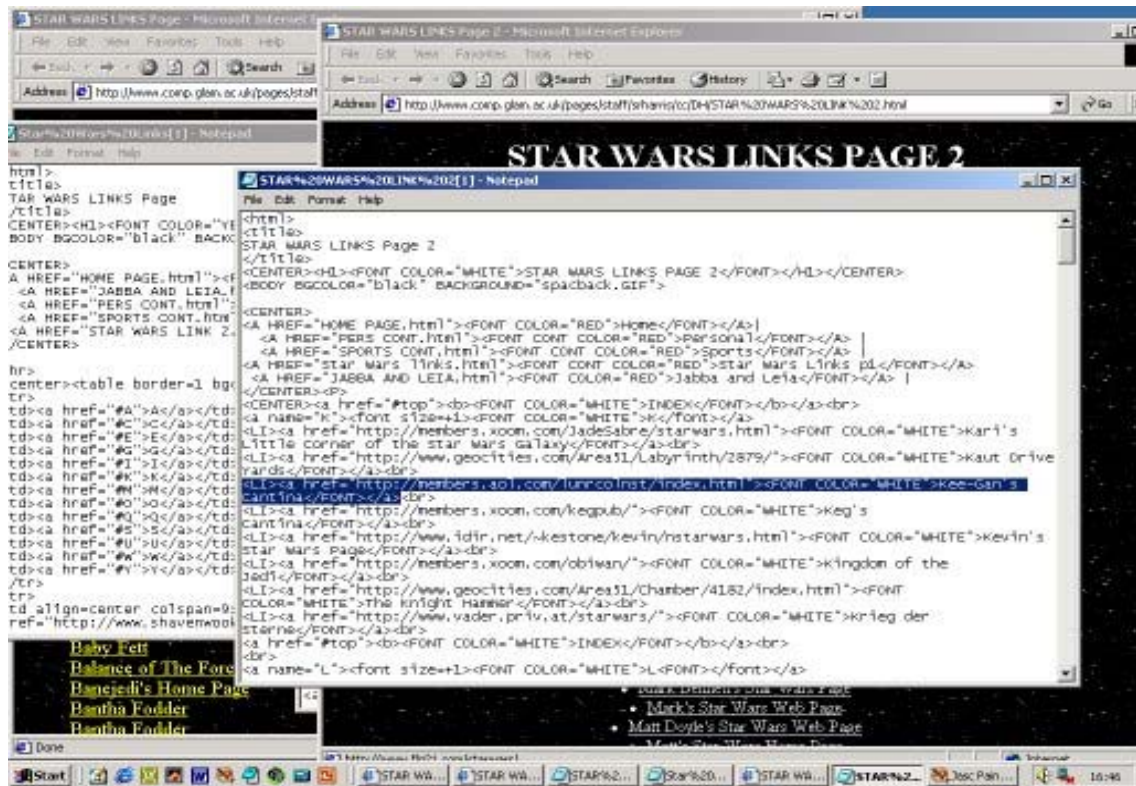
Fig 7.8: Screenshot of DH's desktop during the "check & update hyperlinks" task. Three Notepad and two IE windows are visible in the display area. The taskbar (bottom) indicates that another IE and one PSP window are also in use. Also note the status of the scrollbar in the foregrounded Notepad window.

Figure 7.8 shows a screenshot of the desktop of DH's PC (Mill57) recorded during Session 69. The cluttered nature of the screen is immediately apparent; it can also be seen that due to the large size of the files and the relatively small monitor in use (15 inch CRT, set to a resolution of 800 x 600 pixels), viewing the complete contents of each links page display (in the browser) or its mark-up (in Notepad) required DH to scroll through around 6 screens, even with the application window maximized.[24] Moment-to-moment task performance involved switching between and refreshing windows, scrolling to the correct location, clicking hyperlinks and tool icons, selecting, deleting, copying and pasting text *etc.* For example, each time an HTML source (text) file was edited with Notepad, it was necessary to save the changes, and then identify the appropriate browser window (*i.e.* that whose display reflected the contents of the file just edited), refresh the display, and evaluate the results. If these were

unsatisfactory, the appropriate Notepad window must then be identified and foregrounded before editing could begin again.

In this situation the cognitive load was greatly increased from that anticipated by DH and suggested by the task outlines in Figs. 7.6 and 7.7. With up to seven windows open at any time, not only was the number of "dynamic elements of the task" (§5.4.1) that required tracking very high, but many more decision-making actions were required at each step of the work-process. There was a growing disparity between DH's subjective perception of task difficulty (*i.e.* his motivational state was observed to remain positive) and the actual complexity of the decision-making processes involved, which increased as the task progressed, eventually resulting in catastrophic interaction breakdown. As in the incidents analysed in §7.2.2, DH encountered a major contradiction between the anticipated outcome (goal) of his actions toward the web pages (object) and the actual outcome (result; *cf.* Figs. 2.10 & 7.10 below); his editing operations (at this point mediated by Notepad) failed to produce the anticipated changes in what he perceived as the corresponding IE display windows. The field notes record:

> DH becomes confused as to which page he is actually working on, ending up simultaneously editing the same set of links embedded in two different pages. He says to me "I just can't understand why it's taking so long". (Extracted from field note entry for Session 69, 4 April 2001).

DH initially attempted to recover from breakdown by taking actions such as opening additional windows. The failure of this strategy led DH to seek assistance. Ensuing discussions with SRH resulted in DH realising that he had been working with non-corresponding application windows. However, by this time he had become severely de-motivated with regard to the link-checking and updating task and abandoned it in favour of the "update graphics" task discussed above.[25]

7.2.4.2 Actions involved in the "Check & Update Hyperlinks" Task

The previous section outlined some of the circumstances leading to breakdown in the "check and update hyperlinks" task. In order to proceed from a general qualitative description of the kind given to the next stage of morphological analysis it becomes necessary to use individual goal-oriented actions (rather than tasks or sequences) as the primary unit of analysis (see Fig. 2.7).

1 Launch or restore focus to Web browser (IE3)
    a. If application already running move cursor onto window area and left click *or* move cursor onto taskbar icon and left click.
    b. If application not running, move cursor to application icon and left-click *or* move cursor to start button, left-click, navigate to appropriate menu, choose application icon or label and double left-click.
2 Load or refresh appropriate HTML document
    a. If document is already being displayed, move cursor to refresh icon (or select command from View pull-down menu) and left-click
    b. If document not displayed, load into browser by either selecting File>Open from pull-down menu, then typing file path or browsing to file location in Open dialogue box *or* use left mouse button and cursor to drag file icon from desktop or other location and drop on browser display pane by releasing mouse button
    c. In the display pane, move cursor to hyperlink being checked, left-click on link
3 View resulting display and assess
4 Make decision on whether link needs to be removed or altered
5 Launch or restore focus to text editor (Notepad)
    a. If application already running move cursor onto window area and left click or move cursor onto taskbar icon and left click.
    b. If application not running move cursor to application icon and left-click or move to start button, left-click, navigate to appropriate menu, choose application icon or label and double left-click.
6 Load or review appropriate text (.html) file
7 Identify section of markup that corresponds to link being checked
8 Cut, delete, or modify link markup
9 If moving location of link:
    a. Identify new location in appropriate text file
    b. Navigate text editor to appropriate file and location
    c. Insert cursor and paste link markup
10 Return to Step 1.

Figure 7.9: Sequence of basic technological procedures in the "check & update hyperlinks" task.

Describing the Technical Requirements of the Task

In order to extract discrete actions from the flow of activity observed during task performance it is necessary to identify the (sub)goal, object, and tool of each action; the precise nature of any action is dependent on the interrelation of these components in any particular set of task conditions. In the post-study analysis reported here, the first step toward isolating actions involved producing an idealized general description of the task mainly focusing on the technical requirements involved (Bedny and Meister, 1997, pp. 237-8). Figure 7.9 shows the sequence of basic technological procedures in the "check & update hyperlinks" task; it provides a somewhat more detailed description than the process overviews given in Figs. 7.7 & 7.8, as it makes some basic differentiations between types of action.

Isolation & Classification of Actions

Using the description in Fig.7.9 as a starting point, actions and their operational aspects were then isolated and differentiated according to the (material or mental) object toward which they are directed, and their goal, that is, the subject's desired future result of actions toward the object. During this process the actions were also classified. Two main approaches to the classification of actions have been developed in SSAAD (Bedny and Meister, 1997, pp. 25-33). The first differentiates between types of mental action based on two considerations: (1) the degree to which they require deliberate examination and analysis of the stimulus (their direct connection with, or transformation of, the input); and (2) the dominating psychological process during action performance: sensory, simultaneous perceptual, imaginative, mnemonic, *etc*. In the second classification scheme actions are categorized according to the nature of their object (either material or symbolic), and according to their method of performance, (either practical or mental). This scheme thus distinguishes between: (a) object-practical actions performed with material objects; (b) object-mental actions performed on mental images; (c) sign-practical actions performed with external signs; and (d) sign-mental actions performed through the mental manipulation of signs or symbols.

Table 7.4: Fragment from the action isolation & classification table for the "check & update hyperlinks" task.

Action	Goal	Object	Tools	Type
1	Reach & grasp mouse	mouse		Object-practical
2	Locate display pane	Interface	Graphical interface elements	Sign-practical/ Simultaneous-perceptual
3	Move cursor over hyperlink	Cursor	Mouse	Object-practical
4	Activate link	Hyperlink	Cursor, left mouse button	Sign-practical

Table 7.4 contains a fragment from the action-isolation checklists developed during the analysis of the "check & update hyperlinks" task. The table lists actions related to step 2c in Fig. 7.9, and their classification according to the two typologies outlined above. It can be seen that while actions 2 & 3 involve several

external instruments, no tool of action is defined for action 1. This indicates that the action consists mainly of motor activity not involving external instruments (here the mouse is the object, not the tool of action). However, AT always assumes that motor actions contain cognitive components and, as such, may involve the use of internal psychological tools (see §2.4.2.1, Figs. 2.10 & 7.7, and Bedny *et al.*, 2001a). For example, such internal tools must be assumed in action 2, which involves not only the perception of signs visible on the interface but also their interpretation using concepts and images.

Action isolation and classification provides a basis for evaluating how the physical, handling, or subject/object directed aspects of the application (§3.3.1.2) support the actions of the user at any given moment during the interaction sequence. In action 1 in Table 7.4 it is the physical attributes of the mouse such as its "graspability" that are most relevant, as they provide the operational conditions under which the user's action is carried out. In action 3, the handling aspects of the UI are important: how visible is the mouse cursor at this point? Actions 2 and 4 are more concerned with the subject/object directed aspects of the interaction, and involve informational and decision-making elements: at this point in the interaction, how easy is it to distinguish between windows and identify the correct hyperlink? The account in §7.2.4.1 suggests that this aspect of the design of the applications was implicated in the breakdowns experienced. The next stage of morphological analysis allows closer examination of this issue.

7.2.4.3 Algorithmic Description of the "Check & Update Hyperlinks" Task

The algorithmic stage of morphological analysis employs special analytical units, *members of algorithm*, which are groups of actions directed toward a common sub-goal of activity during task performance. The algorithm graphically portrays the nature of the actions and their temporal and logical interrelationships. Table 7.5 presents a basic algorithmic description of DH's activity during his performance of the "check & update hyperlinks" task, utilizing the symbolic notation developed by Bedny (described in §3.3.2.1).[26]

Reading the Algorithm

The algorithm contains 41 *members*, comprised of 29 *operators* and 12 *logical conditions*. The table is read from top to bottom, proceeding from one member to

the next in numerical sequence (as indicated by the member's subscript number) except where non-sequential transitions between members are designated by up (to) and down (from) arrows linked by corresponding superscript numbers.

Operators (symbol O) denote clusters of 1-4 mental and motor actions grouped together according to a common sub-goal. Superscripts are used to differentiate between three types of operator: the superscript epsilon (O^ε) indicates that the symbol represents a cluster of efferent (*i.e.* outgoing, externally directed) actions by the subject; superscript alpha (O^α) indicates a group of afferent (incoming, sensing, mnemonic) actions; and superscript th (O^{th}) indicates clusters of thinking actions involving the subjects' mental manipulation and comparison of images and concepts.[27] For example, in Table 7.5 member O^ε_7, the seventh operator in the algorithm, clusters the efferent actions 1, 3, & 4 (reach and grasp, move cursor, activate link) shown in Table 7.4. Logical conditions (*l*) portray the logic of selection and realization of different members of the algorithm, and indicate the decision-making processes involved in task performance. For example logical condition l_3, the third member of the algorithm, describes the two choices available to the user at this point in the task: to proceed to the next step (O^ε_8) if the browser display is correct, or, if not, to go to operator O^ε_{11}, where the incoming link is indicated by a down-arrow with the superscript number 3, which corresponds to the numbered up-arrow which follows O^ε_8. This logical condition and its branches loosely correspond to the decision symbol and its connectors labelled "Linked page correctly displayed? – Yes/No" in Fig. 7.8.

Table 7.5: Algorithmic description of activity during the "Check & Update Hyperlinks" task.

Algorithm	Description
$\overset{7}{\downarrow}\overset{11(1)}{\downarrow} O^\alpha_1$	Identify appropriate Web browser window
$\overset{1}{l_1}\uparrow$	If correct Web browser window has focus go to O^α_3; if not go to O^ε_2.
O^ε_2	Bring browser window to foreground by moving cursor onto window area and left-clicking or moving cursor onto taskbar icon and left-clicking.
$\overset{1}{\downarrow} O^\alpha_3$	Check to see if correct Web page is displayed
$\overset{2}{l_2}\uparrow$	If appropriate Web page is displayed go to O^ε_4 ; if not go to O^ε_5
O^ε_4	Refresh browser display by moving mouse cursor to refresh icon and left-clicking or selecting command from View pull-down menu and left-clicking

Table 7.5: Algorithmic description of activity during the "Check & Update Hyperlinks" task.

Algorithm	Description
$\downarrow^{2} O^{\varepsilon}_{5}$	Open correct HTML document by either selecting File→Open from pull-down menu, and browsing to file location using Open dialogue box or use left mouse button and cursor to drag file icon from desktop or other location and drop on browser display pane by releasing mouse button
$\downarrow^{4}\downarrow^{4} O^{\alpha}_{6}$	Identify next hyperlink to be checked
O^{ε}_{7}	Activate link by moving mouse cursor to hyperlink being checked and left-clicking
$O^{\alpha\,th}_{8}$	Look at new page display in browser window and compare with expected result
$l_{3}\uparrow^{3}$	If browser display is appropriate go to O^{ε}_{9} ; if "The page cannot be displayed" HTML file is displayed or if link works but page inappropriate go to O^{ε}_{11}
O^{ε}_{9}	Move mouse cursor to browser Back button and left-click or right-click in browser display pane to invoke context menu and left-click on Back item
O^{α}_{10}	Look at hyperlink and check its alphabetical order in hyperlink list display
$l_{4}\uparrow^{4}$	If alphabetical order is correct go to O^{α}_{6}; otherwise, go to O^{ε}_{11}
$\downarrow^{3}\downarrow^{4}\downarrow^{7(2)}\downarrow^{11(2)} O^{\alpha}_{11}$	Identify correct text editor window
O^{ε}_{12}	Bring text editor window to foreground by moving cursor onto window area and left-clicking or moving cursor onto taskbar icon and left-clicking
O^{α}_{13}	Check that correct HTML file is displayed in text editor by inspecting window title bar
$l_{5}\uparrow^{5}$	If correct file is displayed in text editor go to O^{ε}_{15}; otherwise go to O^{ε}_{14}
O^{ε}_{14}	Open correct HTML file by either selecting File→Open from pull-down menu, and browsing to file location using Open dialogue box or use left mouse button and cursor to drag file icon from desktop or other location and drop on browser display pane by releasing mouse button
$\downarrow^{5} O^{\alpha}_{15}$	Scan HTML mark-up and plaintext in text file; identify link mark-up in text file that corresponds to incorrect hyperlink item in display
$l_{6}\uparrow^{\mu\,th\;6}$	If alphabetical order was incorrect proceed to O^{ε}_{16}; otherwise go to O^{ε}_{21}
O^{ε}_{16}	Highlight link mark-up by dragging mouse across text with left button depressed; cut mark-up to clipboard by using keystroke combination CTRL+X or choosing Edit→Cut from pull-down menu
$O^{\alpha\,th}_{17}$	Identify appropriate location for hyperlink mark-up
O^{ε}_{18}	Paste text from clipboard by inserting cursor in correct location and using keystroke combination CTRL+V or choosing Edit→Paste from pull-down menu; save file by choosing File→Save from text editor pull-down menu
O^{ε}_{19}	Bring browser window to foreground by moving cursor onto window area and left-clicking or moving cursor onto taskbar icon and left-clicking; Refresh browser display by moving mouse cursor to refresh icon and left-clicking or selecting command from View pull-down menu and left-clicking

Table 7.5: Algorithmic description of activity during the "Check & Update Hyperlinks" task.

Algorithm	Description
O^{α}_{20}	Inspect updated browser display
$\overset{7(1-2)}{l_7} \uparrow$	If updated display is satisfactory, return to O^{ε}_2 to check next link; if not, return to O^{ε}_{11}
$O^{\alpha}_{21} \downarrow^6$	Inspect mark-up for spelling or syntax errors
$\overset{8(1-2)}{l_8} \uparrow$	If syntax error identified go to $O^{\mu\,th}_{23}$; if spelling error identified go to $O^{\mu\,th}_{24}$ otherwise proceed to O^{ε}_{22}
$\overset{9(3)}{\downarrow} \overset{10(3)}{\downarrow} O^{\varepsilon}_{22}$	Highlight link mark-up by dragging mouse across text with left button depressed; delete mark-up by using Delete key or choosing Edit→Delete from pull-down menu
$\omega_1 \uparrow_{\omega 1}$	Always false logical condition; default to O^{α}_1 if correction procedure completed, otherwise continue to next member of algorithm
$\overset{8(1)}{\downarrow} O^{\mu\,th}_{23}$	Identify required syntax correction
$\overset{9(1-3)}{l_9} \uparrow$	If unable to identify required syntax correction go to O^{ε}_{25}; otherwise go to O^{ε}_{27} or O^{ε}_{22}
$\overset{8(2)}{\downarrow} O^{\mu\,th}_{24}$	Identify required spelling correction
$\overset{10(1-3)}{l_{10}} \uparrow$	If unable to identify required spelling correction go to O^{ε}_{25}; otherwise go to O^{ε}_{27} or O^{ε}_{22}
$\overset{9(1)}{\downarrow} \overset{10(1)}{\downarrow} O^{\varepsilon}_{25}$	Request assistance from other participants
O^{α}_{26}	Receive information on how to proceed from other participants
$\overset{9(2)}{\downarrow} \overset{10(2)}{\downarrow} O^{\varepsilon}_{27}$	Insert cursor at appropriate position in mark-up and make correction; save file by choosing File→Save from text editor pull-down menu
O^{ε}_{28}	Bring browser window to foreground by moving cursor onto window and left-clicking or moving cursor onto taskbar icon and left-clicking; refresh browser by moving mouse cursor to refresh icon and left-clicking or selecting command from View pull-down menu and left-clicking
O^{α}_{29}	Inspect updated browser display
$\overset{11(1-2)}{l_{11}} \uparrow$	If updated display is satisfactory, return to O^{α}_1 to check next link; if not, return to O^{ε}_{11}

7.2.4.4 Complexity & Contradiction in the "Check & Update Hyperlinks" Task

It can be seen from the algorithmic description in Table 7.5 that in order to carry out each cycle of the task (Figs. 7.7-9) DH was required to identify and foreground appropriate application windows (*e.g.* O^{α}_{1}, O^{ϵ}_{2}); highlight, cut, and then paste source code within or between Notepad windows, save the changes, and inspect the results in a refreshed browser window display, (O^{α}_{15} - O^{α}_{20}); inspect URLs in the source code (*e.g.* O^{α}_{21}) and check for syntactical and spelling errors (*e.g.* $O^{\mu th}_{23}$, $O^{\mu th}_{24}$). The superscript $^{\mu}$ denotes that these complex perceptual and thinking actions involved both short-term (when identifying correct windows and comparing code and display) and long-term memory (comparison of display with overall design plan, recalling rules of URL syntax, *etc.*). They clearly placed particularly high demands on short-term memory, with DH being required to retain information about which code snippet was being edited, code content and syntax while simultaneously performing perceptual and motor actions toward both source and destination windows.

As has been noted, during task performance DH was running both Notepad and IE3 in multiple windows (Fig. 7.8). However, these two applications deal with windows in different ways: in IE3, windows function as several views generated from the same running instantiation of the application; opening a new window is offered as a standard menu option, and closing an open window does not exit the application (unless it is the only open window). In contrast, each Notepad window represents a single instantiation of the program; the content of each window is independent of any other. With the hardware/software configuration in use, it was feasible to load several instantiations of Notepad into RAM at once without impairing performance. This arrangement made it possible to edit the same text file simultaneously in two Notepad windows, making and saving *different* changes to the file in each of those windows.[28]

However, DH's understanding of this situation appears not to have been well-supported by the various elements of the desk-top display. The only visual clues available as to the identity of particular files were the short filenames in the title bars of the Notepad windows - which do not include full file paths - and the complex local URLs displayed in the address bar of the browser (see Fig. 7.8); as

has been noted earlier (§7.1.3.2), interpretation of this information required not only that users understand the local file structure but also the way the application itself stored and handled temporary files. Inspection of the algorithm suggests that these various design features (differences in handling of windows, inadequate feedback) contributed toward interaction breakdown by requiring that the DH expend further perceptual and mnemonic effort during those parts of task performance which were already highly complex, precipitating the catastrophic breakdown situation described in §7.2.4.1 which found DH making changes to source files in Notepad while being unable to identify any corresponding change in the browser display.

In more advanced morphological analyses the elaboration of an algorithm is a precursor to developing detailed time-structure descriptions, which when combined with the algorithm allow the development of formal quantitative measures of task complexity (see Note 20, this chapter). However, the brief discussion above demonstrates that even if analysis is limited to the first stages of morphological analysis, a significant amount of design-information can be generated (*cf.* Sengupta and Jeng, 2003, Sengupta, 2004). Visual inspection of the algorithm can help in identifying specific parts of the interaction sequence where complexity is high, indicating the need for simplification or increased support. The allied isolation and classification of actions can provide insights into which aspects of the application in use are most critical to the interaction at various points in the activity. For example, the sequence of operators from O^{α}_3 to O^{ε}_7 in the algorithm corresponds to Step 2 in Fig. 7.9, "Load or refresh appropriate HTML document"; as already noted O^{ε}_7 clusters the 4 actions shown in Table 7.4. The second action, "Locate display pane" can be considered the most complex in this cluster, as it combines sign-practical and simultaneous-perceptual processes, that is, discernment, recognition and interpretation based on both short-term and long-term memory. Thus, design interventions to alleviate complexity at this point in the task should concentrate on either reducing the amount of choices available to the user (*e.g.* by redesigning the task or applications so as to require fewer windows to be open) or making identifying the correct window easier (*e.g.* by redesigning the OS so that colour-coding can

be used to differentiate multiple application windows and matches linked browser and editor windows).

7.3 Discussion

7.3.1 Combinatorial Activity Analysis

This chapter has demonstrated the use of a variety of activity-theoretical methods for the design-oriented analysis of HCI field data gathered during Phase 1. These methods, which address a variety of levels and stages of activity, were used in combination, both with each other and with HCI/ISD techniques drawn from other traditions. The first part of the chapter (§7.1) utilized the general AT notion of contradictions as drivers of change in activity as a device to identify possible causes of catastrophic and recurrent breakdown in the observed computer-mediated collaborative activity. This analysis was carried out against the background of a more conventional (although still context-aware, see §1.4.3.2) usability engineering approach to evaluating the software applications used in the study. The usability evaluation incorporated an (originally cognitivist) usability inspection technique adapted so as to incorporate activity-theoretical ideas (§7.1.1).

The second part of the chapter demonstrated the application of ATIT methods to a more narrowly delimited object of study: computer-mediated activity during the performance of a specific task or tasks (*cf.* §2.5.3.1, 3.5.2.2 & Fig. 2.7). The contradictions analysis outlined in §7.2.3.2 provided a relatively rapid – albeit fairly general and high-level - means of identifying some specific design factors giving rise to breakdown in the "Update Graphics" task. The focus-shift technique which followed involved the detailed description of discrete object-and-subject-oriented actions during part of the task, their interrelationships, and the role played in the activity by computer artifacts as either mediators or objects of action. This approach - which elicits detailed information about the activity as it unfolds from moment-to-moment and in principle allows the identification of specific junctures in the interaction sequence where design intervention might prove most effective - is correspondingly more costly in time and effort than the preceding techniques.

The second case study explored the use of SSAAD techniques of morphological analysis. It was clear that – in common with other HFE and HCI task analysis methods such as MTM-1 and GOMS[29] - the action isolation, classification and algorithm-creation process can be complex and time-consuming.[30] The analyses described in §7.2.4 involved around 50 man-hours of effort, while the further elaboration of time-structure and complexity measures would have required an even greater commitment.[31] This suggests, firstly, that use of the more detailed stages of morphological analysis will be dependent upon the specific demands of a particular project, and may only be appropriate for mission- or safety-critical aspects of the design and evaluation process; and secondly that the careful selection of appropriate interaction sequences for further morphological analysis is essential. The general methods of task classification provided by SSAT discussed in §7.2.4.1 may provide useful heuristics for guiding such choices.

7.3.2 The Task as an Object of Study for ATIT

As noted above, the second part of this chapter has focused on activity-theoretical task analysis techniques. Task analysis is fundamental to work in human factors/ergonomics (Meister, 1999) and has also always been central to HCI research (Benyon *et al.*, 2004, p. 503, Annett and Stanton, 2000, Diaper and Stanton, 2003, Schraagen *et al.*, 2000, Shepherd, 2001, Crystal and Ellington, 2004, Bedny *et al.*, 2005a). However, the development of a second generation of HCI was associated with numerous critiques of task-analysis methods developed within the framework of human information-processing psychology - such as the GOMS family (John and Kieras, 1996, Kieras, 1998) and other forms of hierarchical and cognitive task analysis (*e.g.* Annett and Duncan, 1967, Vicente, 1999, Barnard and May, 1999) - mainly on the grounds that they tend to ignore the context within which interaction is embedded (*e.g.* Ehn and Kyng, 1984, Draper, 1993, Bertelsen, 1994). Moreover, the notions of task and task analysis have been variously (and somewhat inconsistently) defined within HCI according to authors' disciplinary perspectives and specialised areas of concern (Draper, 1993, Diaper and Stanton, 2003, Crystal and Ellington, 2004).

In the mid 1990s these considerations led many researchers working in or influenced by Scandinavian ATIT to avoid discussing tasks *per se,* generally

preferring to take either *activity* or *activity system* as their primary object of analysis (*e.g.* Rauterberg, 1995b, Holland and Reeves, 1996, Nardi, 1996c, Bertelsen and Bødker, 2003, Turner and McEwan, 2004, Crystal and Ellington, 2004). However, concepts of the goal-oriented task, task-solving processes, and task analysis have been central in both theoretical and applied Soviet AT (§2.4), as without the ability to clearly differentiate between linked sequences and sub-sequences of activity with their corresponding hierarchically organized goals and varying intensities of motivation, detailed and consistent analysis of real-world work and learning activity can be extremely difficult (Bedny and Meister, 1997, pp. 18-25, Bedny *et al.*, 2000, Bedny *et al.*, 2005a).

As noted in §3.5.2.1, there has been a growing recognition that within Scandinavian ATIT "...attempts to fill the gap between academic theorizing and practical design ...most often ...have not quite succeeded in being a genuine resource for practical design" (Bertelsen *et al.*, 2005). This has prompted some ATIT researchers to attempt to combine CHAT with other HCI, ISD and software engineering approaches (*e.g.* Bertelsen, 2003, Korpela, 2004) or to extend the CHAT framework to include additional concepts, elements and levels (*e.g.* Rizzo *et al.*, 2005, Barab *et al.*, 2004). Others have argued that without utilizing the traditional AT concept of task ATIT is likely to continue to face difficulties in progressing from description to prescription (Harris, 2002a, 2005d). Some of the constructs recently put forward within ATIT as possible intermediate objects of analysis ("between" activity and action) appear to come very close to the notion of task as traditionally understood within AT, but in the process confuse and conflate some basic activity-theoretical concepts. The foregoing observations suggest that the need to clarify the basic concepts, terms and analytical units of ATIT (one of the implications of the critical review undertaken in Chapter 3) is particularly acute with regard to the use of the task as a basic object of study.

7.3.3 Breakdowns, Focus-Shifts and Self-Regulation

This chapter has made extensive use of the notion of contradictions as drivers of change in activity as a tool for understanding breakdown in computer-mediated activity. In doing so it has developed a somewhat more specific version of the

responses (to critiques of ATIT) first set out in §3.5.2.2; namely, that the relationships between primary and secondary contradictions as general causes of breakdown and the moment-to-moment enactment of activity through chains of goal-oriented mental and motor actions in specific work processes are difficult analyse in any detail using only CHAT concepts and perspectives. Engeström's high-level schema (Figs. 2.4, 7.1, 7.4), although useful for quickly identifying significant design-oriented issues in an interaction sequence while retaining a strong connection to the context of the activity does not clearly distinguish between important AT concepts such as object and goal, nor differentiate between individual and collective subjects. This can make it difficult to apply at anything but the most general level of cultural-historical analysis (Bedny and Harris, 2005). The focus-shift approach, although clearly capable of producing considerably more nuanced and detailed descriptions, may also tend to reflect this lack of conceptual clarity, as is perhaps evident in Bødker's definitions of its key terms (cited in §3.3.1.3).

On the other hand, SSAAD methods have been specifically designed to provide detailed information on the interaction between external tools such as controls, displays, screens, instructions *etc.* and subjects' "internal tools" such as conceptual models, skills, knowledge *etc.* (Bedny and Karwowski, 2004a). Although the analysis in §7.2.4 did not proceed beyond the early stages of morphological analysis, it was sufficient to demonstrate that the development of descriptions of task performance in terms of discrete actions and low-level goals and their logical relationships can help uncover connections between the physical and logical configuration of the means of work and the temporal, spatial, and logical organization of subjects' activity at any given moment of the task, and thus generate detailed and potentially useful design-oriented insights about the computer artifacts in use - albeit at considerable cost in time and effort. However, analysts should be aware that even highly context-oriented approaches may risk ignoring the wider context of interaction when applying finely detailed task analysis methods. Algorithmic analysis should therefore be employed alongside the kind of general qualitative and cultural-historical descriptions of the use-setting, participants, and observed activity overviews of task and application complexity and interaction breakdown and descriptions of the

computer artifacts in use at varying levels of detail that can provide explicit links to the wider context of interaction. It is arguably a particular strength of activity theory that it has developed a comprehensive, unified and holistic conceptual framework within which to accomplish this integration of different levels, stages, and aspects of activity analysis.
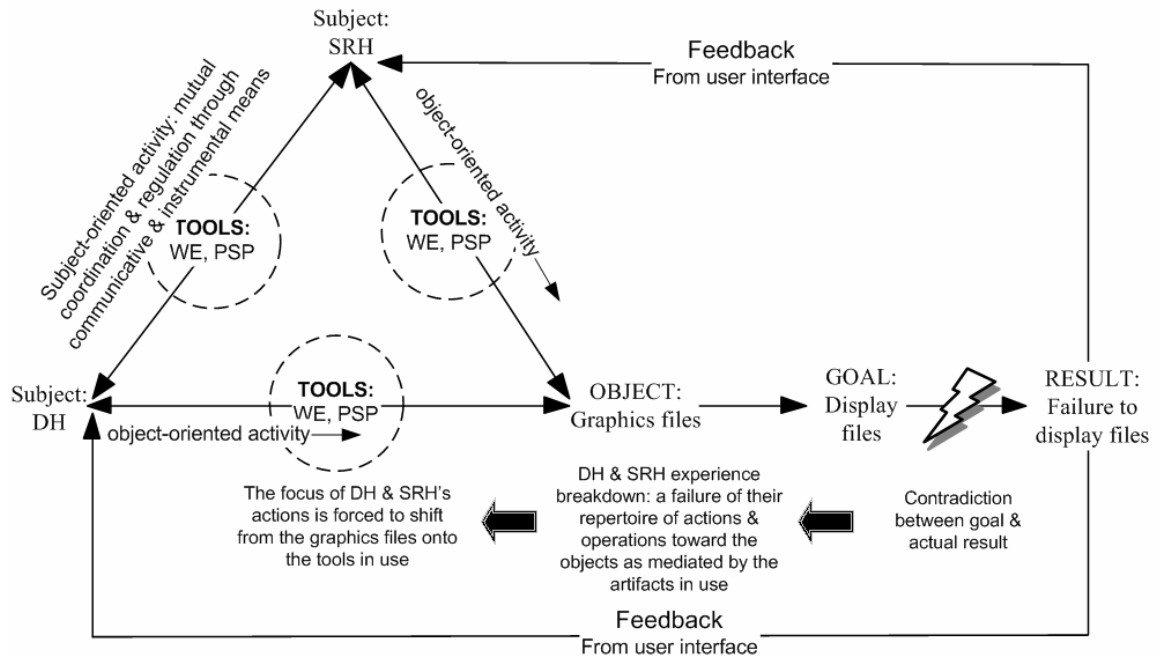
Figure 7.10: Triadic schema of breakdown in the "update graphics" task. Refers to focus-shifts {2}-{5} as depicted in Fig. 7.5. *Cf.* Figs. 2.10 & 3.2.

One insight arising from the literary and historical researches documented in Chapters 2 and 3 is that the integrative power of AT is unlikely be fully realised within ATIT if important perspectives on, and approaches to activity analysis are neglected or kept apart from each other. The combination of Scandinavian ATIT and SSAAD methods demonstrated in this chapter represents an attempt to operationalize this insight by integrating the cultural-historical and objectively-logical perspectives embedded in contradictions and focus-shift analysis with the explicitly individual-psychological approach of SSAT morphological analysis based on an understanding of human tool-mediated activity as a self-regulating, goal-oriented system. Figure 7.10 presents a graphical representation of one aspect of this synthesis. It combines the triadic schema of collaborative activity developed by Bedny and Harris (2005, 2006b), which incorporates elements of

the "Engeström Triangle" or activity system shown in Fig. 2.4, with the graphical depiction of focus-shifts in activity first presented in Fig. 3.2.

The figure shows the interaction breakdowns observed in the "Update Graphics" task (§7.2.3) in terms of contradictions arising between the users' subjective assessments of the actual results or outcomes of their activity and their goals, here understood as those more-or-less precise conscious, cognitive components of activity which orient and guide the users' actions toward the work-object.[32] When the disparity between the subjects' desired goal and actual result exceeds their "subjective standards of admissible deviations" (a function block in the general self-regulation model presented in Fig. 2.9), breakdown occurs. The case studies presented in this and previous chapters illustrate the "double nature" of such breakdowns: on the one hand, they are an unwelcome intrusion into the flow of activity, and can lead to abandonment of the task; on the other, they are essential to learning-in-use. In SSAT, such learning is portrayed as "a transition from one well-known strategy to a new strategy or adaptation of a well-known strategy for a new situation" (Bedny and Meister, 1997, p. 342). The observations and analysis undertaken during Phase 1 strongly suggested that whether a breakdown is "beneficial" - in the sense that in negotiating it users develop alternative and possibly more effective strategies of action - is critically dependent upon the specific circumstances under which it occurs, and that the sociocultural aspects of the use situation are at least as relevant in this regard as the design of the technologies in use. In order to further investigate these and other issues arising from Phase 1 a second phase of empirical fieldwork was undertaken; this is described and discussed in the following chapter.

7.4 Summary

Following the end of active data-gathering the researcher carried out a general usability evaluation was carried out on the applications used in Phase 1. The majority of tools chosen for *Computer Creative* were evaluated as being of moderate to good usability; however examination of the study data suggested that some of the more usable tools could have been used more frequently during the course, while those tools which caused recurrent problems might have usefully been replaced or tasks redesigned to avoid their use. Further analysis of

breakdowns tentatively identified three types of contradiction as factors contributing toward catastrophic and/or recurring interaction breakdown: contradictory representations of task difficulty; contradictions between "assumed" and actual knowledge of users; and the contradiction of adaptation operations. The researcher's main focus in the post-study period was on investigating selected cases of observed interaction breakdown and recovery using a combination of methods and principles derived from differing traditions within AT. The researcher also carried out a detailed, multi-level analysis of two tasks observed during Web authoring activity using contradictions, focus-shift, and morphological methods. The latter were based on SSAT and included task classification, action isolation and classification, and detailed description using techniques of algorithmic analysis. This combinatorial approach facilitated several insights into the nature of interaction breakdown and generated a considerable amount of design-oriented information. It also allowed the researcher to contrast and compare several different approaches to activity analysis.

Notes to Chapter 7

[1] When *in situ* inspection was impracticable, the relevant applications were installed and inspected on the research machine described in Note 9, Chapter 8.

[2] In its original formulation (*e.g.* Polson *et al.*, 1992), the walkthrough technique took a cognitive stance, and was based on a theory of exploratory learning (Carroll, 1982, Shrager and Klahr, 1986). Although some ATIT researchers reject the cognitive walkthrough as inappropriately reductive, Bertelsen (2003) has convincingly argued that effective use of the walkthrough technique is not tightly linked to any particular theoretical framework, and that other types of psychological theory - such as AT - may be utilized for a walkthrough. Due to the inexperience of the researcher, the walkthroughs discussed here were necessarily rather basic; later work (*e.g.* Harris and Reddy, 2005) has attempted to develop rather more sophisticated activity-theoretical usability inspection techniques.

[3] "Usability is the effectiveness, efficiency and satisfaction with which a specified set of users can achieve a specified set of tasks in a particular environment." International Organization for Standardization: *Ergonomic requirements for office work with visual display terminals - Part 11: Guidance on usability* and *ISO/TR 16982:2002 Ergonomics of human-system interaction - Usability methods supporting human-centred design.* See http://www.iso.org/.

[4] See http://www.ucc.ie/hfrg/baseline/.

[5] Although the emphasis of *Computer Creative* was on user autonomy and creativity, some tasks were required (either because they formed part of compulsory course activities or as a consequence of their connection to other parts of the work-process); among required tasks, some

could only be completed using specific tools. For example, in the later stages of the course all participant learners were asked by the tutors to save their work onto recordable optical compact disk (CD-R), necessitating the use of the Nero Burning Rom software, the only package available in Workshop 3.

[6] However, it should be noted that these results can only be considered as giving some very general indication as to the nature of these relationships; due to both the methods adopted and the heterogeneous and incomplete nature of the data attempts to further verify the findings proved inconclusive. On calculating the Pearson product moment correlation coefficient for the two datasets (use frequency and use necessity) it was found that $r = 0.46813$, indicating no significant (either direct or inverse) correlation. This result neither supports nor disproves the inferences set out here. See also discussions in §4.3 & 5.2.1.

[7] Estimates of catastrophic and recurrent breakdown frequency in this section are based on the field note and BDPF data and are subject to wide (+ or – 20%) margins of error. See also §5.2.2.3

[8] In this sense activity theory has always been in part both an "evolutionary" and "cognitive" psychology, both anticipating and at times mirroring trends in Western psychology. Examples of the evolutionary approach in contemporary American cognitive science can be found in Dennett (Dennett, 1993), Pinker (1997), and Plotkin (1998).

[9] During the period in which the exercise described here was carried out (August 2001-January 2002) the author attended a seminar given by Bærentsen's group at the Aarhus University Institute of Psychology on activity-based evolutionary approaches to UI design (see Bærentsen and Trettvik, 2002). These discussions were continued during visits to Denmark in 2004 and 2005. Major work in this area has subsequently been undertaken by R. Nørager; preliminary findings are reported in (Nørager, 2004).

[10] Space precludes discussion of all four sets of data identified as suitable for further analysis. The other three incidents mentioned here involved (1) a sequence of breakdown and recovery with the UVS timeline recorded during a video-editing task (of the type discussed in §6.5.2.5); (2) a non-catastrophic breakdown involving multi-layer animation compositing using PSP and AS (where users were employing the techniques described in described in §6.3.1.1); and (3) a catastrophic breakdown incident involving the generation of an executable file using Multimedia Builder (of the type briefly described in §5.5 & 6.8.5). Each set of data identified contained a slightly different mix of sources; each was examined utilizing differing combinations of the techniques described here and in Chapter 8. These analyses remain partially incomplete at the time of writing (Summer 2006); their completion and writing-up will be the subject of future work.

[11] The use of contradictions and focus-shift analysis described here was mainly based on the account in (Bødker, 1996a).

[12] The basic techniques of morphological (including algorithmic) analysis were first published in English in (Bedny and Meister, 1997, pp. 189-190, 204-210, 232-297). As noted, the first English-language report of the systemic-structural analysis of HCI was (Bedny et al., 2001d). In 2003 accounts of a computer-based work-process study by Bedny & Karwowski (2003b) and a laboratory study based on eye-tracking data (Sengupta and Jeng, 2003) both included brief examples of algorithmic analysis. Subsequently, papers by Bedny et al (Bedny et al., 2005b) and the author (Harris, 2004, 2005d) have specifically dealt with the algorithmic analysis of HCI data.

[13] The algorithmic approach to activity analysis was first suggested in 1957 by the mathematicians G. A. Shestopal and A. A. Liapunov (1911-1973), the latter being one of the leading exponents of cybernetics in the Soviet Union (see Gerovitch, 2002, esp. pp 173-175). It was initially utilised for research in ergonomics in the mid-1960s by G. M. Zarakovsky and henceforth was widely used throughout the USSR (Bedny and Meister, 1997, p. 204 and G. Z. Bedny, personal communication 2005).

[14] During enrolment in September 2000 DH was evaluated as having special learning needs, following a diagnosis of mild dyslexia made by the College's education officer using a standardized test procedure. However, observations of DH's activity during the longitudinal study by participant tutor T (a trained dyslexia assessor) did not provide any further evidence of the condition.

[15] The discussions in following sections assume some basic familiarity with the operation of the World Wide Web (WWW), Hypertext Mark-up Language (HTML), Web browsing software, and

client-server networking generally. Reference materials on these topics can be found in (Naughton, 1999) and online at http://www.w3.org.

[16] The unit "Web page" is used here to refer to (one or more copies of) a uniquely named ASCII text file, containing HTML code and saved with the extension .htm or .html, and its embedded (*i.e.* associated through HTML link coding) media files (graphics, audio, video, *etc.*) in appropriate formats. This definition is somewhat arbitrary (given the possibility of dynamically generated content, windows, *etc.* and the sharing of media assets) but corresponds reasonably closely to the basic Web authoring tasks undertaken during *Computer Creative*.

[17] That is, those HTML files stored on remote servers associated with the URLs (uniform resource locator) included in the mark-up of the hyperlinks activated by DH on his locally-stored Web page.

[18] Although perceived by the user as the making a copy of a remote (*i.e.* held on a Web server) file, this procedure actually involves the copying of a locally cached file to a named location chosen by the user.

[19] The definitions of actions and operations in use here are consistent with those set out in §2.5.3.1 & 3.3.2.1 and the glossary. Although they are smaller and more precise analytical units than those used by authors such as Engeström and Kuutti (see the discussion in §3.5.2) the presence of qualifiers reminds the reader that the "boundaries" between units remain indistinct, both because of the ongoing process of dynamic transformation between "levels" of activity and also because notions such as the "conscious" and "unconscious" regulation of activity are considerably more complex and interrelated than is possible to explore at length here – the interested reader is referred to (Bedny and Karwowski, 2004b). The basic definitions in use – and the ways in which they differ from those used elsewhere in ATIT - are also set out in (Bedny and Harris, 2005).

[20] At this point the latter two stages of morphological analysis (detailed time-structure and quantitative complexity analyses) were both outside the scope of the project and beyond the competency of the researcher. Detailed accounts of the use of these techniques for design will appear for the first time in English in a monograph by G. Z. Bedny to be published by Taylor & Francis in the Autumn of 2006 (Bedny, personal communication). To the best of the author's knowledge this section of the chapter (some of the data in which was first published in Harris, 2004) provides the first examples of the application of SSAAD structural analysis techniques to HCI field data.

[21] Marked-up using HTML elements <UL> and <LI>.

[22] The degree of freedom of performance during a task is related to both the objective complexity and subjective difficulty of the task (§5.4.1, 7.1.3.1), although the degree to which this is a direct relationship will vary according to task requirements, conditions, the experience of the subject, *etc.*

[23] These various categories of task are relative rather than absolute, and categorization of any particular task or sub-task will depend on the level of generality at which it is described. For example, probabilistic-algorithmic tasks often also include non-algorithmic problem-solving components; in the same way, semi-heuristic task-problems may also include algorithmic and semi-algorithmic sub-tasks (Landa, 1983, Bedny and Meister, 1997, pp. 18-25, Bedny and Harris, 2005, pp. 140-141, Bedny *et al.*, 2005a).

[24] Here, "screen" refers to the visible contents of an application window, the presence of further screens of information being signalled to the user by the status of the scrollbar. See *e.g.* Fig. 7.9.

[25] In fact DH never resumed updating the links pages; they remained incomplete at the end of the course.

[26] The algorithm is basic inasmuch as - unlike that shown in Fig. 3.6 - it does not include specific time-values for the duration of members of the algorithm. This means that in its present form Table 7.5 cannot be used as a basis for detailed time-structure analysis or the quantification of task complexity. Table 7.5 also shows the different decision-branches of the logical relationships as having an equal likelihood of being chosen, whereas in more sophisticated probabilistic algorithms different weightings are associated with each option (Bedny and Meister, 1997, pp. 232-297). See also Note 12 above.

[27] In AT, thinking activity can also be morphologically analysed as a structured system of actions and operations on ideal objects such as images and concepts. See *e.g.* (Tikhomirov, 1988).

[28] To add to this complexity, each IE3 window actually displays information derived not from the HTML file perceived (and acted toward) by the user as the source, but from a locally cached version. In several similar cases observed during the study, users automatically launched additional instantiations of Notepad by invoking the 'Source' command from the View menu of Internet Explorer. The HTML mark-up presented is editable, but is derived from a copy of the source file in a temporary directory rather than a named location. This produces difficulties when saving and viewing changes similar to those experienced here, and was a source of considerable additional confusion during Web authoring.

[29] The dual comparison here with physiological and cognitive methods of task analysis is made in order to re-emphasize the basis of morphological analysis in the fundamental activity-theoretical principle of the unity of cognition and behaviour (§2.4.2.1), and thus encompasses physiological, psychophysiological and psychological aspects of the task. In this sense it can be much more complex than most Western HFE or HCI task analysis methods. Many studies of human work carried out under the systems-cybernetic framework in the former Soviet Union involved the integrated capture and analysis of multiple data on the worker's activity; the holistic conceptual framework of AT allows the making of meaningful linkages between measures such as pulse rate, skin conductivity, gaze tracking, *etc.*, external observation and recording of behaviour, and the outputs from standard psychological tests and subjects' self-assessments. Some modern examples can be found in (Bedny and Seglin, 1997, Zarakovsky and Kazakova, 2004, Bedny *et al.*, 2005b, Chainova *et al.*, 2006).

[30] However, it should be noted that advocates of systemic-structural activity analysis (*e.g.* Zarakovsky and Sengupta, 2003, Bedny and Harris, 2005) argue that one of its major advantages over design and evaluation techniques based on cognitive psychology – which mainly utilize experimental and statistical approaches - is that it allows the accurate abstract modelling, evaluation and comparison of different versions of a product or work-process design, thereby reducing the need to build and test costly prototypes.

[31] The process of morphological analysis could clearly be improved in this regard by automating some of its elements, as has been the case with both MTM-1 and GOMS (see for example John *et al.*, 2002). Proposals for future work in this regard are discussed in Chapter 9.

[32] Prior to the work reported here the concept of breakdown (§4.3.4) had not been utilized within systemic-cybernetic AT, perhaps partly because the study of errors and failures was far less developed in Soviet than Western ergonomics (Bedny and Meister, 1997, pp. 162-185).

8. Phase 2: The Video-based Field Study

This chapter describes and discusses the second phase of empirical research, a video-based field study of a desk-top publishing (DTP) session carried out in May 2002. It begins by setting out the motivation for, and aims and objectives of, the fieldwork, going on to describe the study participants and tasks, tools used, and artifacts produced. The activity-theoretical observation and analysis methods employed during the study are then described and discussed. A summary of general findings is followed by a detailed case-study and discussion examining issues of goal-formation and motivation in collaborative computer-mediated activity.

8.1 Organizing & Designing Phase 2

The concurrent and post-study analyses of the Phase 1 data discussed in previous chapters foreshadowed several further lines of enquiry (see §3.5.2.4, 5.4.2, 7.3) and highlighted a number of practical and methodological issues (discussed in §4.1, 5.2.1, 7.2.1.1), indicating that, if carefully designed, some additional fieldwork might prove useful in furthering the aims and objectives of the research project (§1.3).

8.1.1 Aims & Objectives of Phase 2

In January 2002 the researcher (SRH) - again in collaboration with the ABE tutor (T) who helped design and deliver *Computer Creative* - began to design and organize Phase 2. On the basis of experience gained during Phase 1, a general aim for the proposed fieldwork was formulated, as follows:

> To further investigate some general, design-oriented and methodological issues raised by the first phase of study through closely observing analogous creative, collaborative computer-mediated work activity taking place under more controlled circumstances, analysing the resulting data using both established and novel ATIT methods.

This general aim was associated with several specific objectives:

- To further develop, apply and evaluate fieldwork techniques for the observation and recording of collaborative computer-mediated activity;

- To further develop, apply and evaluate activity-theoretical techniques for the integrated macro, meso and micro-analysis of the resulting data;

- To extend the Phase 1 study by: (1) providing a basis for a comparative study of the impact of differing task-conditions (type of task, tools used, etc.) on the structure of collaborative computer-mediated activity; and (2) further investigating the impact of computer artifact design on motivation, perception, goal-formation and learning in collaborative computer-mediated activity.

8.1.2 Design of Phase 2

Defining aims and objectives for the fieldwork helped to clarify its practical requirements. It was decided that the fieldwork would involve: (1) the direct (*i.e.* non-participatory) observation of a smaller and preferably more uniformly experienced and/or technically skilled group of participants than in Phase 1; (2) the imposition of greater external constraints on participants' activity than in Phase 1, so as to reduce the overall degree of freedom in the observed tasks and thus facilitate comparison between individual and group task performances (*cf.* §7.2.4.1); (3) observation sessions of sufficiently limited duration so as to make detailed and comprehensive data-capture and analysis feasible; and (4) the establishment of sociocultural conditions approximating those obtaining in Phase 1.[1] These requirements implied that the study should: (5) be carried out at a time when participants would have already taken part in several collaborative computer-mediated activities, but not yet be under pressure to complete end-of-year accreditation (*i.e.* no later than the middle of the third term – see Note 5, Chapter 1); (6) involve the completion of pre-defined, rather than participant-generated tasks; (7) require participants to organise their collaboration according to some pre-defined norms; and (8) that fewer computer artifacts should be used and produced than in Phase 1.

8.2 The Video-Based Study

The second phase of field study was carried out between 16.30 and 19.00 on Thursday May 9th 2002, in a session specifically arranged for the purposes of the research. At the beginning of the session the ABE/ICT tutor (T) presented eight adult basic skills learners with the task of working together in small groups to plan, research, produce, and evaluate a paper document using desktop publishing

(DTP) software. The session took place in OLC Workshop 3, where the technological environment remained essentially unchanged since Phase 1.[2]

8.2.1 Phase 2 Participants

In the academic year 2001-2 five new integrated ICT/ABE courses – all based in part on the *Computer Creative* model - were offered at the OLC. Among the 50+ enrolees were several students who had participated in the Phase 1 study; others had been part of the *Combined Studies*, *NetWise*, and *Internet Club* cohorts in previous years (see §1.1 & Fig. 1).[3] The courses were canvassed for volunteers and eight learners selected to participate in the study by the researcher and participating tutor T. The selection process aimed to meet the requirements set out in §8.1.3. Thus, apart from their availability to attend the session, the principal selection criteria were: (1) learners' prior acquaintance with each other and the tutor/researchers; (2) familiarity with Workshop 3; (3) their level of ICT expertise, more skilled subjects being preferred; and (4) familiarity with the software packages to be used in the study. The ethical guidelines used in Phase 1 (§4.3.5) again applied; upon recruitment participants were briefed on the aims and objectives of the research and asked to read and sign a research agreement similar to that displayed in Appendix 1.

Table 8.1: Profile of the Phase 2 field study participants.

Code[1]	M/F	Age	Status[2]	Lit.	Num.	ICT	Comments	Sub-Group[3]
JG	F	62	P/TE		-	E3		1
MR	F	63	R	E3-1	-	E3	Mobility problem	
PR*	F	63	R	2	1-2	1		
DC*	F	62	R	2	2	1		2
WE*	F	62	R	2	2	1		
KL	M	76	R	1	-	E3		
SM*	F	37	L/TU	E1	E2	E3-1	SLN, hearing impaired	3
VS	M	59	P/TE	E2-3	-	E2		
T*	F	45		PG	G	2	Tutor	
Total participant learners = 8 (M = 2 , F = 6)								

Notes:
1. Asterisks indicate prior participation in the research project.
2. Coding as described in Table 5.2 & §5.3.3. Dashes indicate assessment information unavailable.
3. Learner sub-groups during the executive stage of the task; the tutor mainly worked with sub-group 3.

Table 8.1 profiles the participant learners, showing the gender, age, employment status, and assessed literacy, numeracy, and ICT skills levels of each individual.

Entries are clustered into the learner sub-groups in which participants carried out the collaborative computer-mediated task. Six of the learners were female and two male; their average age was 60.5 years, with the median 62.5. All were white, British-born, English-speaking UK nationals resident in the UK, and all were from low-income households (see comments in §5.3.1.1 and Notes 10, 11 & 12, Chapter 5). The skill levels shown are based on the results of evaluations by OLC course tutors at the beginning of the academic year 2001-2 (see §5.3.3 & Notes 15, 16, Chapter 5). As required by the study design, in comparison to Phase 1 (Fig. 5.2) participants' skill levels were higher overall: all but one (VS) were evaluated as having ICT skills at the E3/1 level; none were novices. Table 8.1 shows that four learners (PR, DC, WE and SM) had also taken part in the Phase 1 longitudinal study of *Computer Creative*. During the study these research-experienced individuals were distributed among the sub-groups (see also §8.6.1.2 below); this was assumed to spread any effect associated with their prior participation.[4]

8.2.2 Study Tasks, Tools and Artifacts

8.2.2.1 Tasks Observed During the Study

The duration of the observation session was 2.5 hours. At its beginning the tutor presented the learners with a predetermined task, that of planning, producing and evaluating an advertising or information brochure or leaflet,[5] stating that all aspects of the task should be completed by the end of the session. The activity observed during the DTP session fell into three main stages:

1. An "introductory" stage of about 18 minutes during which the whole group was briefed on the task by the tutor and then divided into three sub-groups, two of three learners, one of two (plus the tutor);

2. An "execution" stage, taking up the majority of the session (1 hour 40 mins.), during which the learner sub-groups planned, researched, and carried out the task;

3. A final "rounding-up" stage, lasting about 25 mins., during which the whole group came together again to present and evaluate the results of their work.

The first and third stages of the task mainly involved the learners sitting around the large work tables in the centre of Workshop 3, while the tutor stood or sat at the front of the room near the whiteboard (see Figs. 8.2, 8.3a below). During the execution stage learners used the PCs and printers, with each sub-group sitting at, or near, one of the three banks of Workshop 3 PCs, and producing their finished document on the one machine in each bank running the screen capture software. Learner sub-group 1 used PC Mill57; group 2 PC Mill50; and group 3 PC Mill52 (Figs. 4.1, 8.2).

8.2.2.2 Tools Used and Artifacts Produced
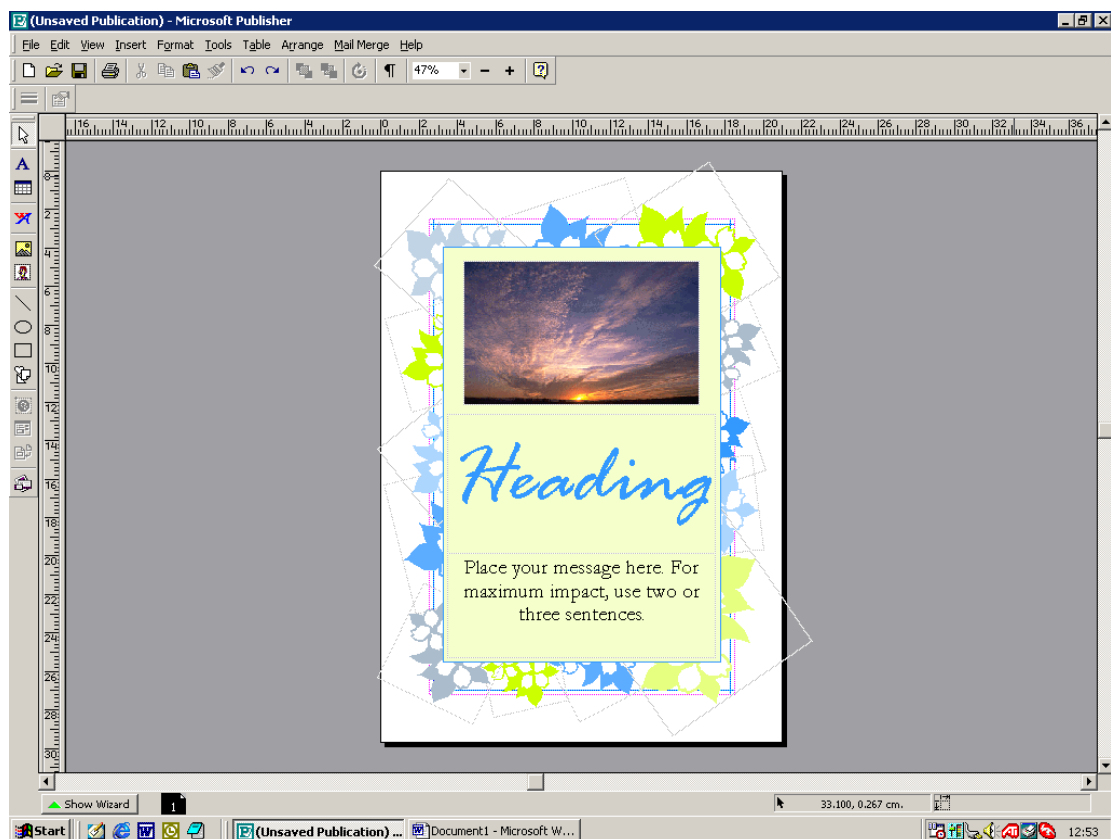
Figure 8.1: The Microsoft Publisher UI. A document template is open for editing in Print Layout view.

The principal application used during the study was the desk-top publishing (DTP) package Microsoft Publisher (henceforth, Publisher; Fig. 8.1). All participants had previously used Publisher at least once (§8.2.1). Publisher is a basic (*i.e.* non-professional) DTP application designed for the home and small business markets.[6] It is highly integrated with other MS Office applications, and shares a similar general UI design and many features and functions with MS Word. Publisher is a direct manipulation WYSIWYG application mainly

operated in a print layout view (as shown in Fig. 8.5). Onscreen menus, buttons, etc. are used to place text-boxes and graphical elements on "pages" which are built up as work proceeds. One of the strengths of the package (at least for novice and non- professional users) is the way in which it simplifies complex design choices by providing document templates which can be easily customised by the user, either directly or through the use of Wizards.[7]
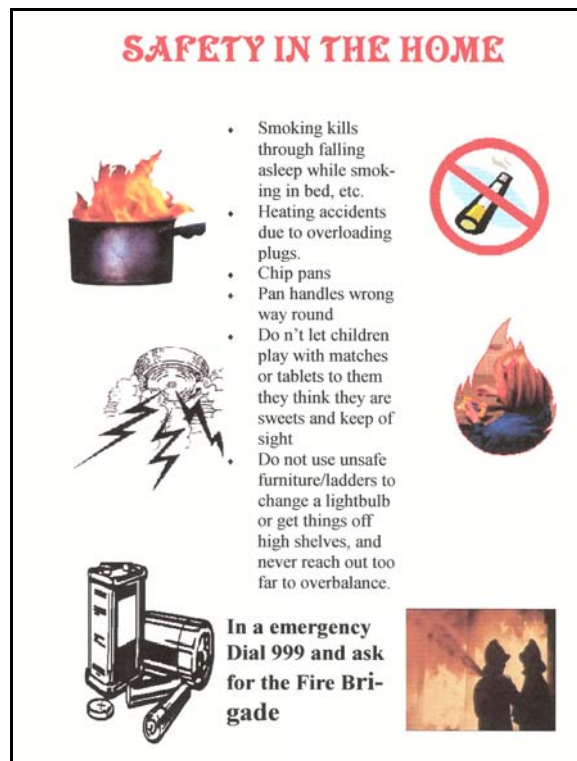
Figure 8.2: Example of publication produced during Phase 2. Shows the 1-page information leaflet created by learner sub-group 3 and discussed in §8.6 below.

The principal digital artifacts produced by participants during the study comprised three individual Publisher documents in native (.pub) file format. Figure 8.2 shows an example. During the creation process these documents were stored on the primary PC used by each group in a dedicated folder on the local HDD. File sizes ranged from 323 and 564 KB in size (see the discussion in §6.2.1 & *cf.* the output file size ranges for other applications listed in Table 6.2). All the documents were also produced in hard-copy. While researching during the execution stage of the task at least one member of each sub-group used the Web browser Internet Explorer (IE, §6.7.1 & 7.1) to access the WWW, primarily to search for images using the Google search engine (§6.7.2). Retrieved images, in JPEG or GIF format, were also stored in the local folder. Two members of

sub-group 2 (DC & PR) also edited images using the graphics application Paint Shop Pro (PSP, §6.2.1). Each sub-group used the Workshop 3 inkjet printers several times; at least one size A4 paper copy of the final document was printed per participant. During the execution stage some participants also used the pens and paper provided in the workshop.

8.3 Observation Methods

In Phase 2 the researcher (SRH) attended the session as an observer but did not directly participate in the teaching and learning activity. The principal data-capture method was video recording,[8] using cameras and screen recording software.

8.3.1 Related Work

The adaptation of film and video-based fieldwork techniques developed by anthropologists and ethnographers for research into technology design is associated with the emergence of a second generation of context-aware HCI and ISD in the mid-1980s (see §1.4.3, 3.1 and *e.g.* Suchman, 1987, Suchman and Trigg, 1991, Heath and Luff, 1991, Blomberg, 1993, Bauersfeld and Halgren, 1996, Mackay, 1999). Video has been used extensively within ATIT; Bødker's work on the focus-shift analysis of video data (*e.g.* Trigg *et al.*, 1991, Bødker, 1996a, Trigg and Bødker, 1994, and see §3.3.1.4, 7.2.3) in particular has integrated activity-theoretical concepts and principles with video-based techniques of interaction analysis developed at Xerox PARC in the 1980s (*e.g.* Jordan and Henderson, 1995, Ruhleder and Jordan, 1998). A number of ATIT studies (*e.g.* Engeström and Escalante, 1996, Koistinen and Kangasoja, 1997, Hasu and Engeström, 2000) have used (participatory) video-recording and analysis methods developed within the Finnish activity-theoretical action research tradition (DWR, §2.5.2.4). Video has also been used to study computer-supported collaborative learning (CSCL) from constructionist (*e.g.* Harel, 1991, Cavallo, 2000a), cultural-historical (*e.g.* Cole, 1996a, and several papers in Kozulin *et al.*, 2003) and activity-theoretical perspectives (*e.g.* Bellamy, 1996, Barab *et al.*, 2001a, Barab *et al.*, 2001b, Barab *et al.*, 2001c). Contemporary cognitivist HCI routinely uses video in laboratory-based user studies (see reviews in *e.g.* Shneiderman, 1998, pp. 127-132, Nielsen, 1994, Preece *et al.*,

1994, pp. 650-654), continuing the tradition within human factors/ergonomics (HFE, §1.4.2.1) of film-based time & motion studies (Barnes, 1980, Karger and Bayha, 1987). In recent years qualitative researchers in many fields have explored the use of digital technologies to link video, field notes, and other data sources (see review in Saferstein, 2005), an approach adopted for the research reported here (see §8.3.4 below). Prior to the work reported in this chapter, several HCI/IS field studies using audiovisual recording had been carried out by the University of Glamorgan School of Computing Hypermedia Research Unit (see *e.g.* Tudhope *et al.*, 2001, Tudhope *et al.*, 2000, Blocks *et al.*, 2002); the experience gained in these projects provided valuable input to the design of Phase 2.

Film and video recording has been found to have some advantages over traditional ethnographic observation and interview methods inasmuch as: (1) it is capable of capturing both the fine detail of individual interaction sequences and much of the broader physical and sociocultural context in which they take place; (2) allows the repeated review of complex and fleeting events at varying levels of granularity; and (3) offers the opportunity to check and amend interpretations of observed user actions in the light of data from other sources (log files, interviews, verbal protocols, etc.) or new analytic insights (Jordan and Henderson, 1995). In direct observation studies (as here), the possibility of making unobtrusive (Blomberg, 1993) or unattended (Bauersfeld and Halgren, 1996) recordings can also help to minimize the impact of observation on the situations being researched. The principal disadvantage of video-based research is that data analysis can be extremely time-consuming. Typically, analysis time to capture sequence time ratios range from 5:1 to 100:1, while very detailed micro-analyses may involve ratios as large as 1000:1 (Fisher and Sanderson, 1996). Thus, to be analytically tractable, video-based field studies need to be carefully planned, both with regard to the amount and relevance of data captured and the subsequent selection of material for detailed analysis. ATIT researchers (see above) have emphasized the identification of tensions, contradiction, and breakdowns as essential starting points for video analysis (*cf.* §2.5.2.2, 3.3.1.3 & 4.3.4).

Chapter 8   Phase 2: The Video-based Field Study

8.3.2 Data-Capture

Six video-data capture devices were employed in the study: three tripod-mounted video cameras and three PCs running screen capture software. The cameras comprised two Canon 450i mini-DV (digital video) cameras and a Panasonic analogue camcorder (described in §4.4.1.3), each with auto-focus capability, optical zoom, and a built-in microphone.[9]

8.3.2.1 Camera Recording
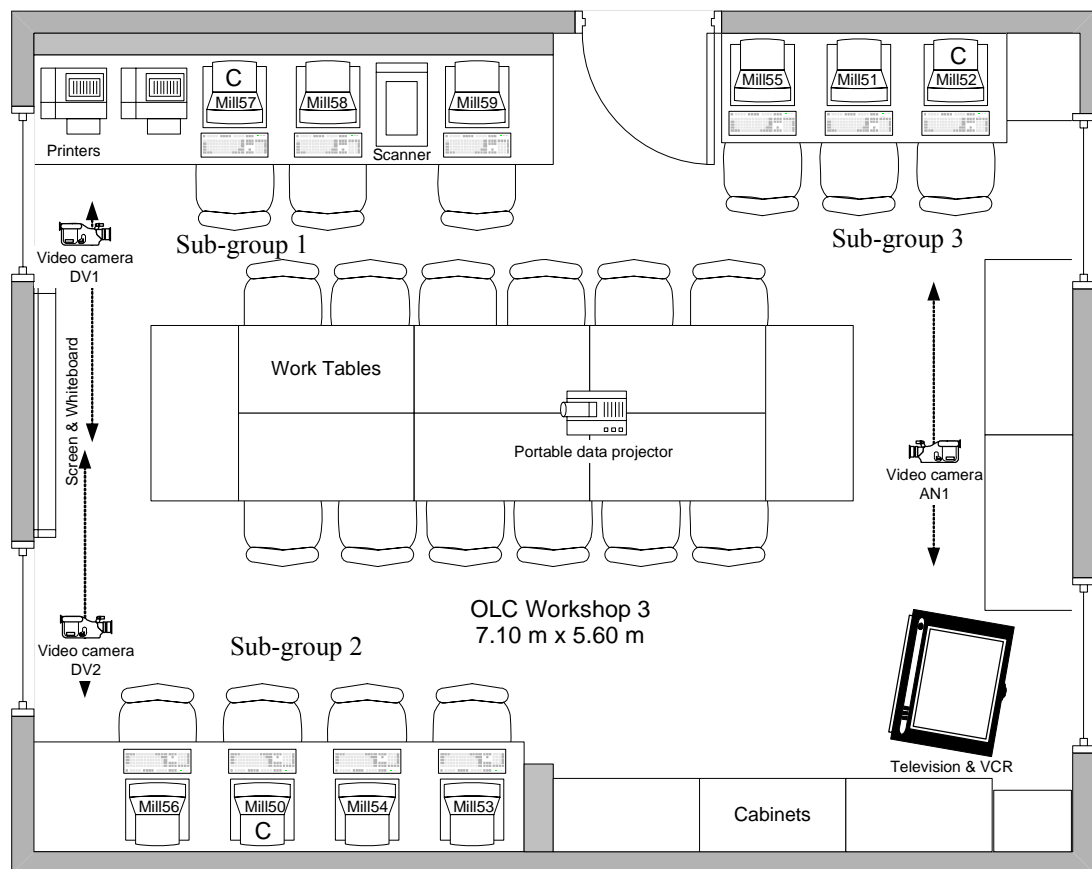
Figure 8.3: Plan of Workshop 3 during Phase 2 showing camera and sub-group locations. Drawing scale 1cm = 0.38 m; cameras not to scale. C indicates PCs running Camtasia screen capture software.

Figure 8.3 shows the equipment set-up; the photographs in Fig. 8.4 depict Workshop 3 during the observation session.

Camera positions were chosen so as to cover as much of the workshop space as possible while also allowing a view of on-screen events on the three main PCs in use (Mill50, 52 & 57, marked C in Fig. 8.2). In order to render the cameras as unobtrusive as possible, operator intervention was kept to a minimum. The

cameras were set to auto-focus, started at the beginning of the session, then left to run. Periodic checks were carried out to ensure that the cameras were still filming, on target and in focus. In-study adjustments consisted of changing the camera angle and zoom to follow the action as groups moved around the room. Major adjustments were only made during transitions between whole-group and small-group work. Camera maintenance involved the renewal of batteries and cassette tapes.[10]

Figure 8.4: Audiovisual recording during Phase 2. **Top:** the view from the corner of OLC Workshop 3 (near PC Mill52, top right in Fig. 8.3) showing analogue camera AN1 in foreground, DV camera 2 in background and PC Mill50 (3rd from left). Learners in sub-group 2 are working on the PCs, while subgroup 3 sit at the table with the participant tutor T standing between them. **Bottom:** view from near Mill53 showing camera DV2, PC Mill57 and learner sub-group 1.

Figure 8.5: Publisher in use. Sample frames from Camtasia screen capture sequence showing user interaction with DTP document via dialogue boxes, and pull-down menus. Frames taken from third video sequence captured on PC Mill54 at a sample rate of approx. 1in 350. The page in view is part of the garden supplies leaflet produced by learner sub-group 2.

8.3.2.2 Screen Recording

Digital video-recording of on-screen events (including cursor movements and mouse-clicks) was carried out using Camtasia Studio.[11] Pre-study tests suggested that attempting to capture on-screen activity for the entire session might negatively affect user interaction, as on some machines the processing and memory demands of the capture software caused the perceptible slowing of simultaneously running applications.[12] It was therefore decided that the package should be installed on only three machines, and intermittent screen recording would be manually controlled by the researcher. Session activities were arranged so that each capture PC (Mill50, 52, and 54, labelled C in Fig. 8.2) was used by

only one sub-group during the study, and was their primary machine, *i.e.* the one used to produce and store their finished document. Prior to the start of the session all Workshop 3 monitors were set to resolution of 800 X 600 pixels, 24-bit depth (16 million colours), and a refresh rate of 85 Hertz. Camtasia was set to capture the full screen area, which was recorded at 15 fps[13] in AVI format, video only. Figure 8.5 shows frames sampled from a screen-capture video.

8.3.2.3 Other Data Sources

Around 20 still photographs were taken during the session, using a Sony Mavica digital camera (see §4.4.1.3). Photocopies were made of the tutor's register and lesson plan for the session; notes, drawings and hard copies of documents produced by the participants were collected and archived. The researcher also made a number of on-the-spot jottings (§4.4.1.1) which were referred to when annotating transcriptions.

8.3.3 Data Preparation, Organization & Archiving

The three cameras recorded approximately 7.5 hours of audiovisual data in total; intermittent use of the screen-capture software produced an additional 80 minutes of video-only data. In order to prepare the recordings for input to the transcription software it was necessary to transfer the files from local HDDs to a suitable research machine[14] and standardize their format and frame size. The DV cameras were directly interfaced with the research PC via IEEE 1394 FireWire; screen-capture files were transferred via CD-ROM. The analogue camera was connected to a capture PC in Workshop 3 (Mill55, Fig. 8.1) via a/v phono and the output digitized using an ATI All-In-Wonder capture card and its proprietary software (see §6.5.1); Ulead Video Studio (§6.5.2) was then used to apply the Microsoft Video-1 codec to the data, with compression quality set at 100%.[15] A basic DV editing application[16] was then used to save the videocassette data onto CD-ROM as discrete AVI files. Once transferred, all files were converted to 320 X 240 pixels and re-compressed to MPEG-1 format.[17] The camera data was divided into approximately equal segments of around 15 minutes duration, producing 30 MPEG-1 video files ("clips" in the jargon of the transcription software) of around 250 MB each. The screen-capture data comprised 16 approximately five-minute clips at around 5 MB each. Following processing all

clips were labelled with codenames indicating their source camera and cassette, archived onto a dedicated 120 GB HDD, and arranged into folders labelled so as to relate clips to participant sub-groups.

8.3.4 Transcription & Annotation of the Video Data
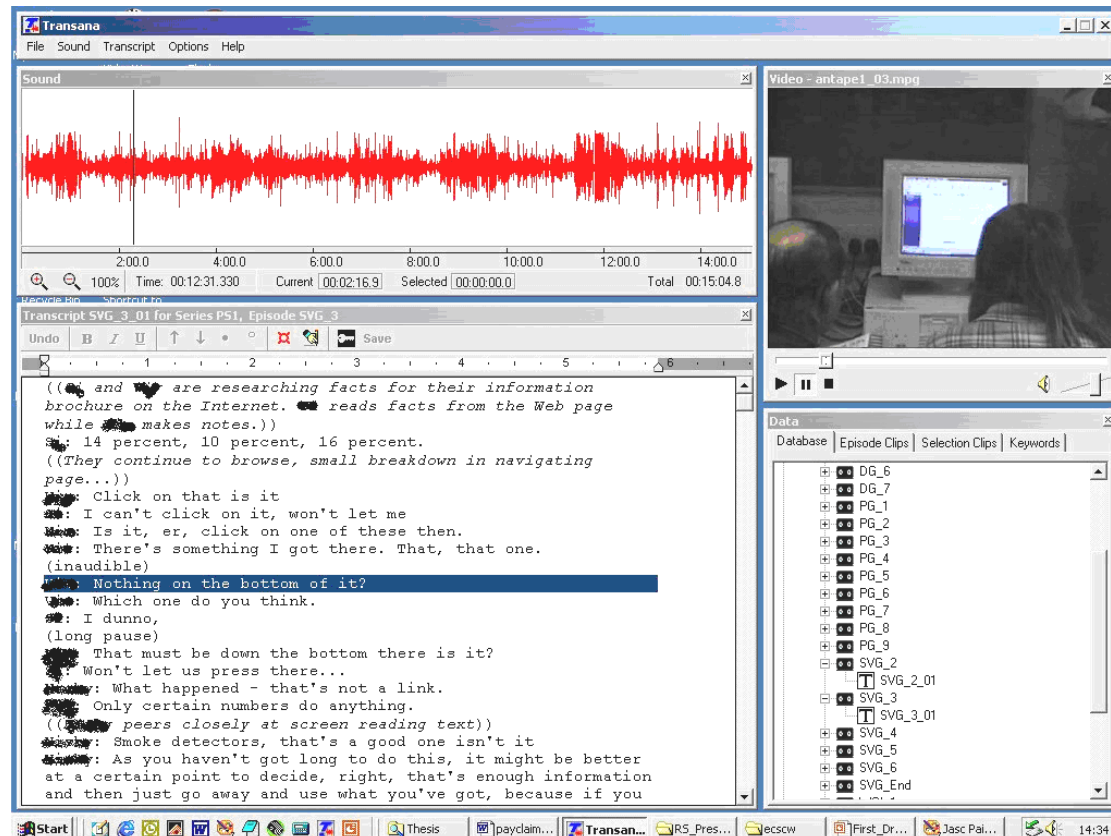
Figure 8.6: The Transana UI with transcription in progress, showing (clockwise from top left) the Waveform, Video, Database & Transcript windows. The image has been edited to obscure names in the Transcript window.

Transcription of the video clips was carried out using Transana (Fig. 8.6), an open-source video-analysis tool developed for educational research.[18] Transana allows the synchronized searching and playback of audio, video and transcripts. This involves the manual embedding (by the transcriber) of automatically generated video time-codes[19] into the text files created during the transcription process. During transcription and review, navigation through clips is either via the video display window, the transcript text, or a waveform image of the audio track automatically generated from the video clip (all shown in Fig 8.6). Each of the 30 camera-originated clips was transcribed in full. Speech was rendered into text, while non-verbal activity as annotated using Transana's Jeffersonian Transcription Notation facility.[20] The transcript texts (stored in the Transana

database as plain ASCII text documents) were labelled with codes indicating the relevant learner sub-group.[21] Screen-capture clips were also annotated and time-coded to facilitate synchronization with the camera data. As an initial step in organizing the data for analysis, keywords were associated with video segments (a segment being a clip plus its associated transcription files) using Transana's database tools. The segments were organized into groups according to the principal learner sub-group featured, this being roughly equivalent to one group per camera and capture PC (see Figs. 8.3 & 8.4).

8.4 Analyzing Phase 2

Analysis of the Phase 2 data required the further development of the combinatorial activity analysis approach discussed in Chapter 7 to include functional approaches derived from SSAT (§2.5.3.2, 3.3.2.2). Methods established in the earlier study were adapted to the analysis of HCI video data through the creation of new instruments. As several of the ATIT methods used have been described in previous chapters, only those techniques specific to Phase 2 are discussed in detail in following sections.

8.4.1 Morphological Analysis of the Phase 2 Data

```
848   S: We want to do the writing in red
849   V: We've lost the color
850   T: So, is this for your heading only? ((takes mouse))
851   V: The headline in red you know, look like er
852   (inaudible)
853   V: (to N) I knew there was something I wanted to ask
854   you. You know when I was here last year, you know er the
855   course I was on, before I started, before I started on
856   this one
857   T: Combined Studies, the one downstairs?
858   V: Do I erm, get a certificate for that, or
859   T: Did you do a qualification?
860   V: Yes, I think we did, didn't we? With er, Suzy.
861   T: With Suzy, erm, best ask Suzy, I can't remember.
862   End of Transcript SVG_5_01 Total duration 00:14:53.2
863   Transcript SVG_6_01 Total duration 00:15:27.5
864   T: Click on whatever color you want
865   S: I want that one
866   T: do you want it... You can choose what style of
867   writing you want...at the moment it's in Arial, which is
868   very plain stick letters, or you can have something a
869   bit more fancy..
870   T: you don't know what they look like until you click on
871   them, do you?
872   S: No
```

Figure 8.7: Extract from whole-session transcript for sub-group 3. NB: this and other extracts from the field data in this chapter use abbreviated participant codenames (see Table 2.1); here S=SM & V=VS.

8.4.1.1 Whole-session Transcripts

It was determined that an essential initial step in the morphological analysis of the Phase 2 data would involve the development of a more detailed time-structure of the observed activity than the general overview set out in §8.2.2.1. However, several factors militated against using either the video-recordings or transcripts as a basis for temporal measurement. In the case of the video-clips, the use of multiple capture devices produced both incompleteness[22] and redundancy[23] in the data; the individual transcript texts reflected these properties of the clips and also presented only a partial picture of the overall session. Accordingly, as a first step in the structural analysis the set of transcripts (text files plus time-codes) related to each learner sub-group were compiled into continuous word-processor documents (using MS Word, see §6.8.1). Transana time-codes were preserved as hidden text fields and sequential line numbering added[24]. Each of the resulting three documents thus represented the entire duration of the session from the point of view of one of the learner sub-groups. An extract from a whole-session transcript is shown in Fig 8.7; the complete transcript is presented for inspection as Appendix 7 of the thesis.

8.4.1.2 Time-structure Diagrams & Tables

Table 8.2: Time-structure table, sub-group 3. Marker & duration units are whole-session transcript line numbers, *cf.* Fig. 8.7; task/subtask levels as shown in Fig. 8.8.

Task/Subtask Name	Task/Subtask Level	Begin	End	Duration
Create a publication	0	201	1248	1047
Get ideas	1	223	291	68
Research	1	293	393	100
Get images	1	410	613	203
Get image of no-smoking sign (NS)	2	407	458	51
Get image of smoke alarm (SA)	2	463	482	19
Get image of chip pan (CP)	2	504	554	50
Get image of child w/matches (CWM)	2	556	594	38
Make layout drawings	1	624	707	83
Draft text	1	645	707	62
Produce publication	1	712	1098	386
Insert no smoking picture (NS)	2	712	802	90
Create a heading 1	2	810	962	152
Create a heading 2	2	962	1001	39
Choose heading colour	3	837	865	28
Choose font	3	866	893	27
Enter text	2	1002	1094	92
Evaluate project	1	1158	1187	29
Collect copies	0	1274	1276	2

Using line numbers as units, the whole-session transcripts were then sub-divided into segments corresponding to the task or subtask in which participants were engaged at that point in the session. Approximate values for segment duration, based on transcript line numbers, were then derived and tabulated. As has been demonstrated by the morphological analyses presented in previous chapters, each of the three major stages of the task (§8.2.2.1) can be conceptualised as comprised of nested sequences, sub-sequences and sub-sub-sequences of action, these various sub-task "levels" being organized around hierarchically-related task- and action-goals. Table 8.2 shows task/subtask durations derived from the whole-session transcript of the activity of participant learner sub-group 3. As in earlier morphological analyses, tasks and sub-tasks were differentiated on the basis of their goals, tools, and objects, with the formation or acceptance of a distinctive goal taken as marking the inception of the task or sub-task and its achievement or abandonment as marking task completion (§3.3.2, Table 7.3). In parallel to the development of the tables, and in order to clarify the nested and hierarchical arrangement of tasks and sub-tasks, diagrammatic representations of the structure of the recorded activity were also produced. Figure 8.8 shows that part of the relevant time-structure diagram corresponding to the task/subtask durations listed in Table 8.2.
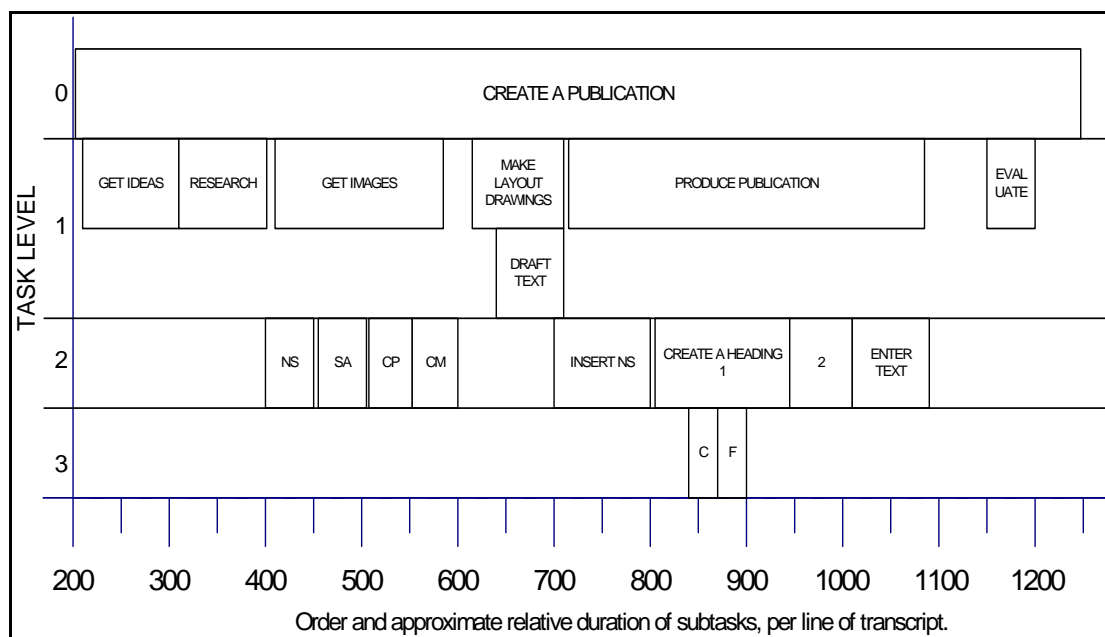
Figure 8.8: Task and sub-task time-structure diagram, sub-group 3. Abbreviations refer to Table 8.2.

8.4.1.3 Time-structure Outlines (TSOs)

Line Nos.	Description
291-292	V signals end of 'get ideas' subtask, T confirms.
293-393	Sub-task 'research'. PC becomes major means of work, Web browser, Search Engine (text search) main material tools mediating activity. S becomes main tool operative. List artifact created by V also supports activity.
297-300	S encounters some physical/behavioral difficulty in assuming the role as PC operator due to physical environmental (space, configuration) and individual (ambivalent handedness) constraints.
367-379	Breakdown in interaction with Web Browser as S & V wish to use text item on Web page perceived as hyperlink that does not respond to left mouse-click. This slows hitherto fluent interaction with site, as users become unsure how to read the semantic properties of the page. Goal-directed action becomes more exploratory, as users pursue what the page can give them rather than what they purposively seek – page becomes object of actions. On return to group, T confirms non-hyperlink status of (underlined?) text and activity moves forward again.
382-392	T negotiates cessation of sub-task 'research', although S & V have not indicated that they feel the goal has been achieved – the subtask goal is too imprecise to clearly guide activity. The tutor, T, is regulating the activity from the point of view of the task goal 'project to be completed in one 2 hour session'.
393	V confirms willingness to end sub-task 'research'

Figure 8.9: Extract from Time Structure Outline (TSO) for participant sub-group 3. The complete TSO and a key to the symbols used can be found in Appendix 8 of the thesis.

The whole-session transcripts (§8.4.1.1) and time-structure tables and diagrams (§8.4.1.2) provided a basis for developing composite tabular representations of the structure of sub-group activity. These documents, called *time-structure outlines* (TSOs), were used to correlate sub-task incidence and duration with brief descriptions of task-related events. To aid interpretation the tables were graphically annotated, with shading and symbols indicating subtask commencement, incidences of breakdown, and passages of interest with regard to goals, tool use, and general HCI issues. TSOs were constructed for each sub-group. An extract from the TSO for participant sub-group 3 is presented in Fig. 8.9; the complete TSO can be found in Appendix 7. During Phase 2 the general structural understanding of the activity obtained by constructing the TSOs was used to inform the functional-analytical approach described in following sections. Sub-group task solution was not further decomposed (into discrete goal-oriented actions) except where specifically required to facilitate other aspects of the analysis. This approach accords with the principles of SSAAD (§3.3.2), which suggest that as activity is multidimensional it cannot be adequately described by any single approach or model; design-oriented analyses should therefore utilise multiple methods and techniques, wholly or in part, in

combinations appropriate to the aims, objectives and conditions of the research and the type and level of activity under study (Bedny and Meister, 1997, p.236).

8.4.2 Functional Analysis of the Phase 2 Data

As noted in Chapter 2, research by Rubinshtein, Luria, Leont'ev, Bernshtein, Anokhin, *etc.* demonstrated the unity of cognition and behaviour (§2.4.2.1) and gave rise to the concept of functional systems (§2.4.2.2). These ideas were developed within the systems-cybernetic school of AT (by Zinchenko, Gordeeva, Kotik, Konopkin and others, §2.5.3) into self-regulation models of specifically human activity, where "self-regulation is an influence on the system which derives from the system in order to correct… its activity" (Bedny and Meister, 1997, p. 52). A person's activity during task performance is conceptualised as a goal-directed, self-regulating functional system in which various processes co-occur over time in (looping, iterative) series of sequential stages. Each of these stages or "blocks" is pictured as integrating cognitive, affective and motor processes to perform a specific role or function at that point in the activity (§2.5.3.2, 3.3.2.2). Studies of activity which focus on these *function blocks* (such as the goal, motive, subjective perception of task difficulty, experience, *etc.*, see Figs. 2.9, 8.9) and their inter-relationships through feed-forward and feedback loops are called functional analyses (Bedny and Meister, 1997, p. 15). A number of techniques for the functional analysis of various aspects of human activity at differing levels and scales have been developed within activity theory, including psychophysiological (Anokhin, 1969, Zinchenko, 1978), cognitive-informational (*e.g.* Bedny and Meister, 1997, Bedny and Karwowski, 2004b) and integrative functional-state approaches (*e.g.* Zarakovsky and Kazakova, 2004, Chainova *et al.*, 2006). Although some theoretical aspects of functional analysis have been discussed within ATIT (*e.g.* Kaptelinin, 1996b, Bardram, 1997), and functional approaches are to some extent implicit in both Engeström and Bødker's work, at the time of the work reported here there had been very little explicit use of these ideas from AT in HCI or ISD.[25]

The functional analyses undertaken in Phase 2 aimed to build on earlier work (see *e.g.* §5.4.2, 6.6.1.2, 7.2.3 and the discussion in §7.3.3) which highlighted the role played by subject-oriented (communicative) interaction in guiding object-

oriented activity during task performance. As several of the issues arising from these earlier analyses were connected with the interaction between the cognitive and energetic- affective components of participants' activity – *i.e.*, between their goals and motives – it was determined that the principal focus should be on the ways in which collaborators develop a sufficiently clear "shared vision" of the desired outcome of their joint activity to enable them to work together toward a satisfactory outcome, and to successfully negotiate (and learn from) the focus-shifts and breakdowns encountered during the work-process. Accordingly, functional analyses using both focus-shift techniques and self-regulation models[26] were carried out for each learner sub-group in the study; §8.6 below presents a case-study of the collaborative activity of learner sub-group 3 which illustrates the analytical process.[27]

8.5 General Findings from Phase 2

8.5.1 Localization, Community-formation & Task Completion

In general, the observations made during Phase 2 confirmed the main empirical findings of Phase 1 (summarised in §5.6 & 6.9), inasmuch as the physical, technological and sociocultural conditions obtaining in the use-setting were found to support participants' expression and further development of ICT skills. All learner sub-groups successfully completed the DTP task - which was evaluated as being of moderate to high complexity using the criteria outlined in §5.4.1 & 7.2.4.1 (see also §8.6.1 below) - within the time allotted. Users' levels of positive motivation appeared to remain high throughout the session, and post-session feedback from learners and the tutor was almost entirely positive. The audiovisual record shows that during the work-process participant learners frequently shifted their focus smoothly and appropriately between the work object and mediating tools, and between the digital and physical domains. All learners worked without breakdown for lengthy periods, and quickly recovered on those occasions when (non-catastrophic, constructive) breakdown did occur. No catastrophic breakdowns were observed with any of the computer artifacts in use, suggesting that participants were able to draw on their previous experience with Publisher and PSP to discern and use those aspects of the packages appropriate to the task in hand.

The phenomenon of localization noted in the earlier study (§5.4.2.1) was embedded into the study design, inasmuch as the data-capture setup constrained activities to certain parts of the room (Figs. 8.3, 8.4) and the task requirements enforced collective activity. Their prior acquaintance and shared experience (§8.2.1), combined with the necessity for collaboration in close physical proximity, resulted in learners forming effective communities of technology-based practice within their sub-groups. As expected, although each sub-group was presented with the same basic task requirements and worked under the same conditions, each formulated the goal of the task differently, adopted different strategies for task-solution, and produced different results in terms of the form and content of their publications (see also §8.6.1 below). Whereas sub-groups 1 and 3 both produced single-page information leaflets (dealing with food hygiene and safety in the home - Fig. 8.2 - respectively), the final output of sub-group 2 was a three-page brochure advertising gardening products (Fig. 8.5). These results (which are discussed further in §8.7 below) can be seen as validating and extending the general principles used to underpin the design of *Computer Creative* (§5.1.1), while also demonstrating that the provision of external task requirements need not necessarily impede creativity and skill development.

8.5.2 Collaboration, Coordination & Communication

The data from Phase 2 provides further evidence of the continuous transformations between subject- and object-oriented activity that take place in collective activity (§2.5.3.3, Fig. 2.10), and in particular the role played by both verbal and non-verbal communication (in Bardram's terms, communicative and instrumental means, see §3.3.1.5) in coordinating collective activity. Examination of the audio track of the camera recordings reveals participants' continuous use of self- and other-directed speech acts to regulate their individual and joint behaviour. Participants can frequently be heard speaking to each other even when the tutor was addressing the whole group; all engaged in conversation throughout the execution stage of the activity. Even while closely attending to their actions toward the work-object, individuals can be seen to be continuously monitoring (and sporadically contributing to) the communicative exchanges taking place around them.

The visual record also provides further evidence of the non-verbal communication phenomena observed during Phase 1: learners' repeatedly indicate their participation in, and support for, joint activities through gestures and pointing, posture and positioning, and touching and holding material artifacts such as chairs, monitors, notepads, etc (*cf.* §5.4.2). For example, at several points during the execution phase of the activity participant DC can be seen and heard taking part in two distinct conversations (one with participant WE, the other with KL) whilst undertaking complex graphics-editing procedures using PSP. Her interlocutors, who sit at machines either side of her, are observed to turn toward her, reach out and point, rest their hands on the back of her chair, etc. at various points of the work-process. Further examples are given in the case study below.

The informal divisions of labour that emerged during collaborative task solution differed between sub-groups, and between stages of the task. For example, during the execution phase one member of sub-group 1 (PR, see Table 8.1) operated the main PC (Mill57, Fig. 8.2) while the other two (MR & JG) sat either side of her guiding and providing continuous verbal feedback on her actions (see Fig. 8.3, bottom). The three members of sub-group 2 (DC, KL & WE) mainly worked separately, each undertaking a different sub-task on adjacent PCs. These arrangements changed for the final compilation phase of publication production, during which WE operated the PC, DC directed her activity from an adjacent seat while the third member of the group (KL) overlooked their activity from a position standing behind and between their chairs. In sub-group 3 one member (SM) sat at and operated the PC while the other (VS) mainly sat at a nearby table making and referring to notes and diagrams created using a pencil and notepad while discussing the task with his partner. On those occasions when the tutor, T, joined this group, she sat between the other two.

8.5.3 Reflections on the Phase 2 Methods

In general, I found the direct observation approach based on audiovisual recording to be successful in capturing a large amount of data that was sufficiently relevant, continuous and detailed to satisfy the aims, objectives and requirements of the study (as set out in §8.1). In line with the findings of other researchers (*e.g.* Jordan and Henderson, 1995) I found that participants became

habituated to the presence of the video-cameras after around 10 minutes of recording. However, examination of the video transcripts shows that during the execution stage of the task sub-group members occasionally attempted to engage me in dialogue, typically by requesting intervention into their group interaction – *e.g.* to comment on a design decision, or assist with a technical operation. This usually occurred when I was adjusting a camera (§8.3.2.1) or manually operating the screen recording software (§8.3.2.2), suggesting that in future work improved technical arrangements might reduce the frequency of this kind of unanticipated researcher-participant interaction.

As indicated by the literature review (§8.3.1), the main challenge of video-based research approaches is effectively dealing with the very large amount of data that is generated. In practice, detailed analysis of the whole corpus of audiovisual data gathered during Phase 2 proved infeasible within the available timeframe (see also Note 26, this chapter). In carrying out any future work using these methods I would seek to utilise greater manpower; improved technical resources would ideally allow automation of some stages of the data preparation and analysis process.

8.6 Case Study: Breakdown & Recovery in DTP Activity

In order to illustrate some of the general findings set out above (§8.5), this case study examines the activity of learner sub-group 3 (comprising learners SM and VS, see Table 8.1) in greater detail, demonstrating the combined use of morphological and functional techniques of activity analysis. Earlier sections described the DTP session from sociocultural (§8.2.1) and objectively-logical (§8.2.2) perspectives; the main focus here is on the individual-psychological aspects of the observed activity.

8.6.1 Morphological Analysis

As noted in §8.4, detailed post-study examination of the activity of each sub-group during task performance began with a morphological (structural) analysis of the field data following the methods set out in previous chapters (*e.g.* §3.3.2.1, 7.2.4) and utilising the video-analysis techniques described in §8.4.1. This involved classifying the DTP task, evaluating its overall complexity, and describing its general temporal structure in terms of a hierarchy of sub-tasks.

### 8.6.1.1 Typing and Evaluating the DTP Task

SSAT suggests that if a task includes some elements of openness or uncertainty it should be classified among those categories which range from semi-algorithmic through probabilistic-algorithmic and semi-heuristic to heuristic, according to the degree to which subjects are required to create their own methods for task-solution (see §7.2.4.1, Bedny and Harris, 2005, and Bedny and Harris, 2006a). In these terms the DTP task observed during Phase 2 can be classified as being predominantly *semi*-heuristic in nature: although at various stages of the task a very high degree of choice, uncertainty and creativity were involved, the space of possible procedures and solutions was by no means completely open, being proscribed both by the tutor's instructions and the design and functioning of the computer applications in use. This kind of creative activity was described by the Soviet engineering psychologist Strumilin (1983) as "independent work within a given set of requirements". Categorising the task as semi-heuristic suggests that (according to the criteria outlined in §5.4.1) it should be evaluated as being of moderate to high complexity. The extent to which this general categorisation and evaluation can be considered applicable will clearly vary according to the stage of the task under examination, and whose point of view is being considered; as outlined in previous discussions (§3.3.2, 5.4.1, 6.6.1.2, 7.1.3.1), activity-theoretical models suggest that whatever the objective complexity of a task, its subjective difficulty will be perceived differently by different participants according to various individual-psychological factors such as their previous experience; social-cultural-historical features of the community of practice; and their individual role within that activity at any given moment. Although such work was considered beyond the scope of the Phase 2 study, one way of exploring these issues in greater detail would involve using techniques of algorithmic analysis (see §7.2.4) to identify points of maximal complexity within the observed activity.

8.6.1.2 Structure of the Observed Activity

Activity theory suggests that in attempting to solve complex, semi-heuristic tasks, different subjects with differing experiences, motives and skills can be expected to arrive at highly idiosyncratic interpretations of the task instructions, to utilise different strategies for task solution, and to produce widely varying

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outcomes (Bedny *et al.*, 2005a, Bedny *et al.*, 2001c). As described in §8.5.2, this was indeed found to be the case in the video-based study. In seeking to better understand the implications of these observations, the morphological task analyses undertaken in Phase 2 aimed to delineate the structure of learner sub-group activity in order to facilitate comparison of the actual, observed structures of sub-group activity with each other and with the idealised programme of action set out in the tutor's initial instructions (but see Note 27, this chapter).

The Introduction Stage: Setting-out the Task Conditions
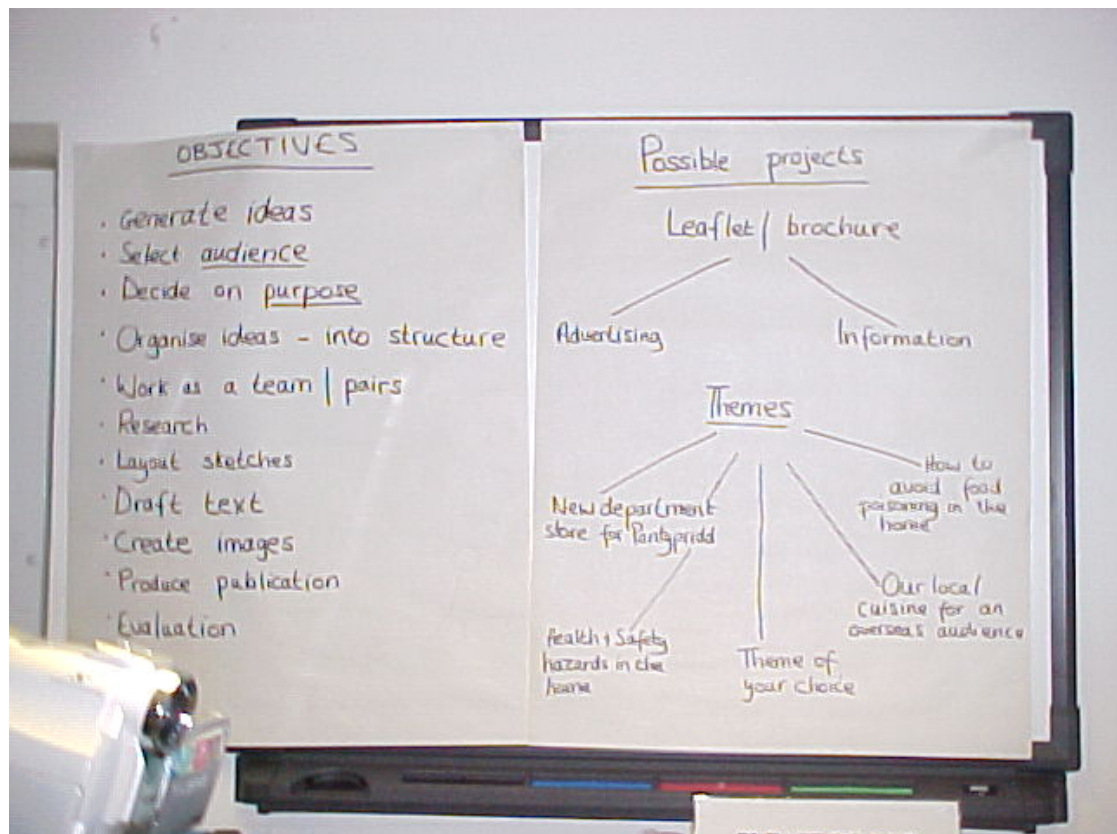
Figure 8.10: The Workshop 3 whiteboard, toward the end of the introduction stage. Video camera DV2 is in the foreground of the picture; the location of the board is shown in Figs. 8.2 & 8.3.

As noted in §8.2.2.1, the observation session began with an "introductory" stage of about 18 minutes during which the participant learners were briefed by the tutor (T) and then organized into three sub-groups. T addressed the eight learners as they sat at the central work-tables (shown in Figs. 8.2 & 8.3). After a brief welcome, T began to set out the overall aim and specific objectives of the session, first presenting the basic task of creating either an advertising or information leaflet and then discussing possible topics and audiences for the

publications. Throughout this part of her presentation T elicited, and responded to, verbal feedback from the learners, and while talking and listening used a marker pen to record important points on paper flip-chart sheets (size A1) attached to a whiteboard located on the rear wall of Workshop 3. The completed sheets are shown in the photograph in Figure 8.10.

T then proceeded to offer some detailed guidelines as to the stages through which the work-process should proceed. She discussed possible sources and methods for research; note-taking and reading strategies; organizational techniques (making lists, sketches, etc.); drafting texts; finding and/or creating images; assembling and formatting the document; and how learners might evaluate the outcome of the work. At several points T also reiterated the requirement to complete the task within the allotted time-frame of around 2 hours. Having spoken for approx. 12 minutes T concluded her instructions with the following summary:

```
T: So decide whether you want to work with maybe the
person sitting next to you, or you want to work as a
threesome, and really, after that, it's just a matter
of getting cracking. Erm, working through every stage
of the process. Generate your ideas or, choose one of
those ((indicates topics list on whiteboard)). And
then decide what you're going to do with those ideas.
You know, do your wordstorming, sketching and so
forth. And then work through. Decide who your
intended audience will be, what the purpose of your
publication will be. Think about organizing the ideas
a bit more. Obviously work together, in the way that
you do best. Carry out some research, very quickly,
if it's necessary. Maybe it won't be necessary. Do
some more detailed layout sketches, quickly draft
some text, put in some, choose some images, and then
put your publication together, and if you had time,
which I doubt it very much, then we'd evaluate at the
end. (From Transcript WG1_02. 00:01:47.5)
```

It can be seen that T suggested subgroup formation as the first step of the work-process. However, at the end of her talk it became evident that two groups of three learners had already decided to work together before the session began (see Table 8.1), having established relationships in other classes at the OLC. These arrangements - unanticipated by the tutor or researcher - left VS and SM to work together as a pair. T decided to offer VS and SM extra assistance during the "get ideas" stage, and subsequently spent much of the first half of the execution phase directly supporting them. Once their task-goal became sufficiently well-

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formulated for them to proceed with the "produce publication" sub-task (see §8.6.2 below), her input became less relevant and she left the pair alone more frequently and for longer periods.

Structure of Observed Activity during the Execution Stage

Figure 8.11b shows the actual structure of the observed activity of learner sub-group 3 in terms of the order, hierarchical relationships, and approximate relative duration of subtasks. This is compared with the idealised program of performance outlined by T during her introduction, which is depicted in Fig.8.11a. Several differences between the suggested and actual structure are evident: while some of the subtasks set out in T's initial verbal instructions were not carried out, others were performed in a different order than that suggested. For example, it can be seen that SM and VS prioritised getting images over drafting text; and spent more time on the actual production process that T had envisaged. These differences - which can be partly understood as reflecting differences between the learners' task-goals, skills and experience and the tutor's - are discussed further below.

At the beginning of the execution stage T suggested various topics to SM and VS; after several minutes of discussion, (with about 20 minutes of session time elapsed) they agreed upon a health and safety leaflet as the high-level task goal for their collaborative activity. The learners then attempted to solve the DTP task within the allotted time. Initially (the sub-task "get ideas" in Fig. 8.11b) the principal material artifacts mediating their actions were paper and pencils. They then used PC Mill52 during the "research" and "get images" sub-tasks, briefly returning to the worktable, pencil and paper to "make layout drawings & draft text". For the remainder of the execution stage ("produce publication") SM mainly operated the PC and DTP software while VS sat nearby reading aloud from the paper drafts, monitoring SM's actions and offering advice and suggestions (see Fig. 8.14 below). After about 1hour 40 minutes T intervened to end the execution stage of the session by printing the publication. For the remaining approx. 12 minutes of the session T reconvened the whole group in an effort to accomplish the "rounding-up" of the activity. In this stage learner VS acted as the spokesperson for the sub-group.
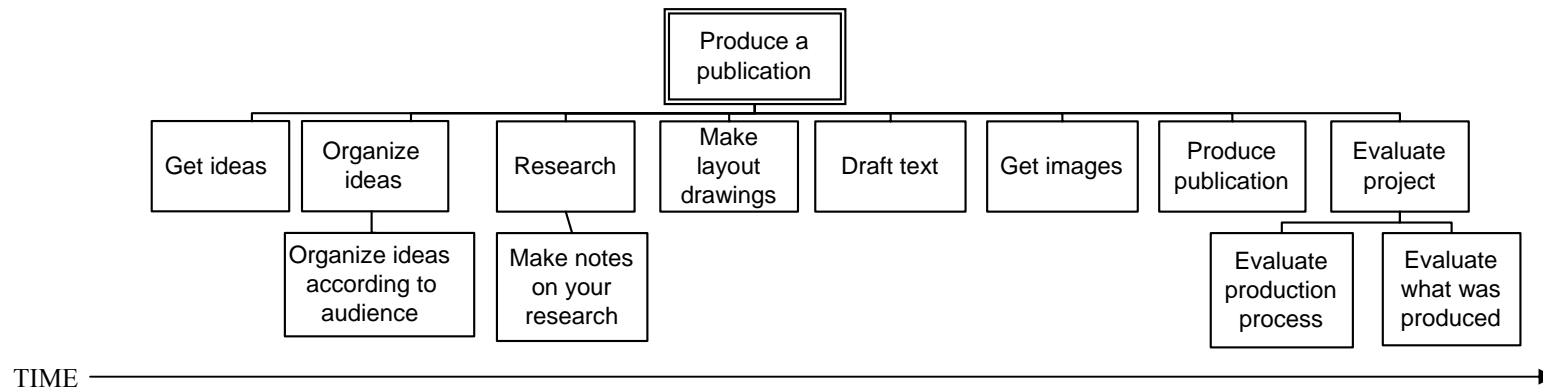
Figure 8.11: Initial task instructions and actual performance, learner sub-group 3. **8.11a** (above) shows T's Initial task instructions, transcript lines 17-134; **8.11b** (below) depicts the actual task performance of learner sub-group 3, transcript lines 201-1180. Recursion within sub-tasks is omitted for clarity. See also §8.4.1, Table 8.2 and Figs. 8.8 & 8.9.
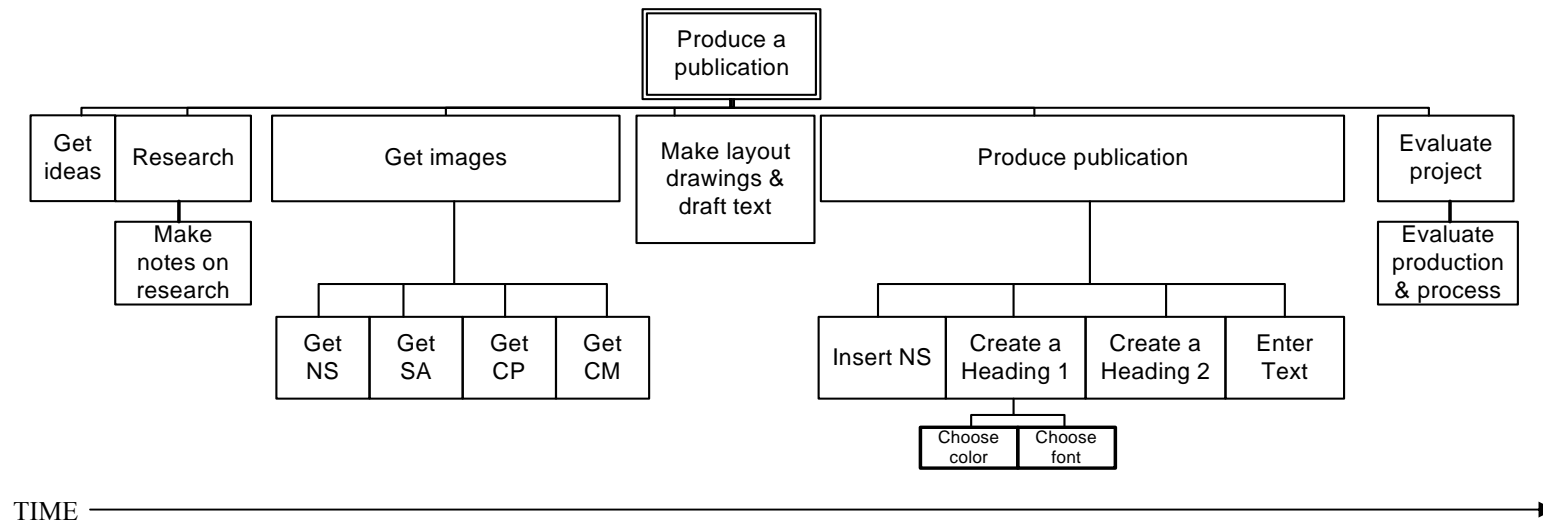
8.6.2 Functional Analysis

Two approaches to functional analysis were utilised during Phase 2. The first used Scandinavian ATIT focus-shift techniques (§3.3.1.4, §7.2.3) to examine some incidents of interaction breakdown and recovery. An example is given in §8.6.2.1 below. The second involved using a self-regulation model derived from SSAT (§2.5.3, 3.3.2) as a "lens" with which to systematically examine the video data, transcripts, and other evidence. This is discussed in §8.6.2.2.

8.6.2.1 Focus-shifts, Breakdown & Recovery in the DTP Task

Figure 8.12 illustrates the use of focus-shift techniques during Phase 2. The graphic combines Bødker's approach (Figs. 3.3 & 3.4) with representational techniques used by workplace ethnographers such as Heath and Luff (1991). It brings together data from the audiovisual record, transcripts and TSOs to depict an incident of breakdown and recovery in the activity of learner sub-group 3. Immediately prior to the incident learner SM was attempting to insert images retrieved from the WWW (using IE, §6.7.1) into her Publisher document. Finding herself unable to locate the relevant graphics file, she turned to the tutor for help.

Boxes 1-6 in Fig. 8.12 portray the ensuing actions. Firstly, T guided SM through a recapitulation of the image download process using IE (boxes 1-3 in Fig. 8.12). Confirming that the file already existed in memory (box 3) the collaborators then again attempted to insert the image into the Publisher document (box 4). Unable to locate the file using the Publisher "insert Picture from File" dialogue, T invoked the Windows Find utility (box 5). This proved successful in locating the file and the sub-task was accomplished (box 6). This incident, which involved a joint recapitulation of the breakdown as a precursor to recovery, is reminiscent of those discussed in §6.6.1.2 and 7.2.3, and many others observed during both phases of study. As the incident unfolds a continual transformation between the object- and subject-oriented aspects of the joint activity is evident; the participants' self- and mutual regulation through both verbal and non-verbal communicative actions allows the direction of joint attention which is central to the recovery process. For example, boxes 3 & 4 show T smoothly switching between other- and self-directed speech acts; in boxes 2 & 4 T gestures at the

screen; and box 6 shows SRH leaning on the back of SM's chair to indicate his involvement and support for the others (*cf.* Fig. 5.4e, f, & g).
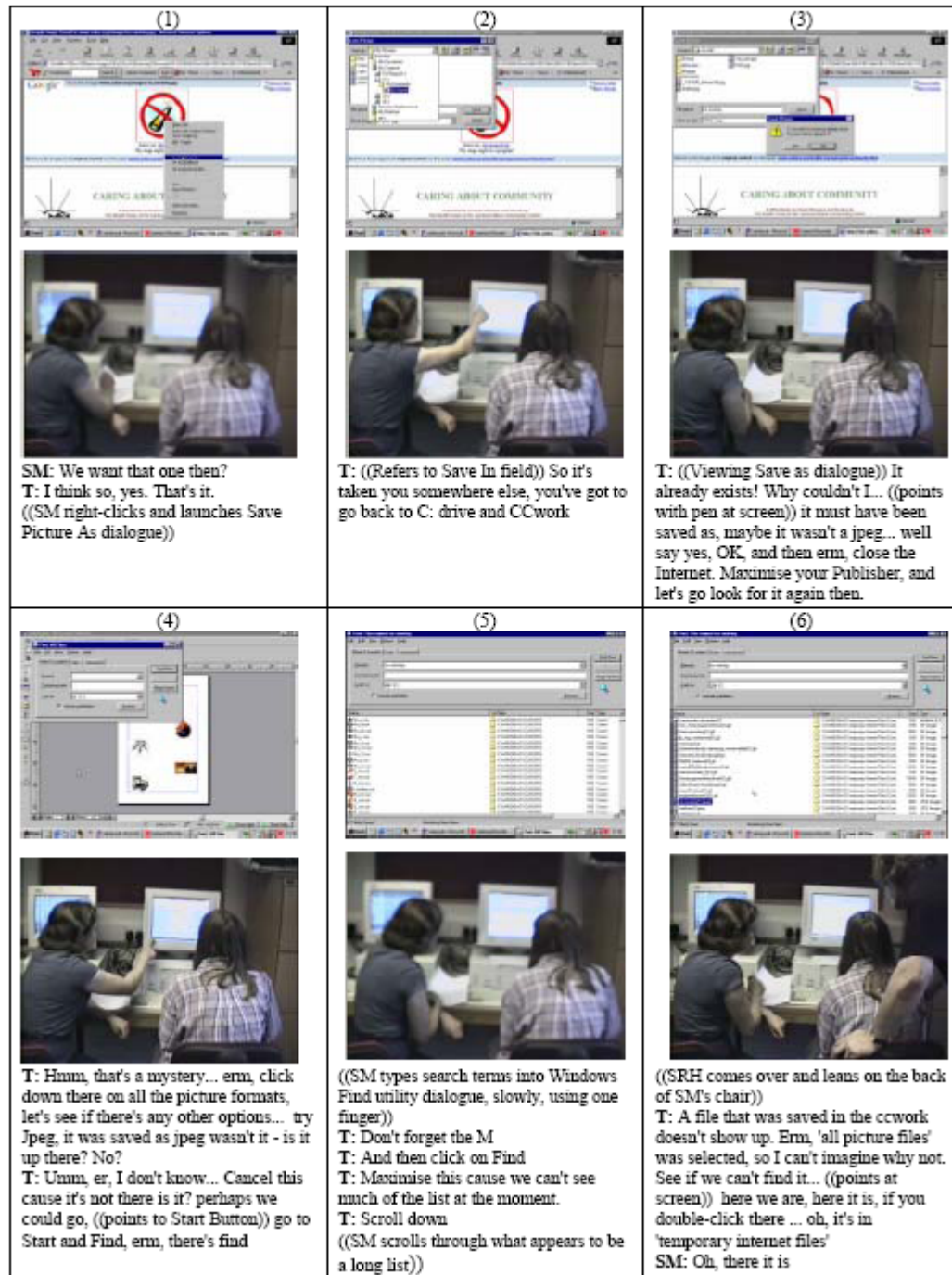

Figure 8.12: Focus-shifts, breakdown and recovery in collaborative DTP activity (*Cf.* Fig. 7.5). Boxes 1-6 show (top) frames from screen capture video on PC Mill 52; (middle) corresponding frames from video camera AN1; and (bottom) corresponding extracts from the whole-session transcript for sub-group 3, lines 713-802. For PC and camera locations see Figs. 8.2 & 8; the full text of the whole-session transcript can be found in Appendix 7 of the thesis.

8.6.2.2 Goal-acceptance, Formation and Orientation in the DTP Task

Figure 8.13 shows the self-regulation model utilised for functional analysis of the Phase 2 field data. It depicts those coordinated systems of sub-functions involved in the goal-formational and orientating aspects of human activity.[28] The figure is a simplified view of one stage (zone A) of the general model of human activity as a self-regulating system presented in Fig. 2.9 and discussed in §2.5.3.2. At its centre is the function-block *goal*, understood as the cognitive, informational sub-system of activity involving conscious representation of the future desired result of actions or activity as images or concepts (see also §2.4.1.2 and the glossary). It can be seen from the figure that AT considers goals as always being tightly associated with *motives* – that is, with the primarily affective, unconscious drives which arise from human needs (§2.4.1.2, 2.4.2.2).[29] Goals guide activity; motives "push" or energise it, determining the amount of effort an individual is prepared to expend on actions oriented toward accomplishing a task-goal. Motivation is discussed further in §8.7 below.

Goals are the primary orienting mechanism for specifically human activity; Fig 8.13 shows that (according to AT) a person's goals during collaborative activity are directly and continuously affected by their subjective assessment of the meaning of the input information available to them. The personal significance (the function block *assessment of the sense of input information* in Fig. 8.13) that a task holds for a specific person in a specific situation is directly and dynamically linked with both their level of motivation and their interpretation of the input information. The latter function is also affected by both immediate and longer-term *experience* (*cf.* Fig.2.9A). In AT, acting subjects are understood as having longer-term tendencies toward typical forms of goal-formation and behaviour connected with their individual personality, character traits and life-history (Bedny and Seglin, 1999b, 1999a).[30]
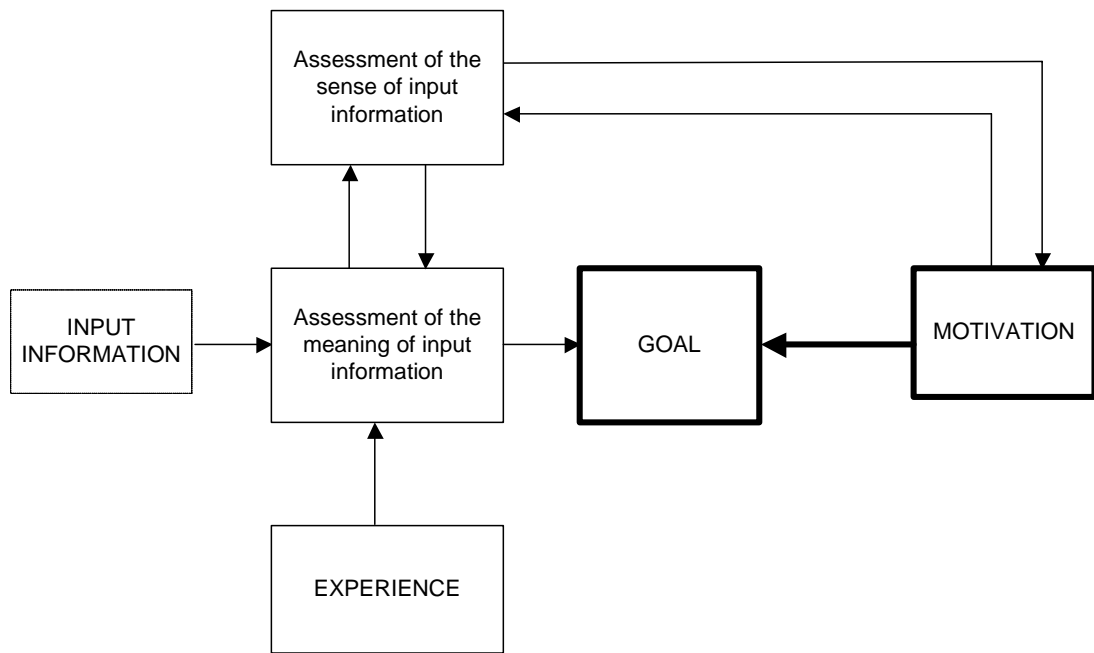
Figure 8.13: Functional model of the goal-formational and orienting aspects of human activity. After (Bedny and Meister, 1997, Bedny and Karwowski, 2003b). Arrows indicate feed-forward and feedback influences; bold outlines indicate primary components. *Cf.* Fig. 2.9, zone A.

"Scanning" the Activity of Learner Sub-group 3

The model in Fig. 8.13 was used to examine the activity of learner sub-group 3 during their performance of the DTP task. It can be seen that in this case *input information* was generated from external sources such as the graphical display presented by the (shared) computer monitor, the whiteboard (Fig. 8.10), T's verbal instructions, and the collaborators' dialogues; evidence of these inputs was captured by the audiovisual recordings and transcripts. "Internal" sources of input information originated both from participants' immediately previous experience during task performance and their longer-term familiarity with the norms and rules appropriate to this kind of setting, task and tool (*cf.* Figs. 2.4 & 7.4). As noted earlier (§2.5.3.3, 3.5.2.4, 7.3.3), as these individual-psychological aspects of the activity can only be partially understood from the field data their analysis must also draw on objectively-logical and cultural-historical sources of evidence (*e.g.* §8.1 & 8.2, and also the descriptions in §4.2).

Goal-acceptance & Formation

Assessments of how subjects' experience, motivation and interpretation of the sense and meaning of input information developed during performance of the task were made by examining the field data. As described in §8.6.1.2, the overall

goal of the DTP activity and some intermediate sub-task goals were set out by T during the introduction stage. AT suggests that the acceptance of an objectively-given set of task requirements by an individual involved in a collective activity can be conceptualized as the transformation of objective requirements into a hierarchy of personal goals; according to the way the task requirements are formulated (by the instructor) and interpreted (by the subject) these goals may be more or less clear and precise (Bedny and Meister, 1997). Consideration of the circumstances surrounding their attendance at the session (§8.2.1) suggests that VS and SM were predisposed to accept and attempt to achieve goals set by T; however, the creative content of the task (§8.6.1.1), and the rather general and vague nature of T's instructions (§8.6.1.2) obliged them to further specify and clarify the task and sub-task goals and formulate additional intermediate goals in order to proceed. This is reflected not only in the way in which the structure and outcomes of their observed activity differ from those of the other sub-groups (§8.6.1) but also in the significant differences between the tutor's goals and those of the learners which became evident at several points during task performance. The following extract from a discussion about a text element that learner SM had placed into the Publisher document illustrates one such point of divergence:

```
985.  SM: Eh, that's nice innit?
986.  T: Not very readable though
          (From Transcript SVG_6_01. See Appendix
          7)
```

Here, SM's subjective criteria for success (apparently primarily aesthetic) differ markedly from those of the tutor, T, whose required outcome of the activity (readability) reflects her pedagogical concerns. Several similar examples can be found in the data (*e.g.* lines 1075-1096, Transcript SVG_End_01; see Appendix 7, p. 45A).[31]

Goal-refinement, Alignment and Task-execution

According to systemic-structural AT, activity self-regulation involves four interconnected stages: (1) the formation and acceptance of the goals (future desired result) of activity and tasks; (2) evaluation of the difficulty and significance of the task; (3) performance of the task; and (4) evaluation of the actual result of activity (Bedny and Meister, 1997, p. 85. *Cf.* Fig. 2.8). In collective activity, the "plan" for the work incorporates both external and

internal, pre-planned and situational elements, and emerges out of the instrumentally and coordinated goal-formative, orienting and evaluative activity of the collaborators (Bardram, 1997, Bardram, 1998, Bedny *et al.*, 2004).[32] Some degree of mutual alignment of collaborators' individual goals and subjective interpretations of the current state of the situation is thus required before the transition to executive actions can take place (Harris, 2005d). Examination of the Phase 2 video data using the self-regulation model reveals several such points of transition in the activity of sub-group 3. For example, about 49 minutes into the observation session, during the subtask "make layout drawings & draft text" (Fig. 8.11b) SM and VS appear to arrive at a joint visualisation of the final form of the Publisher document which is at a sufficiently precise level of detail to allow them to proceed with the subtask "produce publication". This is described in the following extract from the TSO (the full version of which can be found Appendix 8):

> SM repeatedly passes her hands across the screen as she speaks, indicating (to herself & VS) where the block elements of the page layouts should go. The image-goal is now precise enough for her to implement it directly; at 704, 705, 706, SM & VS exchange utterances that indicate that they are now both visualizing a similar image & text. (TSO for sub-group 3, 691-707)

The relevant video sequence (Figure 8.14 presents a sample frame) shows the collaborators leaning in toward the screen; as SM gestures to indicate to VS the position of text and image elements in the document being created the following dialogue takes place:

```
691    SM: Erm, that smoking one might fit if you
       have it up on
692    like on trains and buses, so what would be
       good for that
693    one is erm, smoking, smoking over there.
694    VS: See if I can get this 26 percent
695    SM: Ah. Ah you could put that right... 26
       percent ...of
696    people in their house, right, cause this is
       the house
697    one innit - that's right - then you could
       put erm
698    ((Gestures across screen without speaking
to
699    indicate layout and text))
700    ((indicator of goal-image precision))
701    SM: 26 percent of people in the house...
and
```

```
702    VS: How about if you put "smoking kills 26
       percent"
703    SM: In houses
704    VS: Smoking in bed (S: ah yes) when a
       cigarette...
705    SM: Falls out the ashtray
706    VS: and it goes down the side of a chair
707    SM: Go on then.

          (From Transcript SVG_6_01. See Appendix
          7)
```


Figure 8.14: A critical moment in the creative work-process: VS and SM engage in dialogue while looking and gesturing at the on-screen document. Sample video frame extracted from clip SVG_06.

Subsequent video segments and screen recordings show SM quickly placing screen elements into the indicated positions while VS monitors her activity, repeatedly referring to the notes he has made previously while sitting at the work-table.

8.7 Discussion

8.7.1 "Tuning" Collaborative Activity

According to activity theory, creative (heuristic, semi-heuristic) work is characterized by multiple exploratory, orienting and decision-making actions and the ongoing evolution of action strategies (Konopkin, 1980, Landa, 1974,

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Tikhomirov, 1988, Zinchenko, 1996). A person's orientation within a creative task situation depends on conditions such as whether that situation is familiar or strange; what the possibilities are for reaching the desired result by methods they already know; how specific their representation of the task situation is, as provided either by verbal descriptions or direct observation; and the extent to which they can distinguish key elements for task solution (Gal'perin, 1969, Bedny and Karwowski, 2004b). As has been seen, an individual's goals can be considered as a hierarchically-ordered, semiotically-mediated dynamic system which, by projecting into the future, constrains their actions, feelings and thoughts in the present (Zinchenko, 1981, Zinchenko, 1978). It is mainly through explorative, orienting actions that task- and action-goals become sufficiently precisely formulated for acceptable outcomes to be achieved (Gal'perin, 1969, Leont'ev, 1978).

The creative, collaborative work with computer artifacts observed during the field studies may be analysed using these general concepts and principles. Many of the participants' actions can be understood as contributing (either directly or indirectly) toward their development of sufficiently clear and mutually aligned visualisations of the situation, tools, and artifacts under production to enable joint executive action (see also entries for *imaging* and *imagining* in the glossary). As was seen in the case study in §8.6, in activities such as desk-top publishing, orientation, goal-formation and task-solution are extremely tightly coupled; users jointly produce and analyse sequences of trials-and-errors, create hypotheses about the situation, and formulate preliminary goals until a mutually acceptable basis for task-completion is established. The moment-to-moment unfolding of creative computer-mediated collaborative activity involves continuous coordination through a wide variety of communicative and instrumental means (dialogue, gesture, body language; examination and evaluation of the actual outcomes of action, *etc.*; see also Figs. 2.8, 2.9 & Table 3.3). In many of the breakdown situations observed (*e.g.* §6.6.1.2, 7.2.3.3, 8.6.2.1) participants' mutual (re)orientation through subject-oriented activity forms an essential part of recovery.

The multiple focus shifts and joint (re)directions of attention that take place can be conceptualised as a dynamic process of "situation awareness" (Endsley and

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Garland, 2000) through which collaborators continually adjust and align their individual understandings of results, task-goals and conditions (Bedny and Karwowski, 2004b, Bedny *et al.*, 2003). The ATIT researchers Raeithel and Velichkovsky coined the terms "discursive tuning" and "co-mimetic tuning" to describe the cognitive and motivational aspects of the process through which collaborating users produce what they termed a "shared task-model" (Raeithel and Velichkovsky, 1996, p. 228). Figure 8.15 reproduces their graphical representation of the process, which (taking a similar approach to Bardram, see §3.3.1.5) relates different types of "tuning" or alignment to Leont'ev's hierarchical model of activity (Fig. 2.2).
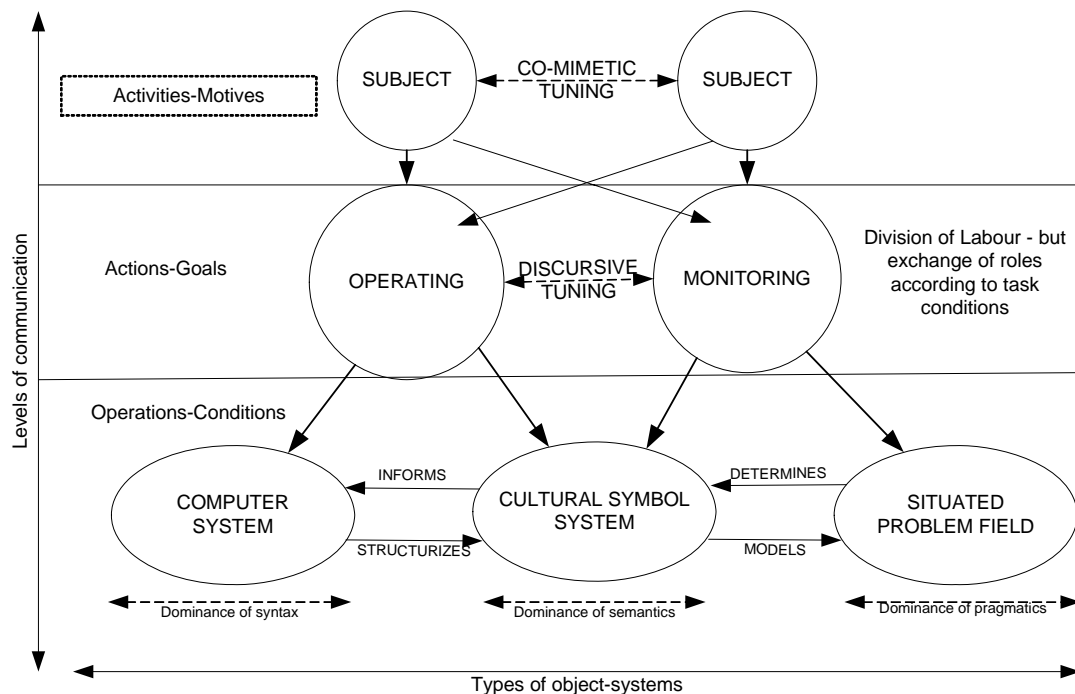
Figure 8.15: Cooperative production of a task model. "Discursive tuning" implies goal-alignment through communicative and instrumental means; "co-mimetic tuning" indicates the similar alignment of motives. Adapted from Raeithel & Velichkovsky, 1996. *Cf.* Figs. 2.2, 2.3, 2.10 & 3.5 and Table 3.3.

The arguments outlined above suggest that some alignment of individual participants' cognitions (goal-images and situational understandings) is essential for successful collaborative work. The studies reported in this thesis also suggest that an important aspect of this "discursive tuning" is the role played in self- and mutual-regulation by discrepancies between collaborators' goals and orientations. Many AT studies have shown that during task performance acting subjects develop "operative images of the task" (Bedny and Meister, 1997, p.
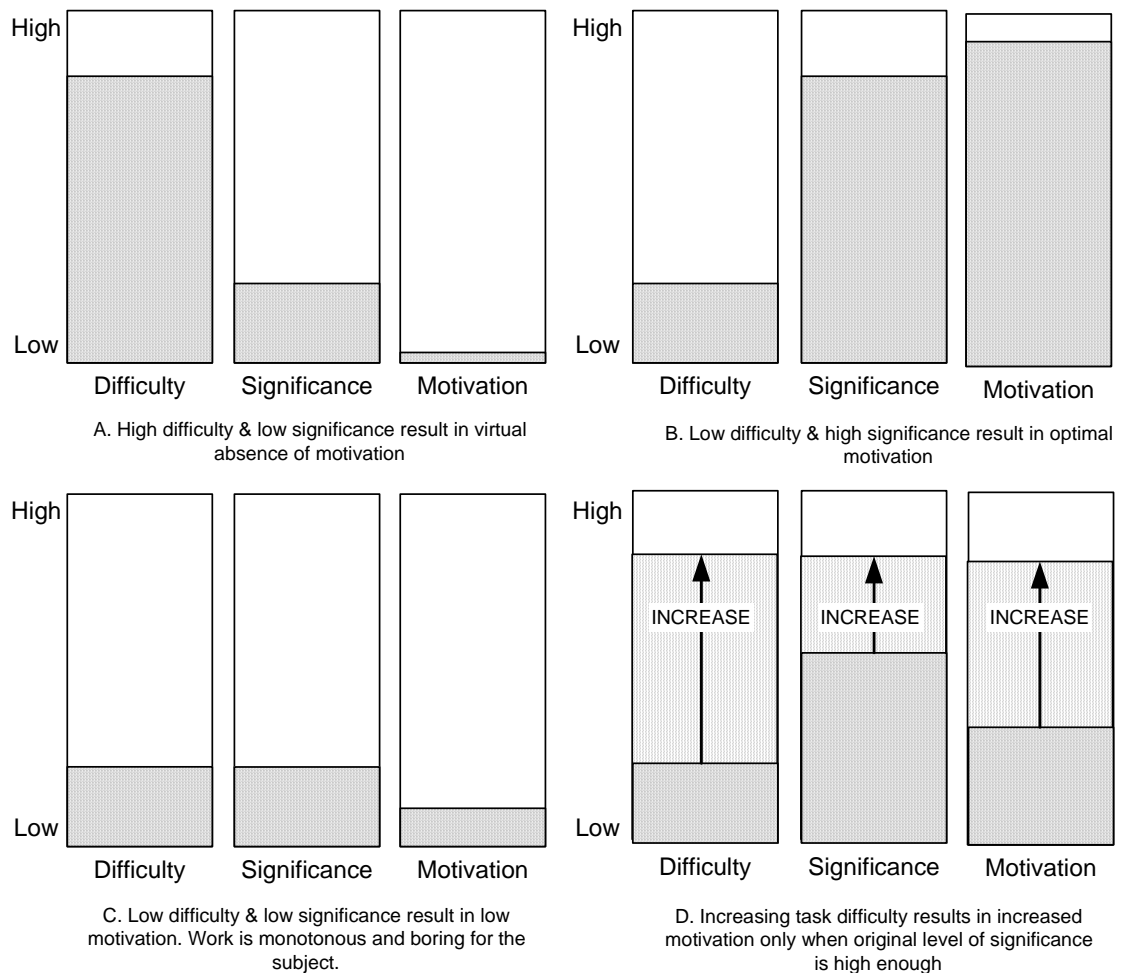
115, Konopkin, 1980, Ponomarenko, 2004) which are both affected by, and affect, their perception of instrumental stimuli. Subjects tend to recognise and remember materials perceived as relevant to the goal of their activity, and thus may "filter-out" (objectively) relevant information which does not accord with their operative goal-image or indeed "filter-in" unconnected stimuli they mistakenly perceive as being relevant to the goal (Tikhomirov and Klochko, 1976/1981, p. 347). In both phases of empirical study it was observed that the informal divisions of labour that emerged often involved at least one participant playing the role of an "observer" monitoring the executive actions and corresponding results of those of their fellow workers who take on the role of "operator" (§5.4.2, 6.6.1.2, 7.2.3.3, 8.6). In such arrangements (a general case of which is portrayed in the actions-goals level of Fig. 8.15) the discrepancies between different participants' goal-images appears to make a positive contribution toward the overall effectiveness of the work-process. As each individual is filtering on, and alert to, slightly different aspects of the situation, they can, for example, direct each other's attention toward missed stimuli, such as symbolic representations on the user-interface (*e.g.* selection marquees, §6.2.1.3). From the point of view of learning-in-use (§3.5.1.3-4), this aspect of the "tuning" of collaborative activity might be said to amount to the creation of "zones of proximal development" (§2.3.3) in which collaborators "scaffold" (Bruner, 1974) each others' efforts in ways that support the development of more effective strategies of action.

8.7.2 Motivation, Coordination, & Learning-in-Use

The previous section focused on the function of the goal in the self-regulation of activity. However, as Figs. 8.13 and 8.15 emphasise, motivation plays an equally important role in collective human work-processes. Just as goal-images vary according to individual-psychological characteristics, different actors will exhibit differing levels of motivation at different stages of task performance, each according to their individual interpretation of the current state of the situation (Bedny and Karwowski, 2003a). As noted in §8.6.2.1, in general the level of motivation for any subject at any stage of any given task situation is dependent upon the complex interaction between their assessment of the personal sense, or significance of the work and their evaluation of its difficulty, that is the

likelihood of their being able to achieve a successful outcome under the current conditions. Figure 8.16 illustrates four recurring patterns in this dynamic relationship. The figure is based on reviews of relevant work in AT presented in (Haenen, 1996) and (Bedny and Meister, 1997, esp. pp. 87-88).

A. High difficulty & low significance result in virtual absence of motivation

B. Low difficulty & high significance result in optimal motivation

C. Low difficulty & low significance result in low motivation. Work is monotonous and boring for the subject.

D. Increasing task difficulty results in increased motivation only when original level of significance is high enough

Figure 8.16: Dynamic interrelationships between difficulty, significance & motivation in work activity. *Cf.* Figs. 2.8-11 and discussions in (Haenen, 1996) and (Bedny and Meister, 1997, pp. 87-88).

Read anti-clockwise, the figure begins by portraying relationships between difficulty and significance which are typically associated with low levels of motivation. Fig. 8.16A (top left) suggests that if the personal significance of a task is low, and it is perceived by the user as being highly difficult to accomplish, their motivation to undertake or complete the work may be almost non-existent. This is the kind of situation described in §6.6.3 and 6.8.4. In cases where both task significance and difficulty are subjectively assessed as low, motivation will again be low as the work appears uninteresting and unimportant (Fig 8.16C, bottom left); such situations can occur in repetitive, relatively unskilled ICT

work-processes (such as data entry) or in poorly designed learning tasks (*cf.* the discussion of CLAIT in §1.12). The right-hand side of the figure illustrates more positive motivational states. Figure 8.16D (bottom right) suggests that if the initial level of task significance is quite high, increasing task difficulty may result in an increase in motivation; the user responds to the challenges presented by the task by increasing their efforts (see *e.g.* §6.2.1.4 & 6.5.2). Finally (Fig. 8.16B, top right), shows that when a task is perceived as relatively easy to accomplish, and its personal significance is high, motivation toward task performance will be very strong. This can be considered as an ideal level of positive motivation, of the type associated with activities where subjects feel fulfilled and fully engaged in work and learning.

As discussed in previous chapters, *Computer Creative* and other ICT/ABE courses at the OLC aspired toward establishing conditions that encourage learners' development of the positive motivational states portrayed in Figs. 8.15B and D. In ABE generally (§1.1.2, 4.2), positive learner motivation has long been seen as crucial. Positively motivated learners "take ownership" of their learning programme, relating it to their own needs and actively engaging with tasks, tutors and fellow students; they are much more likely to gain positive outcomes from their course (Barton and Hamilton, 1998, Barton *et al.*, 2000, Schuller *et al.*, 2002). Much ABE teaching is directed toward supporting learners to (re)discover, develop and sustain a positive attitude while in the classroom, through techniques such as the careful selection of tasks and materials so as to support early and continuing success and minimise the possibility of failure; integration into supportive learning groups; and help with fiscal, childcare and counselling needs (Harris and Shelswell, 2001a, 2005).

However, motivations are complex and capable of rapid fluctuation. In AT, the preliminary or intermediate goals that collaborating individuals form during activity (see §8.7.1 above) can be understood as corresponding to a particular level of aspiration, inasmuch as they result from evaluations of task difficulty that includes not only an assessment of the objective characteristics of a task, but also elements of *self*-evaluation (Bedny *et al.*, 2005a, Hacker *et al.*, 1982, Holzkamp, 1991). It is also clear that contradictions and conflicts between different motives can arise during collective work and learning activity, both

within and between individuals; one person may be strongly positively motivated to achieve a task goal, but feel themselves incapable of carrying out the required processes and procedures (*e.g.* as depicted in §6.2.1.1); if his or her collaborator forms a negative assessment of task difficulty or significance it might lead them to reject the goal altogether, leading to breakdown in the collective work-process (see §6.5.2.1). It has also been established that in collective activity individual actions may be coordinated either collaboratively or competitively (Bardram, 1998, Bødker, 1993, 1996b). Recent work on this topic in cultural-historical psychology (Branco, 2001) has shown that the social and physical structure of an activity setting can produce "cultural canalization", where collaborating subjects are encouraged toward more cooperative behaviour, negotiating ways of overcoming divergence and competition in individual goal-orientations and motivations. These findings resonate with constructionist approaches (*e.g.* Sipitakiat, 2001) and work on situated learning in communities of practice (Lave and Wenger, 1991, Wenger, 1998), particularly those studies which have pointed to the role of conflict and contradiction in structuring group relationships (*e.g.* Harris and Shelswell, 2005).

According to general activity theory, the possibilities for successful alignment or "tuning" of individual goals and levels of motivation within collective activities is partly dependent upon those individuals' perceptions of the likelihood of realising their personal needs by participating in the satisfaction of collective needs (Leont'ev, 1957, 1978). If individuals feel that by taking part in a collective activity they will achieve improved control and better quality of life they may be motivated to positively contribute to the creative "expansion" of that activity in new directions (Engeström, 1987, 1991a, 2001). Conversely, if collective activity is perceived as offering little possibility of improved conditions or quality of life, people may focus on coping with the contradictions between their own and collective needs, defensively seeking to avoid any lessening of their sense of control or any reduction in their possibilities for action (Holzkamp, 1991). How individuals view the possibilities for fulfilling needs within a collective activity may also be affected by their perception of where the locus of control is situated (Roth, 2002, Roth and Tobin, 2002).

ICT users from communities and cultures with experiences and values which differ markedly from those explicitly and implicitly objectified into the design of computer artifacts and computer-mediated work-processes may be especially vulnerable to feeling that they have little or no control in breakdown situations (see *e.g.* §6.5.2.1, 6.6.1.2) and consequently be more likely to engage in "defensive learning" by *e.g.* rejecting the tool or abandoning the work-process (§6.2.2, 6.4, 6.6.3, 7.2.4). Fig. 8.16A suggests that such reactions may be especially likely in situations where the task appears difficult to, and has little personal significance for, the persons concerned. However, it is precisely in encountering, and working through, such breakdowns, that the experiential learning central to skills development takes place. The studies at the OLC described in this and previous chapters suggest that it is possible to create conditions which can encourage even non-professional users from disadvantaged and marginalised communities to make positive evaluations of the significance and solubility of ICT tasks, and thus engage in motivated, expansive learning-in-use with computer artifacts.

8.8 Summary

The researcher carried out a second phase of field study at the OLC in May 2002, with the aim of following-up various issues arising from Phase 1. This investigation was based on the direct observation over 2.5 hours of a group of 8 ABE learners as they worked to complete a set DTP task using MS Publisher. The principal data-gathering method employed was video-recording using cameras and screen-capture software. Following preparation, transcription and annotation the data was examined using a combination of established and novel ATIT techniques, including both morphological and functional methods of activity analysis. These analyses confirmed that the physical, technological and sociocultural conditions obtaining in the use-setting supported the participants' exercise and further development of their ICT skills.

The audiovisual data also provided further evidence of the role played by both verbal and non-verbal communication in coordinating collective activity. Examination of the activity of the three sub-groups in which learners worked for the majority of the session showed that they adopted differing strategies for task-

solution and produced different results in terms of the form and content of their publications, suggesting that each formulated the goal of the task differently. Functional analyses using focus-shift techniques and a self-regulation approach of breakdown and recovery in the activity of one learner sub-group highlighted processes of goal-acceptance/formation, orientation and motivation in the collective activity. Of particular interest were the various ways in which the individual participants "tuned" their activity, with the alignment of goals, motives and situational understandings emerging as being central to expansive learning-in-use.

Notes to Chapter 8

[1] Those social and organizational conditions which tend to favour the formation of communities of practice are discussed in (Lave and Wenger, 1991) and (Wenger, 1998). ABE/ICT-specific discussions of this topic can be found in (Harris and Shelswell, 2001a, Harris, 2003, Harris and Shelswell, 2005) and (Shelswell, 2005).

[2] Due to funding constraints the parent College (§4.2.2) agreed to maintain the OLC's equipment – originally purchased with external grant funding (Harris, 2002b) - but not to update or replace it. At the time of writing (autumn 2006) some equipment installed in autumn 1997 remains in use.

[3] Findings from Phase 2 contributed to subsequent ICT/ABE developments at the OLC. Accounts of projects undertaken in 2002-3 can be found in (Shelswell, 2005) and (Harris and Shelswell, 2005); (Harris, 2005b) and (Harris and Reddy, 2005) deal similarly with 2003-4.

[4] In line with the review of the outcomes of that course in §5.1.2, comparisons with Table 5.2 suggest that those learners who participated in *Computer Creative* had made significant improvements in basic skills and ICT since their evaluation a year earlier. Participant tutor T also reported ICT skill improvements which she judged as having resulted from her work on *Computer Creative*.

[5] Only the general purpose of the document was set out by the tutor at the beginning of the session; there were no specific instructions to either content or detailed formatting requirements (*e.g.* bi-fold *etc.*), except that the document should be printable on A4 paper. For the reasons discussed in §8.7.3, the Tutor's aim was that task-solution should be achievable with participants' existing technical skills.

[6] At the time of the study (May 2002) the professional DTP market was dominated by applications designed for the Apple platform such as Adobe PageMaker and Quark Xpress.

[7] Publisher Wizards are semi-automated interaction sequences which guide the user through the process of customizing a document template using dialogue boxes, radio buttons, drop-down lists, etc.

[8] Throughout the chapter *video-recording* should be read as referring to the simultaneous capture of video and audio data except where otherwise specified. Likewise, *video* will generally indicate data comprising both pictures and sound.

[9] During transcription it was found that the high sensitivity of the omni-directional camera microphones produced recordings in which it was sometimes difficult to clearly separate the discourse of different speakers, particularly if the speaker was out of the camera's (more limited)

visual range. The use of additional external directional microphones would be recommended for future work of this nature.

[10] 8 tapes were used in the study. The 60-minute analogue cassette in camera AN1 (see Fig. 8.3) was replaced once, the two 45–minute DV tapes in DV1 & 2 twice per camera. Each exchange took between 45 and 120 seconds. Batteries on the DV cameras were replaced once, taking around 90 seconds per camera. The analogue camera used mains power.

[11] See http://www.techsmith.com/products/studio.

[12] In pre-study tests the response time of running applications were found to increase perceptibly while screen capture was in progress, mainly as a consequence of the limited processing capacity of the 16MB video cards. The HDD capacity of the Workshop 3 PCs was also a concern, as the networking set-up (§4.2.3.2) meant that capture files must be stored locally. A typical file captured at 15 fps in AVI format averaged 650 KB per 60 seconds of recording. At the time of pre-study tests free HDD space on the machines in use varied from 0.5 to 2 GB according to past usage; however, as Workshop 3 was in continuous use by other learning groups during the study period not all of this capacity could be relied upon (see also §6.2.1.2). Thus, it was not possible to accurately predetermine the available storage capacity of individual PCs. See also Note 14, Chapter 6.

[13] FPS: Frames per Second, a standard measure derived from pre-digital film technology that indicates the rate of change between discrete images in animation sequences. The minimum frame rate to achieve a motion effect is around 10fps; full-motion video is normally played at around 30 fps. The settings chosen here therefore represent a working compromise between capture file size and quality.

[14] A networked and automatically backed-up multimedia PC with a Pentium 3 processor running at 800 MHz, using the Windows NT OS and fitted with two high-capacity (20 & 120 GB) hard disk drives and 256 MB RAM. Numerous difficulties (*e.g.* application interoperability problems, lengthy processing delays) connected with this platform were encountered during the analysis. In subsequent studies (*e.g.* Harris, 2005b) Apple PowerMacs running OSX and compatible video software have been used with improved results. For further discussion of the technical requirements of video-analysis, see (Saferstein, 2005).

[15] This was necessary as the analogue-to-digital capture card utilized hardware compression, so that the resulting files, although in AVI format, were dependent on that card for decompression and playback until processed further.

[16] Presto! VideoWorks. See http://www.newsoftinc.com.

[17] Using a freeware batch-conversion utility, TMPGnc; see http://www.tmpgenc.net.

[18] Transana was developed at, and is maintained by, the Wisconsin Center for Education Research. It is available for free download from http://www.transana.org. Further discussion of the use of Transana in field research can be found in (Thorn, 2002).

[19] The codes represent elapsed time (from the beginning of the clip) and use the standard format: *hours: minutes: seconds: milliseconds*.

[20] A standard transcript notation system. For a description see (Jordan and Henderson, 1995).

[21] For example, the code SVG_3_01 indicates the first transcript of the third video segment relating to the activity of a subgroup including learners S and V (subgroup 3, Table 8.1).

[22] Around 80% of the total session time was actually recorded. This was due to operational contingencies such as a delay in initiating recording at the start of the session; time spent replacing camera batteries and video-cassettes during the session (see Note 10 above), and some uncertainty as to when the session ended. For example, the whole-group transcript relating to subgroup 3 (presented as Appendix 7) shows a total elapsed time of 01:52:06.04, a shortfall of around 25 minutes (approx. 18.25%) from the estimated total on-task time for all groups of 02:17:00.0.

[23] There was considerable overlap between camera recordings during the opening and closing whole-group activities. Issues of incompleteness (Note 22 above) and redundancy in the video data highlight the difficulty of managing and synchronizing multiple video sources using home video equipment. Future work with multiple video-capture devices would seek to employ

professional equipment allowing synchronization via SMPTE (Society of Motion Picture & Television Engineers) time-code.

[24] The version of Transana used in the study (2.1) does not automatically number transcript lines. Where extracts from whole-session transcripts are used to illustrate the thesis text, line numbers have been added using MS Word.

[25] This still remains very much the case at the time of writing (autumn 2006). As the discussion in §3.5.2 points out, a major problem for Scandinavian ATIT is the lack of sufficiently clear distinctions between the various functional components of goal-oriented activity – as can be seen from the conflation of the concepts of goal, object and result in the "Engeström Triangle" (Fig. 2.4).

[26] Due to the lack of such studies in ATIT (see §3.5) the techniques utilised were mainly derived from general materials presented in (Bedny and Meister, 1997) and thus represent an experimental, rather basic "first-take" on the functional analysis of computer-mediated activity using systemic-structural principles. Since the time of the research described here other English-language accounts of functional analysis have become available, including articles by Bedny *et al* (Bedny and Karwowski, 2004b, Bedny *et al.*, 2004) and Zarakovsky & Kazakova (2004) in the July-August 2004 special issue of *Theoretical Issues in Ergonomics Science* (Vol. 5, No. 4) edited by G. Z. Bedny.

[27] The case-study of learner sub-group 3 in §8.6 is used to illustrate the general principles and findings of Phase 2 post-study analyses. Comparisons between the performances of the sub-groups remained incomplete at the time of writing (autumn 2006) and are the subject of work in progress.

[28] See also §8.4.2 and Note 26 above. More complex self-regulation models can be found in (Bedny and Karwowski, 2003a, 2004b, Bedny *et al.*, 2001a, Bedny *et al.*, 2003, Bedny *et al.*, 2004, Bedny and Meister, 1997). In AT, the orienting *stage* of activity is understood as comprising those steps in the (looping, iterative) process of activity which precede and enable action execution and which are modified by subjects' evaluation of the outcomes of their actions (Gal'perin, 1969, Bedny and Karwowski, 2003a). Activity theorists commonly distinguish between this stage and *orienting activity* which is a general type of activity in which the main goal is exploration and understanding of the situation (*e.g.* as in vigilance or monitoring tasks). See also glossary.

[29] From the point of view of activity theory, while it is entirely possible for someone to envisage a future result that does not depend on his or her own actions, these kinds of imaginings cannot be directly used to regulate action, and thus are not categorised as goals (Bedny and Harris, 2005).

[30] In Soviet psychology the investigation of unconscious and preconscious tendencies toward particular types of goal-formation is mainly associated with the work on the psychology of set undertaken by D. N. Uznadze and collaborators (see *e.g.* Natadze, 1969, Ketchuashvili, 1994, and Note 26, Chapter 2). Recent work in SSAT (*e.g.* Bedny and Karwowski, 2004b) has attempted to integrate the concept of set into models of the unconscious (operational) aspects of activity self-regulation.

[31] These points of contradiction between individual actors' goals and motives within the collective activity system might be also be modelled using the notations developed in Figs. 7.5, 7.10 & 8.12.

[32] An excellent discussion of the concept of "plans" and their role in collective work from an ATIT perspective can be found in (Bardram, 1997). In this paper Bardram critiques and extends Suchman's (1987) well-known work on situated action, itself a critique of the planning models used in early cognitivist HCI (see §1.4.3.1). Comparative analyses along similar lines can also be found in (Nardi, 1996c) and (Bedny *et al.*, 2004).

9. Conclusion

Chapters 1-3 set out the motivation for, and general practical and theoretical background of, the research. Chapters 4-8 focused on the empirical aspects of the work. This final chapter of the thesis begins by summarising the main findings and conclusions of the desk and field research; it then presents some guidelines and recommendations for the application of activity theory to the design and evaluation of ICT-enabled work and learning processes. This is followed by a brief reflection upon the conduct and outcomes of the research, including a summary of the principal contributions of the thesis to the field of activity-theoretical information technology design (ATIT). The thesis concludes with some suggestions for future work.

9.1 Findings and Conclusions

9.1.1 Theory and Methods

9.1.1.1 History & Theory

The central focus of the research on the application of activity theory to interactive system and use-setting design and evaluation entailed a thorough review of related work in activity-theoretical information technology design (ATIT). This review - which was undertaken in parallel with the empirical research - established some of the main shared concepts and principles of ATIT (summarised in §3.5.1) and, as the fieldwork progressed, allowed the identification of numerous theoretical and methodological challenges. Several of these were encountered as instances of more general concerns within ATIT, such as the difficulties in developing AT-based data-gathering and analysis methods able to get sufficiently "close to the technology" to inform user-interface design. This line of enquiry led to the conclusion that the current status of ATIT reflects both the specific cultural-historical context within which AT was first introduced to HCI and ISD and longer-term trends in the development of activity theory itself, both within and beyond the former Soviet Union.

The foundations of ATIT were laid by researchers associated with the Scandinavian participatory design (PD) movement of the 1970s and 80s. This

research, which drew on interpretations of activity theory developed within Danish and Finnish psychology, was primarily associated with practical design contexts involving the participatory development of bespoke computer artifacts for specific work-processes. It was also often explicitly formulated in terms of opposition to the cognitivist paradigm which at the time provided the main theoretical base for HCI. Thus, the evolution of AT-based HCI methods within the Scandinavian School has tended to emphasize AT's cultural-historical perspectives while paying less attention to those aspects of the tradition more closely resembling Western cognitive science and behavioural ergonomics, *i.e.* the systems-cybernetic strand of AT developed by Anokhin, Bernshtein, *etc.*

Tracing the roots of the then-current situation within ATIT and exploring possible responses to it necessitated further research into the history and content of Soviet activity theory. These investigations confirmed that the central tenets of ATIT were in the main based upon Scandinavian interpretations of Vygotsky's cultural-historical psychology and the cultural-historical strand of development within Soviet AT associated with the work of Vygotsky's collaborators and students such as A. N. Leont'ev and A. R. Luria. However, it was also established that not only had extensive work on the application of AT to the design of work-processes, equipment and training been previously carried out in the former Soviet Union, but also that a modern, specifically work-design-oriented synthesis had been underway within the systems-cybernetic strand of Soviet AT since the early 1970s. This work - which was found to have continued following the collapse of the USSR and was at the time this investigation began just becoming available in English – appeared to be applicable to design problems in HCI and ISD, and thus potentially useful for the further development of ATIT.

9.1.1.2 Methods & Techniques

For the first phase of fieldwork the researcher utilised ethnographic data-capture methods within a participatory action research (PAR) framework. Incidents of interaction breakdown provided the main starting-point for data selection. This approach proved effective in capturing a large amount of (mainly qualitative) data from multiple intersecting sources. Preliminary and further analyses of the data based on AT were carried out both concurrently and post-study using

structural, task-analytic, parametric and usability-evaluation methods in various combinations, utilizing a mixture of established and novel ATIT macro- and meso-analysis techniques. Post-study analyses of the Phase 1 data indicated that combining traditional (*i.e.* Scandinavian, CHAT-based) and novel (*i.e.* derived from systemic-structural AT) ATIT techniques has the potential to produce descriptions of computer-mediated collaborative activity able to get "close to the technology" while retaining a sufficient connection to the context within which the interaction takes place to preserve what Benyon *et al* (2004, p. 541) term the "ecological validity" of the analyses.

The main disadvantages of the PAR/ethnographic approach used in Phase 1 were found to be: (1) the difficulties encountered in appropriately balancing teaching and research responsibilities; and (2) the difficulty in capturing adequate amounts of sufficiently detailed and continuous data to support the extensive use of micro-analysis techniques. In order to address some of these concerns the researcher adopted a somewhat different approach for the second phase of empirical research. This follow-up study employed a direct observation (non-participatory) approach based on audiovisual recording from multiple sources. Activity-theoretical data analysis was carried out using previously employed methods, but also involved the development of several novel instruments and the experimental application of techniques of functional analysis.

Audiovisual recording was found to be effective in producing a large amount of continuous and detailed data well-suited to the integrated application of macro-, meso-, and micro-analytic techniques. Its principal disadvantages were found to be: (1) it was less appropriate for use in the research-setting, requiring more intrusion into, and alteration of, normal practices; and (2) the very large amount of data produced could not be fully analysed within the resource constraints of the project. This latter difficulty was also found to arise with other forms of detailed activity analysis utilised during the research (see *e.g.* §7.3.1). Such approaches are inherently time-intensive, suggesting that: (1) the use of such techniques should be dependent upon the specific demands of a particular project, and may only be appropriate during the design and evaluation of mission- or safety-critical computer applications or interfaces; and (2) that the

development and application of effective protocols to guide the selection of interaction sequences for detailed analysis is essential. It might also be desirable to identify and develop ways of improving the speed and efficiency of detailed activity analyses.

9.1.1.3 Developing ATIT

Taken together, these historical, theoretical and methodological findings indicate the possibility of expanding the conceptual and methodological framework of ATIT to include perspectives, methods and techniques drawn from across the whole range of Soviet and post-Soviet activity theory. More specifically, they suggest that it might be both desirable and possible to: (1) establish clearer definitions of basic AT terms and concepts, including what constitutes the subjects, objects, and units of activity analysis; and (2) balance the use of cultural-historical perspectives with greater consideration of the individual-psychological aspects of activity. Much work in the later stages of the project focused on these aims by attempting to combine methods developed within the Scandinavian School of ATIT with ideas and techniques drawn from systemic-structural activity theory. These efforts can be seen as complementary to other work aimed at developing systemic-structural techniques for HCI activity analysis and design (*e.g.* Bedny *et al.*, 2001d, Bedny and Karwowski, 2003b, Zarakovsky and Sengupta, 2003, Sengupta and Jeng, 2003, Sengupta, 2004) and as being more generally aligned with recent research exploring the use of non-CHAT interpretations of activity theory in HCI and ISD (*e.g.* Fjeld *et al.*, 1999, Fjeld *et al.*, 2002, Törpel, 2005a, Lauche, 2005).

Table 9.1 summarises (and compares the main attributes of) the specifically activity-theoretical methods which were applied in various combinations to the analysis of computer-mediated activity during the research, indicating those sections of the thesis where they are described and discussed.

Table 9. 1: Activity-theoretical methods for the analysis of ICT-enabled activities used during the research. *Cf.* Fig. 2.7.

Method	Subject(s) of Analysis	Unit(s) of Analysis	Focused On	Primary Perspective(s)	Example(s)
Cultural-historical analysis	Societies, Organisations, Communities (of Practice)	Activity Systems, Activity	Historical, cultural & social contexts	Cultural-historical	§1.1.2, 1.4, 2.2-6, 3.1-5, 4.2, 5.1, 5.5, 7.2
Contradictions analysis	Activity Systems, Activities	Activity Systems, tasks	Conflicts and contradictions between components of activity systems and tasks	Cultural-historical, Objectively-logical	§7.1.3, 7.2.3.2,
Focus-shift analysis	Activity during task performance	Action, Operation	Relations between subjects, tools, and artifacts	Individual-psychological	§7.2.3.3, 7.3.3, 8
Qualitative description using flowcharts, process models, etc.	Activities, Work-processes, Tasks	Inputs/raw materials, tools, basic technological procedures, outputs/results	Technical and logical requirements of tasks and work-processes	Objectively-logical	§5.5, 6.1-8, 7.1, 7.2.4.1-2, 7.2.4.4
Functional analysis	Cognitive, behavioural & motivational processes & states during task performance	Function Blocks Physiological Units Temporal Units	Self-regulation processes and functional states during task performance	Individual-psychological Objectively-logical	§6.6.1.2, 7.2.4.1, 7.2.4.4, 8.
Morphological analysis: general	Activity during task performance	Action, Operation	The general structure of activity during task performance	Individual-psychological Objectively-logical	§7.2.4, 7.3, 8.4.1
Morphological analysis: Algorithmic	Activity during task performance	Mental and Motor Actions & operations Members of Algorithm	Logical sequence & probability of occurrence of actions	Objectively-logical, Individual-psychological	§7.2.4.1-3
Morphological analysis: Time-structure	Activity during task performance	Tasks & Sub-tasks Mental and Motor Actions Temporal Units	Duration Temporal Sequence & Simultaneity	Objectively-logical, Individual-psychological	§5.4, 7.8.2.2.1, 8.6.1.2
Task Typing & Task Complexity analysis	Activity during task performance	Task; Member of Algorithm Temporal Units	Qualitative and quantitative evaluations of task complexity	Objectively-logical, Individual-psychological	§5.4, 7.2.4.1, 7.2.4.4, 8.6.1.1

9.1.2 Empirical Findings

9.1.2.1 The Development of ICT Skills

The first phase of fieldwork established that the project-based ICT/ABE course *Computer Creative* supported participant learners' development of ICT skills through learning-in-use. Although clear limitations to participants' technical abilities were evident (see *e.g.* §6.5.2.1 and Note 15, Chapter 6), in general they became able to "express, explore, and realize ideas with new technological media" (Papert and Resnick, 1995 as quoted in §1.2.2.2), undertaking and successfully completing increasingly complex ICT tasks. These findings were strengthened by observations made during the second phase of fieldwork. Taken together the two studies confirmed that social-constructivist pedagogical principles can provide an effective framework for computer-based education and training courses aimed at developing the technology skills of non-professional users from low-income, low-education backgrounds. In neither study were any significant correlations found between users' assessed levels of basic literacy and numeracy skills and their subsequent development of ICT skills. However, users' previous experience with ICT and the expectations formed by that experience were found to impact on their willingness to persevere in learning and using specific applications. These findings are consistent with earlier informal observations at the Centre and the work of other researchers in the field of technology-based educational activity (Kafai and Resnick, 1996, Resnick *et al.*, 1998, Cavallo, 2000b, Sipitakiat, 2001).

9.1.2.2 Community-formation, Motivation & ICT Use

Concurrent and post-study analyses of the data from both phases of fieldwork indicated that the environment in which the studies took place played a pivotal role in supporting participants' learning-in-use and the development and exercise of ICT skills. The material and sociocultural conditions pertaining in OLC Workshop 3 facilitated the rapid establishment of communities of practice (Lave and Wenger, 1991, Wenger, 1998, Wenger *et al.*, 2002, Harris and Shelswell, 2005) within which individuals were able to provide each other with mutual support and encouragement, rendering the activities and tasks undertaken both collectively meaningful and personally significant. Learners' participation in a

community of technology-based practice allowed them to establish and maintain appropriate formal and informal divisions of labour; to generate, sustain and align (§8.7.1-2) levels of (positive) motivation sufficient for them to be willing to exert the effort required to overcome setbacks such as interaction breakdowns; learn from them; to develop new repertoires and strategies of computer-mediated action (*a.k.a.* functional organs or systems); and thus to undertake and complete increasingly challenging tasks.

9.1.2.3 Communication & Co-location

In the field studies both the collective process of community formation and individual participants' expansive learning-in-use with the available computer artifacts were found to be linked to their engagement in subject-oriented, communicative activity through gesture and body-language and dialogic and self-directed speech acts. Learners frequently exchanged task- and/or tool-relevant knowledge in the form of brief narratives or anecdotes, often embedding their "episodic knowledge" (Bærentsen, 1996) into "war stories" (Orr, 1996) concerning episodes of breakdown and recovery (*e.g.* §3.1.3, 6.5.2.6, 8.5.2). Skill development was observed occurring within a metaphorical "zone of proximal development" set up through the communicative interaction of persons of differing capabilities and experiences in relation to the specific task-problem or tool. On finding themselves in difficulty, learners almost invariably preferred to seek help from the tutors or their peers rather than consult online help systems, tutorials or manuals. These observations are in line with the findings of other studies of collaborative human-computer/man-machine interaction (*e.g.* Bannon, 1986, Suchman, 1987, Lave, 1988, Hutchins, 1990, Hutchins, 1996).

As noted, the material and sociocultural conditions pertaining in OLC Workshop 3 were found to be supportive of participants' learning-in-use. Physical co-location in a suitably spatially arranged and technologically furnished environment appeared to facilitate participants' use of both verbal (speech) and non-verbal (eye-contact, gesture, body-language) communicative actions which were established as an important aspect of their work and learning processes. These material characteristics of the work setting were accompanied and reinforced by local rules, norms and practices (*i.e.* an organizational and classroom culture) which encouraged discussion, dialogue, the collaborative

formulation of course goals and tasks, and the alignment or "tuning" of individual goals and motives. Users' collective experience of interaction with common (material and virtual) tools and work-objects appeared to provide the shared sensory, bodily experience which activity theorists (Leont'ev, 1978, p. 81, Larsen, 1989 and Vasiljuk 1988, 1990) have argued is an essential prerequisite of successful inter-personal communication (Bærentsen and Trettvik, 2002).

9.1.2.4 Task Complexity, Breakdown & Learning-in-use

Due to the creative and open-ended nature of the work, both field studies were characterised by participants' engagement in probabilistic-algorithmic, semi-heuristic, and heuristic tasks of medium to high complexity. These (primarily) computer-mediated tasks were typified by a high ratio of orienting and exploratory actions to executive actions (see §7.2.4.2-4, 8.7.1 and Tikhomirov, 1999, Kaptelinin, 1996b, Bedny *et al.*, 2001b, Bedny *et al.*, 2001d, Bedny *et al.*, 2005a). The limited presence of routine (*i.e.* algorithmic) elements meant that the dominant coordination modes were communicative and instrumental (rather than scripted, see Table 3.3), and that various forms of breakdown were frequently encountered. These characteristics of the tasks were seen as being important for skill development and were associated with collaborative learning-in-use – often prompted by interaction breakdowns - and participants' formation and mutual alignment of sufficiently clear task-, sub-task, and action-goals. Both "constructive" (*i.e.* those associated with expansive learning-in-use) and "catastrophic" interaction breakdowns appeared most likely to occur during more complex tasks and at points of maximal complexity during task execution.

9.1.2.5 Application and User-Interface Design, Use & Usability

Neither phase of empirical research showed any clear correlation between specific application or user-interface design features and the ways in which those tools were appropriated into activities. Rather, ICT tools were found to be one (albeit important) component of complex sociotechnical systems of activity in which both the immediate, situational aspects and longer-term (cultural) aspects of the work-processes and task-conditions involved impacted on interaction. Neither was any clear correlation found between the number of errors or breakdowns experienced with a particular tool and its contribution toward an

individual's development of ICT skills. Rather, whether or not expansive learning-in-use took place during ICT-enabled activity was found to be affected by multiple, intersecting task-conditions.

Thus, the support offered for learning-in-use by any specific tool in any specific activity could not be accurately predicted in advance or easily generalised (*cf.* discussions in Bødker, 1991, 1999a, Bertelsen, 2000, 2005). Although some attractive, learnable and usable applications (*e.g.* §6.2.1, 6.3.1-2, 6.8.2-3, 6.8.5), were quickly and easily appropriated into learners' activity, others appeared to be rejected for task- or person-specific reasons (*e.g.* §6.2.1.1, 6.8.1, 6.8.4). Conversely, it was also observed that learners would persist in learning and working with lower-usability tools when they perceived the task-goals with which they were connected as being of sufficient significance. However – as predicted by activity theory, see §8.7.2 - even when tasks were presented as important and necessary by tutors, if they had little intrinsic significance for learners and the tools were of low usability, such tasks and tools were avoided or abandoned.

Analysis of the longitudinal study data did, however, suggest that some applications (and combinations of applications) were persistently associated with recurrent and/or catastrophic breakdown during certain tasks. Attempts to identify the underlying causes of such breakdowns highlighted two main user-interface design issues: (1) contradictory representations of task difficulty; and (2) contradictions between the assumed and actual knowledge of users. The latter factor was particularly evident in several applications' inadequate provision of information to guide initial parameter-setting operations. A third factor, the contradiction of adaptation operations at the user-interface, was also tentatively identified as a possible contributor to cases of recurrent and/or catastrophic interaction breakdown; however, findings in this area were inconclusive.

As noted above, it was also found that online help systems, tutorials and application documentation such as manuals had little relevance to users' needs in the situations observed. In those few cases where such resources were used (*e.g.* §6.8.2), learners preferred hard-copy over on-screen material, the affordances of physical texts apparently allowing them to be more easily incorporated into established work practices (which typically utilised combinations of digital and

material artifacts), possibly because they provided additional instrumental means to mediate the coordination of collaborative activity (*cf.* the discussion from an information-processing viewpoint in Shneiderman, 1998, pp.410-438).

9.1.2.6 Alignment of Goals & Motives

Post-study meso- and micro-analyses of the Phase 1 data (Chapter 7) and of the video data captured during the second field study (described in Chapter 8) provided further evidence that the expansive learning-in-use associated with skills development through computer-mediated collaborative work involves a highly complex moment-to-moment interplay between the object-oriented (instrumentally-mediated) and subject-oriented (communicative) aspects of users' activity. The intensity and (positive or negative) orientation of users' motivational states during interaction were found to be closely linked to their subjective assessments of the difficulty, (social, objective) meaning, and personal significance (sense) of the tasks being undertaken. Processes of formulating, continuously adjusting, and mutually aligning task and action-goals, of evaluating the actual outcomes of tool-mediated actions against those goals, and of setting subjective standards for those applications, were all found to be critically dependent upon communicative interaction. These observations accord with the work of other ATIT researchers applying activity-theoretical approaches to the analysis of collaborative computer-mediated work activity (*e.g.* Bødker, 1996a, Bouvin *et al.*, 1996, Bardram, 1998) and recall work in other contextualized approaches to HCI (*e.g.* Winograd and Flores, 1986, Ehn, 1988). The identification of users' verbal self- and mutual regulation of their collaborative computer-mediated activity as a centrally important aspect of collaborative HCI supports earlier work by Bødker (1991, 1996a, 1999a), Bardram (1998), Raeithel & Velichkovsky (1996) and other ATIT researchers and accords with recent findings by cultural-historical psychologists on the role of speech in adult learning and collaboration (§2.3.2, 2.5.1.1 Ramírez, 1992, 1994, Ramirez *et al.*, 1999, Azevedo dos Santos *et al.*, 2002, Branco, 2001).

9.2 Design Guidelines and Recommendations

One of the overall aims of the research discussed in this thesis was to generate activity theory-based recommendations, guidelines, methods, and principles for

the design and evaluation of interactive technologies and their use settings (§1.3.1). The main findings and conclusions of the research have been summarised above; this section considers examples of their practical application to design. It discusses three major aspects of the "information ecology" in turn: use-settings, tasks and work-processes, and computer artifacts (including hardware, applications and user-interfaces). Each section presents a set of guidelines containing general advice and principles and, where appropriate, also provides some more specific recommendations suggesting how they might be utilised in practice. The recommendations and guidelines seek to address as many of the typical components of computer-mediated collaborative work and learning activity (subjects/users, tasks/goal conditions, tools, methods, objects and results, see Fig. 2.6) as possible. The aim is to provide a diverse "toolbox" (Bødker *et al.*, 1995) or "checklist" (Kaptelinin *et al.*, 1999) from which designers and evaluators can select those ideas and techniques most suitable to their specific circumstances.

In what follows the main emphasis is on design, with only some brief remarks offered on other stages of the HCI/IS development process; these topics remain for further development in future work (see §9.4 below). It should also be noted that the recommendations and guidelines do not deal directly with organizational design, although they clearly imply the need for organizational contexts within which it is possible to meet the requirements of the recommendations for designing use-settings and work-processes. In line with the original aspiration of the research to contribute toward the building of "bridges across the digital divide" (Harris and Shelswell, 2001a), neither do they deal with issues such as the pre-selection of users or the development of training materials, although some thoughts on the latter topic can be found in Harris and Reddy (2005) and Harris (2005b).

As noted by other ATIT researchers (*e.g.* Kuutti, 1996, Mwanza, 2001, Nardi and O'Day, 1999, Hedestig and Kaptelinin, 2002) the adoption of activity theory as a conceptual framework for interaction design implies the recognition – to quote Bødker's well-known dictum - that "design of a computer application is design of conditions for the whole use activity" (Bødker, 1999a p. 5). In this sense ATIT exemplifies the tendency in post-cognitivist, context-aware information

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technology design toward an increasing overlap between the concerns of HCI and ISD (discussed in §1.4.2-3); it also perhaps implies a conceptual (re)unification of both those fields with the wider concerns of human-factors/ergonomics - a trend also evident in much current research output from the international ergonomics community (see *e.g.* Pikaar *et al.*, 2006).

9.2.1 Use-Settings

Interactive system use-setting designs based on activity-theoretical concepts and principles should seek to include some or all of the following characteristics:

- Simultaneous use by multiple, collaborating users;

- Encouragement and support for multi-modal communication between users at all stages of the work-process;

- Access to multiple traditional and computer artifacts, preferably in an "immersive" work environment where all artifacts are quickly and easily accessible;

- Sociocultural, material and technological conditions that remain stable over periods of time sufficient to allow community-formation.

The various conceptual and technical challenges currently associated with maintaining multi-modal communication at a distance (*i.e.* through telepresence) and/or creating virtual environments (see *e.g.* Sutcliffe *et al.*, 2004) suggest that physical co-location of multiple, collaborating users will often be the most practicable means of establishing the general conditions outlined above. Designers seeking to create shared use-settings may also wish to consider some or all of the following recommendations:

- As physical spaces, use-settings will preferably allow participants to easily see each other, ideally both when seated and standing; will provide possibilities for mobility of users within the space; will be quiet enough to allow conversation; will contain material artifacts (furniture, computer hardware, etc.) which afford clustering, leaning, *etc.*; and will provide sufficient room for several users to gather around individual input/output devices (see also §9.2.2.3 below);

- As social spaces, use-settings will preferably provide (or allow for the emergence of) rules and norms which encourage all forms of dialogue, discussion, and peer mentoring, and legitimise social, communicative activity as an integral and important feature of the collective work-process;

- As technological spaces, use-settings will preferably include a wide variety of readily accessible material and digital means of work, and provide support for their combined use; where the physical requirements outlined above are not readily achievable, designers might also consider providing technical support for multi-modal communication such as mirrors, video-links, instant messenger/chat software, *etc.*

It should be noted that these recommendations for use-setting design do not assume the need for one workstation/PC per user (see also §9.2.2.3 below).

9.2.2 Tasks & Work-Processes

Tasks and work-processes based on activity-theoretical concepts and principles should seek to include some or all of the following characteristics:

- Work-processes will preferably be sufficiently open-ended, creative to allow task-goals to emerge out of discussion, dialogue, and exploratory tool-mediated activity, with goals open to modification both by the results of previous and related activities and by sociocultural factors;

- Work-processes should aim to support steady, user-led progression toward the inclusion of tasks of greater complexity as their proficiency and confidence develop;

- Work-processes and tasks will preferably be designed so that different aspects and stages of the activity can be distributed among a variety of collaborating persons using a variety of mediating (ideal, material and virtual) artifacts, and so that the division of labour with regard to any work-process or task can, as far as is practicable, emerge from within, and be facilitated by, the local community of practice;

- Tasks will preferably be predominantly semi-heuristic or heuristic, that is of sufficient complexity and open-endedness to allow idiosyncratic goal-

formation, and the alignment of those goals within sufficiently encompassing individual and collective standards of task-sufficiency;

- In general it can be assumed that creative work involving computer artifacts will always require a sufficiency of algorithmic (step-by-step) elements of activity to ensure some automatization of actions through repetition, negating any need to introduce deliberately repetitive tasks. However, to ensure this aspect of skill development is supported designers may wish to find ways of providing stability and continuity in the technical environment; so that users are encouraged or constrained to repeatedly use a broadly similar toolset over a series of interaction sessions.

Participatory approaches to the design and development of computer-mediated tasks and work-processes have been shown to be especially effective in producing motivated, expansive learning-in-use, and therefore designers should consider using such methods wherever practicable (see also §9.2.3.1). Efforts might also be made to identify, and if possible avoid, design decisions that lead to unnecessary task complexity; similarly, it will often be preferable to avoid the introduction of too many repetitive elements into the work. In both cases, the aim is to optimise those conditions tending to support positive motivation during work activity. Noting that, as task complexity increases, sense-making and problem-formulation actions become increasingly critical, designers and evaluators may wish to identify those points in a task or work-process where subjective perceptions might tend to under- or over- represent the difficulty of the required actions (using *e.g.* techniques of algorithmic and functional analysis, see Chapters 7 & 8), in order to attempt to provide additional support for users at such junctures.

9.2.3 Computer Artifacts

In general, designers and developers aiming to create computer artifacts which incorporate insights from activity theory may wish to seek to:

- Avoid the assumption of "one device, one user";

- Consider that the artifacts will often be used in combination with a wide variety of other material and digital tools;

- Design artifacts which facilitate collaborative work, but not necessarily joint control.

9.2.3.1 Hardware

It is possible to visualise ICT hardware designed so as to better facilitate communication and collaboration along the lines set out in §9.2.2.1 above. This might involve the creation of large or dual-faced (back and front) display screens; cabinets and mountings which facilitate leaning or touching by non-operating collaborators; "collaborative computer workstations" suitable for 2 or more persons incorporating desks, multiple PCs and displays, and configured in ways that preserve maximum visibility and audibility between collaborators; and so on. As noted in §8.7.1, multi-user hardware and applications need not necessarily support joint multiple control by users; rather, as the coordination of collaborative activity regulation is mainly carried out through observation, speech, gesture, the joint direction of attention, *etc.*, their main function would be to make this mutual- and self-regulation more effective. For example, one might design workstations with multiple mouse-like pointing devices, but where only one such device allows the invocation of commands. It is also evident from the field studies that the use of complex combinations of material and virtual tools and work-objects constitutes a central feature of collaborative ICT-enabled work and learning processes. This suggests firstly that furniture and mountings for computer hardware might be designed so as to allow the simultaneous presence of material artifacts and secondly that augmented reality artifacts and tangible interfaces, if appropriately designed, are also likely to support the development of ICT skills. Some interesting prototypes incorporating several of these features have already been developed by ATIT researchers (see Fjeld *et al.*, 2002, Fjeld *et al.*, 1999) and others (*e.g.* Beardon *et al.*, 2002).

9.2.3.2 Software

This section summarises the findings set out in Chapters 6 and 7, which suggest that in general, when creating software which aims at incorporating activity-theoretical concepts and principles designers should seek to:

- Remember that applications will often be used in combination with many other material and digital tools, and design accordingly, *e.g.* avoiding including too much functionality in a single package (§6.8.1);

- Either aim for a high level of interface design consistency within and between applications (*e.g.* when using common Windows interface elements and conventions, see remarks in §6.2.1.1, 6.8.3 & 6.8.5) or seek to utilise clearly different and unique designs (see §6.3.2). Application designs which appear superficially similar but function differently when handling multiple windows, multiple files, multiple program instantiations, etc. should be avoided wherever possible;

- Handle automation with care. The observations discussed in (§6.3.1.2) lend support to arguments by Bødker (1991) and Bærentsen (2000) that removing the necessity for user intervention into, and the visibility of, transitions between application states may inhibit learning-in-use and provoke contradictions between user perceptions and the actual status of the work process. For example, the semi-automated conservation of screen space and high level of user customisation designed into the PSP UI (see *e.g.* §6.2.1.2) - design choices which arguably objectify the assumption of single-user interaction - may prove counter-productive in a collaborative use setting. Users may also find the apparent autonomy of the interface disconcerting inasmuch as it suggests a distal locus of control (§8.7.3);

- Simplify the design of initial parameter-setting dialogues and contextualise the choices available (as noted in §6.5.1), whilst remaining aware that parameter-setting operations, which can be task-critical, often assume general background and application-specific knowledge (§6.5.2.2, 6.6.3, 6.6.1.1). As users tend to accept default settings, which are not always appropriate, task analysis techniques may prove useful for establishing optimum default parameter settings;

- When creating "Wizards" and templates, designers should consider minimising the number of complex choices available to the user, and may also wish to ensure that sufficient information is available on the interface to provide a context for decision-making (§6.6.3);

- If possible, the necessity for modal changes such as those invoked by selection might be better avoided altogether; designers should consider using alternative methods of targeting user actions, such as the toolglass and other devices discussed in (Beaudouin-Lafon, 2000, Beaudouin-Lafon and Mackay, 2000);

- When changes in application modality are unavoidable, it may be advisable to ensure that they are clearly and continuously signalled, especially when potentially "hidden" in *e.g.* selection marquees *etc.* (§6.2.1.3, 6.3.1.2, 6.5.2.4). This might be achieved, for example, by placing a "selection active" indicator on the interface;

- Caution is advisable when implementing designs that require users to possess certain "scientific concepts" (§6.6.1.1) and other background knowledge (§6.6.3, 7.1.3.2). Designers may wish to reflect upon whether some details of the way their designs function (or make use of metaphors on the UI) may either consciously or inadvertently embed such (possibly unfounded) assumptions about users' conceptual and technical knowledge.

Designers concerned to make use of insights from AT may also wish to bear in mind that activity-theoretical research has demonstrated that it is the goal-oriented nature of human activity that has the most significant impact on what is perceived by the user (§6.3.1.1, 6.8.2, 8.7.1). Traditional HCI guidelines concerning graphical representation on the interface generally emphasize the value of grouping elements with similar functions, colour-coding, designing "affordance" and so on (Faraday and Sutcliffe, 1997) (*cf.* Beaudouin-Lafon, 2000). However, findings from AT suggest that designers should also attempt to locate important icons, signals e*tc.* close to where the focus of the user's attention is most likely to be at any given stage of the task. Often this may be assumed to be the work-object as seen "in" or "through" the user-interface (see Figs. 3.1a & 3.1b). Such considerations present particular challenges when designing complex user-interfaces such as PSP (Fig. 6.1) and emphasize the points made above concerning automation and modality.

In light of the discussions in §7.2.4, designers of operating systems might also consider deliberately limiting the number of multiple simultaneous instantiations

of tools and objects available to the user at the interface at any one time during the work-process. Developers are advised to consider whether the likely limited use made of supporting materials such as manuals and on-screen help systems (§6.5.2.6), justifies the effort and expenditure incurred by their design and manufacture. Designers may also wish to aim for internal consistency and conformance to "adaptation operations" (§7.1.3.3) in their treatment of interface elements. Where possible, virtual "objects" should persist and retain their integrity through series of operations (see §6.6.1.2); state changes should preferably be continuous and gradual (*cf.* Bærentsen, 2000).

Finally, it should be noted that in those many cases where hardware, applications and interfaces are not available for direct (re)design (such as in the work reported here), efforts that focus on those other aspects of the information ecology discussed above will not necessarily prove any less effective in providing improved support for users (*cf.* Schmidt and Bannon, 1993, and, Robertson, 1998, on the "articulation work" and "tailoring" involved in appropriating information systems into collective work practices).

9.3 Assessing the Outcomes of the Research

This section reflects upon the extent to which the initial aims and objectives of the research were achieved; the possible wider relevance, reliability and validity of the research findings; and the nature and scope of the contributions made by those findings to knowledge in relevant fields of research.

9.3.1 Meeting the Aims & Objectives of the Research

In Chapter 1 the overall aim of the investigation was stated as:

> To study the relationships between the social, psychological, and technical aspects of interaction in creative, collaborative computer-mediated work activity; to seek to understand those relationships both practically and theoretically; and then generate activity-theory based recommendations, guidelines, methods, and principles for the design and evaluation of interactive technologies and their use settings.

During Phase 1 this general aim was associated with four overall objectives (§1.3.2). These involved (1) identifying and analysing aspects of the information ecologies under study where design intervention might be successful in providing improved support for participants' learning-in-use through ICT-enabled

activities; (2) identifying effective, activity-theory based methods by which such design interventions might be carried out; and (3) developing a coherent conceptual framework and consistent terminology to guide these efforts. The final objective (4) involved relating the methods and findings of the research to more general issues in ATIT, HCI and ISD. The aims and objectives of Phase 2 (§8.1.1) involved the further and more detailed investigation of issues raised during the first phase of study.

Preceding sections of this chapter have summarized the overall success of the research with regard to objective 1, with various guidelines and recommendations for effective design intervention being listed in §9.2.2. According to a review by Plowman, Rogers and Ramage (1995) a common failing of workplace studies and ethnographies such as those described here is that they fail to provide specific design guidelines; Benyon *et al* have suggested that this may be due to many projects' failure to generate prototypes (Benyon *et al.*, 2004, p. 719). While (as noted above) the research has produced some design guidelines, the empirical testing of those recommendations in the concrete form of applications and user-interfaces remains for future work (§9.4).

By the close of the research the development of design-oriented ATIT methods remained in its early stages; although a range of activity-theoretical methods and techniques were used in various combinations during the research (see Table 9.1) they were used mainly for the evaluation and criticism of computer artifacts and work-processes. The outcomes of the project in this regard consist mainly of the identification of potentially fruitful directions for future work. Thus, objective 2 can only be said to have been partially met, and a similar judgement must be made with regard to objective 3. One of the principal concerns of the research has been the clarification of those shared concepts and principles which constitute contemporary ATIT (§3.5.1); the identification of some challenges and issues currently facing research in the field (§3.5.2); and the setting out (and very limited testing) of some possible methods of addressing those challenges (§3.5.2.4, 7.2-3, 8.6-7). However, these contributions can only be considered as preliminary steps toward developing a coherent conceptual framework for HCI and ISD research based on activity theory. With regard to objective 4, §9.1.2.1 has summarized those outcomes of the project considered relevant to other

efforts within ATIT; the following section discusses the possible wider relevance of the research.

9.3.2 Relevance, Reliability & Validity of the Research

9.3.2.1 Relevance of the Research

The research initially aimed for outcomes applicable to a very specific research setting (§1.3), and was mainly conducted using participatory, ethnographic and interventionist methods designed to be appropriate to, and acceptable within, that specific setting (§4.3). Thus, while the findings of the research were evaluated as useful within that setting, gauging their wider applicability is more problematic (see also discussions of generalisation of field studies in Atkinson *et al.*, 2001, Fetterman, 1998, Kemmis and McTaggart, 1988). One of the aspirations of the research was that investigating ways of improving the practical applicability of AT to ICT design might prove useful to other researchers and practitioners in the field; any evaluation of the extent to which this proves true is necessarily dependent on the subsequent dissemination and review of this thesis and publications derived from it. In this context it may be worth noting that interim reports of the research have found an audience (see the list of related work by the author that prefaces the main text). The use of a well-established, general, and (fairly) unified theory of human cognition, motivation and behaviour grounded in extensive empirical investigation (*i.e.* activity theory) as a framing for the interpretation of the research findings may also be considered as offering some grounds for assuming that those findings may find applications in the wider fields of HCI, ISD, HFE and CSCW.

9.3.2.2 Reliability & Validity of the Research

Numerous methods for evaluating the validity and reliability of qualitative, observational studies such as those described here have been suggested in recent years. Typically, these involve - *inter alia* - value-judgements based on concepts such as "trustworthiness" and involve questions of the integrity, credibility, dependability, transferability, and confirmability of the research (Guba and Lincoln, 1982, Lincoln and Guba, 1985). For each of these components specific methodological strategies have been suggested. The main difficulty with applying such approaches (which involve techniques such as audit trails, member

checks, peer debriefing, negative case analysis, structural corroboration and referential material accuracy) to evaluate research carried out by a single investigator is that they must necessarily be carried out mainly by the researcher themselves. In the work described here, the main effort to ensure the integrity of the data involved prolonged and persistent observations "indefinitely triangulated" (§5.2.2.1) through the use of multiple data sources. Member checks - that is the testing of research conclusions against participants' perceptions – were also consistently carried out in dialogues about research methods and findings between the researcher and the participant learners and tutor, while peer debriefing was carried out with the PhD supervisory team at weekly meetings. Published accounts of the research (cited in the text and listed in the bibliography) were also made available for study participants' scrutiny.

Evaluating the dependability or accuracy of the accounts offered here involves some consideration of issues such as their concordance with other research accounts and findings, the researcher's previous track record, and the openness of the research project to external scrutiny and independent verification (Lincoln and Guba, 1985). Here, there are three obstacles to comparative judgments of account accuracy: the uniqueness of the research setting; the comparative rarity of studies of similar user-groups in the HCI and ISD literature; and the fact that this was the researcher's first major project. However, points of convergence and confirmation with other work have been noted and cited throughout the text. The thesis has also attempted to address dependability issues through explicit statements of the research assumptions and theoretical bias, and by offering detailed descriptions of the data-capture and analysis methods used. A measure of external scrutiny was provided by the University, host organization, and the project participants themselves. Some qualitative researchers (*e.g.* Morse *et al.*, 2002) have advocated a process of verification *during* research as a means of ensuring study reliability and validity. The suggested strategies include: methodological coherence; appropriate sampling; collecting and analyzing data concurrently; thinking theoretically; and engaging in theory development. In developing the research approach and procedures described in previous chapters many of these requirements were considered and at least partly addressed; for

example, the need for *investigator responsiveness* emphasized by Morse *et al* (*ibid.*) was discussed in §3.2.2.

9.3.3 Contributions to Knowledge of the Research

This section briefly summarises the principal contributions made by the thesis to knowledge in the fields of activity-theoretical HCI and ISD.

9.3.3.1 Theoretical & Methodological Contributions

Overall, a central theoretical contribution of the thesis to knowledge in the field of ATIT lies in the attempt to incorporate a number of terms, ideas, methods and techniques derived from systemic-structural activity theory into the conceptual framework of Scandinavian AT-HCI and ISD. Contributions attributable to the author in this regard include: the discussion and application of various methods of morphological analysis including: time-structure approaches, HCI task classification using SSAT typology, techniques for HCI action isolation and classification, and algorithmic analysis; and the introduction of functional analysis techniques using self-regulation models.

A secondary aspect of the theoretical discussions undertaken in the thesis are the various attempts to clarify those objects of study, units of analysis, and analytical techniques appropriate for activity-theoretical HCI and ISD. These include the re-definition (mainly from a systemic-structural point of view) of various fundamental activity–theoretical terms such as activity, task and action; and the introduction of terms and concepts not hitherto widely used within ATIT, such as function block, functional analysis, and self-regulation. An additional contribution in this regard included in the thesis was initially formulated collaboratively (with G. Z. Bedny). This is the triadic schema of activity incorporating systems-cybernetic AT elements (Figs. 2.10 and 7.10; see also Bedny and Harris 2005, 2006b).

Methodologically, the thesis makes original arguments for the establishment of the *task* as an essential and fundamental object of study for ATIT, advocates and attempts the balanced use of all three perspectives (cultural-historical, objectively-logical, and individual-psychological) on activity analysis, and suggests and demonstrates the utilisation and combination of concepts and methods from all branches of activity theory. It offers examples of the

application of focus-shift analysis techniques to the work and learning activity of non-professional users, demonstrates the application of various systemic-structural activity analysis techniques to HCI field data and combines various new and established ATIT methods in several ways. In addition the thesis introduces a number of specially developed activity-theoretical instruments and techniques for the analysis of HCI field data.

9.3.3.2 Empirical Contributions

The principal empirical contributions of the thesis comprise the presentation and analysis of original data on the creative and collaborative use of ICT by low-income, low-education users in a previously undocumented work and learning setting. Such data might be considered relatively rare in the HCI, ISD, or ATIT literature, which currently offers few studies of users from marginalized or disadvantaged communities. Studies such as this may contribute toward an improved understanding of the design issues raised by the increasing ubiquity of interactive systems, and may also usefully inform wider debates around the "digital divide" between rich and poor, particularly with regard to the focus of the studies on the quality (and thus arguably the "empowerment potential", see Herrmann, 2003, Page and Czuba, 1999, Rappoport, 1984, Zimmerman, 1995) of ICT use in work and learning processes. The practical contributions of the research are summarised in the guidelines and recommendations presented in §9.2.2-3 above. The majority of these guidelines align with other work in context-aware HCI and ISD, and in particular strengthen findings from the Aarhus-Oslo school of ATIT.

9.3.3.3 Other Contributions

Chapters 2 and 3 discuss the origins, development and current status of activity theory and ATIT. Although some new data were generated (mainly through formal and informal semi-structured interviews with researchers in relevant fields), the majority of the findings were derived from the published literature, and thus cannot claim to make any substantive original contribution to the history of Soviet psychological science (for a guide to primary and secondary historical sources see Note 1, Chapter 1: Notes 4, 18, 20 & 29, Chapter 2; and the bibliography). The author can, however, claim to make some useful contributions

in this regard to ATIT, inasmuch as the thesis presents facts, arguments and interpretations not commonly found elsewhere in the English-language literature, and which in places depart radically from the currently canonical accounts.

With regard to the history of AT, these contributions include: the identification of differing strands within the activity approach and the development of terms for their discussion; an account of the origins of activity theory which identifies S. L. Rubinshtein as its principal co-founder (with A. N. Leont'ev) and clearly distinguishes it from Vygotsky's cultural-historical theory; brief summaries of theoretical concepts developed within the systems-cybernetic and systemic-structural schools of AT; an overview of the applied uses of AT in the former Soviet Union and its relationship to Soviet cybernetics and computer science; and an account of the dissemination of AT and its take-up by Western researchers which differentiates between CHAT and other modern forms of AT & CHP, thus providing an historical and theoretical background for the critical analysis of the origins, development and current status of ATIT undertaken in Chapter 3.

These theoretical and historical discussions also serve to direct attention toward some currently neglected, but important work in ATIT drawing on the systems-cybernetic tradition of AT (*e.g.* Bardram, 1997, Raeithel, 1992, Raeithel and Velichkovsky, 1996); and to identify some hitherto little-used primary source materials in the English-language AT literature (*i.e.* Simon, 1957b, Simon and Simon, 1963). As noted in §2.1, the account in Chapter 2 and the bibliography which accompanies it in some respects differ markedly from those most frequently encountered in the ATIT literature. These resources may provide a starting point for the expansion of the theoretical and methodological knowledge-base of the field which is one of the recommendations of the thesis.

9.4 Suggestions for Future Work

The research findings summarized in this chapter tend to confirm the suggestion that activity theory, with its rich history of the rigorous and systematic study of human praxis, has great potential to provide a holistic and unifying framework for context-aware interactive systems design and evaluation. However, to be truly useful such a framework must provide an array of concepts, methods and

techniques of sufficient consistency and practicality to enable researchers and practitioners to engage with, and make tractable, the extremely high levels of complexity evident in real-world interaction. It is a central conclusion of the research discussed in this thesis that in order to fully realise the potential of activity theory in this regard, ATIT researchers must become much more familiar with, and make greater use of concepts, data and findings from the whole corpus of Soviet and post-Soviet activity theory, paying especial attention to work carried out in the applied sphere. Accordingly, it is recommended that in the immediate future, research in ATIT should focus on:

1. Increasing utilization of concepts from across the whole spectrum of the activity approach, drawing on both historical and contemporary sources;

2. Continuing efforts to establish practical analysis and design methods, particularly with regard to designing elements of collaborative computer-mediated activity under circumstances where extensive user-participation is impracticable;

3. Continuing efforts to establish which methods and techniques are most applicable under which circumstances;

4. Continuing efforts toward the clarification of AT and ATIT concepts and the standardization of ATIT terminology;

5. Further clarification as to the appropriate objects of study and units of analysis for ATIT, including the reinstatement of the task as a legitimate and central object of study for ATIT (§5.4.1, 7.2.3-4, 7.3.2);

6. The further development of notational conventions and other methods of communication and knowledge-sharing between ATIT researchers.

With regard to possible contributions to be made by this researcher toward the development of ATIT in the general directions outlined above, previous discussions have highlighted several theoretical and practical lines of enquiry. For example, a logical next step would be to test the proposals generated by the research discussed here through the design and evaluation of prototype work-processes, tasks, tools and use-settings, possibly in more controlled observational settings. Such efforts would involve, *inter alia*, the further adaptation and development of activity-theoretical task classification and analysis methods.

Combinatorial activity analysis techniques could also be applied to more tightly focused problem domains. Chapter 8 used ATIT techniques to investigate orienting and goal-formation activity in a DTP task. This approach might also prove useful, for example, when analysing user behaviour during information search and retrieval (*e.g.* from the WWW or large-scale databases), where initial query formulation and users' orientation within the information architecture of the resource have a major impact on task performance.

It has been noted and discussed elsewhere that the circumstances pertaining during Phase 1 of the empirical investigation resulted in some inconsistency and incompleteness in the dataset, rendering the selection of data for detailed analysis problematic. Building on Phase 2, future work should aim to develop more consistent data-capture strategies, so as to facilitate the further development of (1) multi-level data analysis methods, and (2) the greater use of comparative and developmental analyses, along the "historic-genetic" lines proposed and practiced by Soviet activity theorists and cultural-historical psychologists. This latter aim might involve, for example, carrying out video-based studies in which a stable cohort of participant users is presented with series of successively more demanding and rigorously defined versions of a set task (*cf.* the series of experiments reported in Tikhomirov and Klochko, 1976/1981). Each task performance in the series would then be analysed using the same combination of activity analysis methods, facilitating the identification of "boundaries" between differing levels of task complexity and their impact on users' strategies and motivation. Alternatively, task requirements could be held constant while the mediating means available to users (hardware, software, external assistance, *etc.*) are systematically varied over a series of trials. Such an approach would not only be likely to yield useful empirical findings but could also underpin further methodological development within ATIT through the comparative evaluation of different activity analysis techniques and combinations of techniques.

Studies such as these will clearly require the development and testing of improved instruments and techniques. During the empirical investigations described in the thesis, a series of "design artifacts" (Bertelsen, 2000) were used to focus data-capture in the field. Initially these were simply loosely formulated sets of questions based on those compiled by other ATIT researchers. Later in the

studies somewhat more sophisticated instruments were developed: detailed checklists of analytical questions (Table 5.1), proformas (§5.2.2.3), focus-shift charts (Fig. 7.5), and time-structure outlines and diagrams (the tables and figures in §8.4.1). Future work would seek to develop these tools further, and in particular should aim to provide improved support for functional approaches to HCI activity analysis. Such work would also seek to improve methods for the morphological analysis of HCI data through the further adaptation of existing SSAT methods and techniques. This would involve the use of probabilistic and/or multi-subject algorithms for the structural analysis of collaborative computer-mediated collaborative activity and the mathematical formalization of task-complexity evaluation using the methods described in Bedny and Meister (1997, pp. 271-277). It is also possible to envisage the development of improved graphical representations of collaborative computer-mediated activity by combining elements from the various schemas presented in Figures 2.4, 2.10, 3.2, 7.10, 8.12 and 8.15.

An important adjunct of the work outlined above would be the effort to develop further the use of combined physiological, psychophysiological and psychological methods of data-capture in ATIT research, in order to support more fully integrated analyses of the behavioural, motivational and cognitive aspects of computer-mediated activity. Methods for the simultaneous capture and analysis of such multi-modal data were well-established in Soviet activity theory and have continued to be developed in the post-Soviet era (see, *e.g.* Luria, 1979, Leont'ev, 1981b, Zinchenko and Gordon, 1981, Tikhomirov, 1988, Bedny and Meister, 1997, Bedny *et al.*, 2000, Chainova and Yakovetc, 2005, Chainova *et al.*, 2006). Within ATIT, attempts in this direction have so far been represented mainly by efforts to combine the use of qualitative methods with audiovisual recording (*e.g.* the work reported in this thesis and studies from the Aarhus-Oslo school such as Bødker, 1996a) and/or the use of eye-movement registration techniques (*e.g.* Raeithel and Velichkovsky, 1996, Sengupta and Jeng, 2003). To date, little attention has been paid to other physiological measures (heart rate, brain activity, *etc.*), although mobile equipment suitable for use in the field is becoming widely available.

Several possibilities for increasing the use of integrated multi-modal data-capture and analysis can be visualised. One involves the incorporation of standardised measured time-and-motion systems such as MTM-1 (Karger and Bayha, 1987) for use with algorithmic analyses, as already demonstrated by Bedny *et al.* (Bedny *et al.*, 2001c, Bedny and Meister, 1997), allowing ATIT analysts to pay closer attention to the behavioural components of computer-mediated activity. Another would seek improved technological support for activity analysis and design, perhaps along the lines suggested by Avouris *et al.* (2005). In the field of human factors/ergonomics there have been recent technical advances in automated, multi-modal data-capture and analysis systems. Hardware-software ensembles are now commercially available which allow the simultaneous and synchronized capture of physiological and behavioural data, allowing (for example) the measurement of heart-rate and skin-resistance at the same time as capturing room video, eye-movements and on-screen activity (see *e.g.* http://www.noldus.com/). Such systems also provide means for the automatic collation, annotation, coding and analysis of the resulting very large multivariate datasets, potentially significantly reducing the workload associated with detailed activity analysis. Preliminary investigations by the author and his collaborators indicate that such systems may be successfully adapted for use with the conceptual framework of activity theory, opening up many exciting possibilities for future work in ATIT.

Glossary

This glossary defines terms and concepts from activity theory and ATIT used in the text. References to sources supporting, extending, or offering an alternative view on the given definitions are provided for some entries; comparable AT glossaries can be found in (Tolman, 1988) and (Gilgen and Gilgen, 1996, pp. 46-48).

A

Abilities. In AT, ability, as distinct from *character* and *temperament*, is considered to be a substructure of personality characterized by the acquisition of knowledge and skills important for particular kinds of practical and theoretical performances. Abilities develop from an integration of intellectual and emotional-volitional (motivational) features of an individual and are exhibited through knowledge, skills, competencies and aptitudes. Ability is seen as a determinant of the dynamics of skill acquisition and performance and the overall level of performance. See also (Bedny and Seglin, 1999a, 1999b).

Action. An action is a discrete element of activity that fulfils an intermediate, conscious *goal* of activity. Actions involve the exploration, manipulation, or transformation of an *object* (either material or symbolic), from some initial state to a final state, in accordance with the goal. Actions include unconscious *operations*, the specific natures of which are determined by the concrete conditions under which activity takes place. All actions have a temporal dimension. The initiation of a conscious goal (goal acceptance or goal formulation) constitutes the starting point of an action; it concludes when the actual result of the action is evaluated in relation to the goal. The structure of activity during task performance is formed by a logically organized system of motor and mental actions. In order to extract individual actions from a task structure it is necessary to identify the object, *tool* and goal of action.

A number of different approaches to the **classification of actions** have been developed in system-structural theory. One differentiates between types of mental action based on two considerations: (1) the degree to which they require deliberate examination and analysis of the stimulus (their direct connection with, or transformation of, the input); and (2) the dominating psychological process during action performance: sensory, simultaneous perceptual, imaginative, mnemonic, *etc*. A second, more generalized classification scheme, categorizes actions according to the nature of their object (either material or symbolic), and their method of performance, (either practical or mental). This scheme thus distinguishes between: (a) **object-practical actions** performed with material objects; (b) **object-mental actions** performed on mental images; (c) **sign-practical actions** performed with external signs; (d) and **sign-mental actions** performed through the mental manipulation of signs or symbols.

Action Regulation Theory, ART. (Sometimes also referred to as Action Theory). A German application of activity theory to work and organizational psychology developed by W. Hacker, W. Volpert, H. Heckhausen and others. ART combines *activity theory* with cognitive psychology to offer a coherent body of principles for

human-centred task and work-process design. In ART the "work task" is a central category for the psychological consideration of activity and behavioural analysis. Action regulation theory assumes a hierarchical-sequential pattern of goal setting, action and evaluation. If the pattern is incomplete or interrupted, this is seen as impacting on both the quality of the result and the motivational value of the task. Action Regulation Theory is considered to be not only a description tool but also a normative guide to efficient and humanized work and has been influential on European developments in engineering and work psychology and HFE. German action theorists have contributed to the establishment of a number of international standards for work design, *e.g.* ISO 9241-2. See also (Hacker *et al.*, 1982, Hacker, 2003).

Activity, Human Activity. (In Russian *Deyatelnost*, German *Tätigkeit*). A coherent system of internal mental processes and external behaviours, motivated by needs, combined and organized by the mechanisms of self-regulation and directed toward the achievement of a conscious goal. This usage of the term activity denotes a specifically human form of behaviour which always has some conscious element (*action*), and where the relationship between the acting subject and objective reality is mediated through the use of physical and mental tools. Activities normally involve the completion of some kind of *task* with a specific *goal* or desired outcome. An activity is performed by a *subject*, interacting with an *object* through a system of *actions*, using (real and symbolic) tools. Actions are carried out through a series of non-conscious *operations* which depend upon the specific conditions in place at the time of task performance. In activity, subjects may also interact with other subjects, using (symbolic) tools such as language. This kind of intersubjective social activity is distinguished from object-transformational activity by the Russian term *obshenie* (social interaction). Both aspects of human activity, intersubjective and object-oriented, affect and continuously transform into each other. Activity is always situated, that is created by and adapted to specific circumstances through *self-regulation*; however it also always involves some pre-specified components such as plans, scripts, etc.
The term "activity" briefly translates the German *tätigkeit*, which can be more accurately rendered as "the specifically human, inherently collective and societal, purposive and goal-directed, subjective and objective, internal and external, exploration and transformation of the human and natural environment" (*cf.* Leont'ev, 1978, esp. Chapters 2 & 3). It is clear that using the everyday English term "activity" risks seriously distorting this meaning; for this reason some have argued that tätigkeit should remain un-translated, as has been the case with the psychological term *gestalt* (*e.g.* Schurig, 1988).

Activity approach. See also: *Activity Theory, Action Regulation Theory, SSAT.* A term used here to indicate an epistemological orientation within the human sciences which originated in the Marxist-Leninist psychology, psychophysiology, and philosophy developed in the Soviet Union during the early part of the 20th Century. The activity approach encompasses activity-oriented strands in the development of dialectical materialism, and encompasses such interconnected and overlapping traditions as Cultural-Historical Psychology (CHP); Sociocultural Theory; General, Systemic-Structural, and Cultural-Historical Activity Theory (*AT, SSAT, CHAT*); the cultural, critical, literary and linguistic theories of the

Bakhtin circle; and German *Action-Regulation Theory* (GAT) and *Critical Psychology* (CP).

The activity approach is a holistic materialist epistemological paradigm that contrasts with, and complements, naturalistic approaches to understanding reality. Whereas in naturalistic approaches individuals confront natural objects which are considered independent of their activity, the activity approach states that the meaning of life (for humans) takes shape through the process of human activity. The activity approach has resonance and interconnections with approaches developed from other philosophical roots, such as American Pragmatism, Ecological Psychology, and some aspects of Systems Theory.

Activity System. According to Engeström's *Cultural-Historical Activity Theory* the activity system is a model of the structure of collective activity which represents "the smallest and most simple unit that still preserves the essential unity and integral quality behind any human activity" (Engeström, 1987, p. 38). This *unit of analysis* interprets Vygotsky's work on tool mediation and Leont'ev's elucidation of the structure of activity and combines them with a basic Marxist-Leninist exegesis on the fundamental contradiction between production and consumption as the driver of growth and change in capitalist economies. It is often graphically depicted in a 6-point schema known as the "Engeström triangle".

Activity Theory, AT. (*Syn.* Human Activity Theory, The Russian Theory of Activity, General Theory of Activity; *related:* (German) Action Regulation Theory; Sociocultural Theory; *Cultural-Historical Psychology*; *Cultural-Historical Activity Theory* (CHAT). A general term for a psychological framework (meta-theory, paradigm) that portrays collective and individual human activity – both external-practical and internal-psychological - as a dynamic, self-regulating and hierarchically structured system. Activity theory originates in the works of the Soviet scientists S. L. Rubinshtein (1889-1960) and A. N. Leont'ev (1904-1979), and was significantly influenced by the cultural-historical psychology of L. S. Vygotsky (1896-1934). Activity theory is specifically concerned with the study of human, socially-situated, tool-mediated activity, understanding human activity as a self-regulating system involving motives and conscious goals. A fundamental principle of AT is the unity of consciousness and behaviour; cognitive mental processes evolve as a result of the external activity of subjects, mediated by intersubjective relations. Thus, according to activity theory, the human mind develops out of historically contextualized, object-practical activity.

Over the course of around 60 years of development, AT became a fundamental scientific approach within both theoretical and applied Soviet psychology. Since the fall of Communism it has continued to develop globally. Currently, AT contains three main strands: the General theory, which addresses general psychological principles; the systems-structural approach, which is more specifically oriented toward the understanding and design of work processes and tools (see *SSAT*); and the *Cultural-Historical Activity Theory* (CHAT) developed mainly in Scandinavia and the US.

Afferent (actions). *Lit.* "toward". Term originally from psychophysiology, now widely used in ergonomics. In systemic-structural AT, used to describe those actions of a subject which involve the reception and interpretation of information from perception and/or memory.

Algorithm, human algorithm, algorithmic analysis. Human algorithms are developed in the second stage of the *morphological* approach to *systemic-structural activity analysis*, being used to extend and refine qualitative descriptions of activity as a structured system. A human algorithm is a symbolic representation of goal-directed activity during task performance as a logically organized step-by-step problem-solving procedure, including both external-practical and internal-psychological actions. Discrete goal-oriented actions are clustered into qualitatively distinct units, called *members of algorithm,* each of which usually comprises 3-5 actions organized by a supervening goal. A notational system is used to represent members of the algorithm, which denote efferent or afferent actions, the deterministic and probabilistic logical conditions that structure their relationships, and the various links between them. Human algorithms, as the name implies, are strictly anthropocentric in their approach; this distinguishes them both from other modelling techniques such as flow charts and from computer algorithms. In conjunction with time-structure analyses, which are developed in the third stage of systemic-structural analysis, human algorithms provide a basis for quantification of task complexity. The idealized models of human activity during task performance produced during systemic-structural analysis can be used as a basis for evaluating alternative designs of *e.g.* work tools and processes.

Anthropocentric Approach. In HCI: an approach to man-machine system design that, in contrast to systemic-technical approaches, asserts that machines are tools for the human. By emphasizing man-machine asymmetry the anthropocentric approach makes central to the design enterprise a concern to support people in more effective, easy and enjoyable task performance. This general term can be seen to share many characteristics with Western approaches to system design such as User-Centred Design (Norman and Draper, 1986) Usability Engineering (Nielsen, 1994) *etc.* More generally, used to refer to human-centred approaches in general philosophy and the philosophy of science, *esp.* Marxism. The Soviet philosopher of activity Evald Ilyenkov (1924-79) argued for a philosophical anthropocentrism as a cornerstone of his approach to understanding the concept of the ideal, (see Bakhurst, 1991).

Anticipatory Reflection. Anticipatory reflection guides activity through the afferent synthesis of (extero- and proprio-) perception of the situation and memories (*i.e.* personal experience), forming an anticipation of the future state which may result from the activity about to be performed.

Appropriation. Process by which humans adopt, adapt, and adapt to the meanings and practices *objectified* in culturally-historically formed material and ideal artifacts such as tools, words and rules. In AT, the transmission of human culture and the production and reproduction of human subjectivity are visualized as taking place through cycles of objectification and appropriation as humans participate in collective, motivated, goal-oriented activity.

Artifact, Artefact. *Lit.* Any object produced or shaped by human craft. In AT, this is taken in the sense of indicating anything produced or shaped by human *activity* in its holistic sense. The products of collective human work are both material *and* non-material; procedures, rules, *etc.* are *ideal* artifacts produced by human labour, just as machinery, dwellings *etc.* are material ones. Moreover, as material artifacts

are shaped by human activity, all such artifacts are seen as having a dual nature that includes not only their physical existence but also the meanings, experiences and practices they embody. The process of exteriorizing or embedding human activity into material form is referred to as *objectification*. Writers in AT use a variety of terms, with varying degrees of rigour, to signify specific kinds of material and ideal artifacts, *e.g.* tools, instruments, signs, symbols, rules, norms *etc.*

AT-HCI. Activity-theoretical human-computer interaction. Action-oriented approach within human-computer interaction research based on *activity theory*. Founded in the late 1980s by the Danish scientist S. Bødker, who also contributed to the establishment of the participatory design (PD) and computer-supported cooperative work (CSCW) movements in information technology design. AT-HCI seeks to develop design-oriented understandings of the role of computer artifacts as mediators and objects of human work activity, taking account of the reality that the (actual or proposed) use of interactive systems always takes place in specific, complex, and historically developing sociocultural and technical contexts.

ATIT, AT-IT. Activity-theoretical information technology design, development, and evaluation. Term introduced by the Danish researcher O. B. Bertelsen to denote the use of "activity theory based practical methods for IT design… (software, IS, HCI, CSCW, PD…)" (Bertelsen, 2004, personal communication).

Automatization. (*Ant. Deautomatization, Conceptualization*) The process in skill acquisition whereby action control is transferred from conscious to largely unconscious psycho-physiological mechanisms. This transfer from the level of (conscious) action to (unconscious) operation is normally associated with the stabilization, *i.e.* decreased variability, of task performance. Also sometimes referred to (*e.g.* in Bødker, 1991, 1996a, 1999a) as *operationalization*.

B

Breakdown. Forced shifts of the subject's attentional focus that result in an interruption to, or the cessation of, transformative actions toward the *object* of activity. Breakdowns indicate contradictions within or between aspects of artifact design, individual characteristics of the subject, and sociocultural conditions. See also *focus shift*.

C

Character. Considered in AT to be a substructure of *personality* (the other main substructure being *abilities*). Denotes a consistent style or manner of relationship and behaviour in diverse situations. Character represents the totality of individual features that are elicited in typical circumstances occupied by a person, and determines the style of behaviour and attitudes under those circumstances. Character triggers programs of performance in typical situations – that is, while behaviour is principally derived from goals, the style and nature of behaviour director toward a goal varies among individuals, according to their character. Character has motivational force and its individual characteristics are closely connected with the subjects' *personal sense* acquired during social learning.

Variations of character appear not only in multiple qualities but in the intensity of expression of specific features. Character is mainly treated as the socially acquired features of *personality*, but also considered as dependent on features of the neural system and temperament.

Conceptualization. (*Syn. Deautomatization*). Term for used by Bødker *et al* to denote the process of transformation of operations into actions. Avoided in this thesis in order to minimize confusion with the both the general English usage of the term and the specific developmental processes of concept formation described by Vygotsky.

Coordinated activity. When individuals are gathered together to work on a common object, but their individual actions are only externally related to each other. They act as separate individuals, each according to his individual task (Engeström, 1987). Each subject follows scripted roles, coded in rules, plans, schedules, traditions, norms *etc.* An example of coordinated activity is the activity of house building, where one person lays bricks, anther does carpentry tasks *etc.* This means that subjects may not hold a conscious image of the overall outcome of collective activity, but will each be focused on the goal of their own actions. This may mean that the subject does not see his action as part of a larger activity.

Critical Psychology, German Critical Psychology. A system model of psychology originated by Klaus Holzkamp (1927-1995) in the late 1960s on the basis of Marxist-Leninist philosophy and Leont'ev's work in *activity theory*. Focused on the conceptual reconstruction of the basic categories of psychology to include *dialectical materialist* understandings of subjectivity. See also (Teo, 1998, Tolman, 1994, 1991).

Cultural-Historical Activity Theory, CHAT. Influential cultural-historical, activity-theoretical approach to collective and organizational learning developed during the 1980s by the Finnish educational psychologist Yrjö Engeström. Reformulates a number of the basic ideas of *CHP*, *AT*, and Marxist-Leninist dialectics to produce a generalized model of processes of learning and transformation in collective human activity. Based on a review and critique of developments in Vygotsky's *cultural-historical theory* and the Leont'evian tradition of *AT*, Engeström produced a graphical depiction of the "activity system" as a basic unit for the analysis of collective practice. Engeström used this schema as a basis for developing his views on individual, collective and organizational learning as a multi-level phenomenon driven by contradictions and conflicts both within and between past, present, and future activity systems. What began as an almost purely theoretical project has been operationalized through a program of participatory action research; the resulting empirical experience being formulated into a methodology called developmental work research (DWR).

Cultural-Historical Psychology, CHP. General term for psychological approaches based on Vygotsky's *cultural-historical theory*; in its modern form usually also draws on cultural-historical strands within *activity theory*.

Cultural-Historical Theory. *Dialectical materialist* theory of the sociocultural-historical determination of mind developed by L. S. Vygotsky (1896-1934).

Asserts that the origins of human consciousness lie in the use of signs as tools to mediate mental activity.

D

Dialectical Materialism. (*Also "Diamat"*). A non-reductionist form of philosophical materialism, principally developed in the former Soviet Union, based on the writings of Marx, Engels and Lenin. Dialectical materialism asserts that an objective reality exists external to the human mind, and obeys natural laws. Knowledge is seen as deriving from the influence of the externally existing material world on the knowing subject (through *reflection*), who is understood as an entirely material being. All nature, including human nature, is seen as explicable in terms of matter and energy; it denies any supernatural influence on nature and opposes the view that there exist any forces or phenomena that are inaccessible, in principle, to scientific explanation. Dialectical materialism is committed to physical, biological, and evolutionary viewpoints. The development of matter during the history of the earth - through chemical and geological stages, the origins of life, evolution by natural selection, the advent of human beings, and their transition into the current cultural-historical phase of evolution - being seen as a series of quantitative transitions involving correlative qualitative changes. Diamat differs from earlier forms of materialism (such as Greek atomism and 19th Century scientific materialism) in repudiating reductionism - the belief that all phenomena in nature, including human behaviour, can ultimately be explained in terms of the simplest interactions of matter. This anti-reductionism, by asserting that social laws cannot be reduced to biological laws and biological laws cannot be reduced to physicochemical laws sought to preserve a place for uniquely human values within a materialistic framework and provide safeguards against scientistic exaggerations based on biological or behavioural explanations of social values, such as eugenics, socio-biology, Behaviorism, or evolutionary psychology. While none of these approaches became as widespread in the Soviet Union as in the West, some principles of dialectical materialism (transformed into the ideology of historical materialism) were used by the Communist Party as a rationale for totalitarianism.

Deautomatization (*aka. Conceptualization*). The process whereby operations are made into conscious actions in order that they may be amended, adapted, or discarded in response to new conditions or demonstrated to others. The transfer from the level of operation to action may be either voluntary, that is initiated by the subject in response to some need; or involuntary, that is, the subject is forced to consciously examine formerly automatic or semi-automatic aspects of task performance by their failure to achieve the expected outcome. Processes of automatization and deautomatization may be closely associated with attributes of the mediating artifacts in use, and as such are central to a design-oriented analysis of tool-mediated activity.

Developmental Work Research, DWR. Participatory action research approach to organizational change and learning based on *CHAT*.

E

Efferent (actions). *Lit.* "away from". Term originally from psychophysiology, now widely used in ergonomics. In systemic-structural AT, used to describe those (object-oriented and/or communicative) actions of a subject directed toward the manipulation of external reality.

Errors. From a systemic-structural point of view, *learning* can be characterized as a movement from preliminary, through intermediate, to finalized strategies of action. *Errors* often signify the transition from one strategy to another - in fact they should be seen less as problems and more as iterations toward an adequate structure of activity. *AT* distinguishes operator errors from operator failures, and *SSAA* offers a number of taxonomies based on this distinction and other parameters.

F

Focus Shift. A shift of conscious or semi-conscious attentional focus in activity more deliberate than that caused by *breakdowns*, (Bødker, 1996a).

Focus-shift Analysis. Activity-theoretical HCI analysis technique developed by Bødker (1996a). The description of computer-mediated activity in terms of a movement of the acting subjects' focus of attention between the *object* undergoing exploration or transformation and the *artifacts* mediating actions toward that object. During interaction this necessary shifting is a response to changing conditions, as the mediating artifacts require exchange, adjustment or modification; as soon as adjustments are accomplished actions are easily redirected toward the work object. In a *breakdown* situation, the subject is forced to direct actions toward the mediating artifact by a discrepancy between the emerging results and the goal, caused by a failure of the subjects' repertoire of operations with the artifact to produce the desired/expected/envisaged result. This results in a *deautomatization* of operations with the artifact, with accompanying changes in the *motives*, *goals* and sub-goals of action. Focus-shift Analysis uses qualitative observational data to build a picture of how specific design attributes of computer applications and their use setting either support, hinder or force focus shifts during task performance. Concentrates on identifying voluntary and involuntary *deautomatization* necessitated by characteristics of the components of the activity system under study, especially the artifacts in use.

Functional Analysis. SSAA method which traces various aspects of the (non-homeostatic) self-regulation processes which govern human goal-directed activity, at different levels of detail and different stages of activity. Based on the development and application of self-regulation models comprising *function blocks* and their interconnections. Produces functional descriptions which, firstly in conjunction with other methods of individual-psychological analysis such as *parametrical* and *morphological* analyses, and then in coordination with social-historical and objectively-logical descriptions, can be used to produce a holistic understanding of activity.

Function Block, Functional Block. A unit of macro- or micro-structural activity analysis that represents a coordinated system of sub-functions having a specific purpose within the structure of activity. While remaining functionally invariant, the

specific content of a function block changes as activity unfolds; function blocks mutually affect each other through feed-forward and feedback influences. Used as components of self-regulation models of activity, function blocks are represented as 'black boxes' assumed to contain more molecular sub-functions that may need to be further decomposed at other stages of activity analysis. They can be applied at all levels of activity analysis, as models using function blocks are able to encompass a range of more or less specific and integrative elements into one top-level structural representation.

Functional Mechanism. Aspects of the functioning of activity that have a particular purpose in the self-regulative process of activity, and specific interconnections with other such mechanisms. Examples include the goal, subjectively-relevant task conditions, past and new experience, *etc.* When functional mechanisms are represented as constituent parts of *self-regulation* models of activity, they are called *function blocks*.

Functional System. According to Anokhin (1962) a functional system can be understood as a combination of processes and mechanisms, dynamically formed into a system in a particular situation, which can lead to an optimal adaptive result for the organism in that particular situation. A functional system acts as a self-regulating system with multiple feed-forward and feedback interconnections, and it includes various neural components. In *systemic-structural activity theory*, functional systems are understood as dynamic self-regulating entities which are mobilized and formed during activity and which disappear on consummation of their mobilizing activity. They embody the process of self-regulation at the physiological and psychophysiological levels.

The closely related concept of **functional organ** developed by Leont'ev (Leont'ev, 1981b 152-154) and Luria, and introduced to HCI by Kaptelinin (Kaptelinin, 1996b) presents the idea of functionally integrated, goal-oriented configurations of internal and external resources. External tools support and complement human abilities in ways that can lead to higher accomplishment. The use of external tools develops internal capacities for action. Examples: notepads and pencils as aids to memory and analysis; scissors/saws etc plus hands & eyes plus skills improve cutting and shaping; eyes plus eyeglasses improve visual perception and with language skills constitute functional organs for reading. From the point of view of the subject, during the initial stages of learning to use a tool its properties are conceived of as part of the objective outer world, to be mastered; once the tool becomes integrated into the subjects' actions as a constituent of a functional organ its properties are experienced as subjective. Computer tools offer a unique challenge from this point of view inasmuch as they often do not have one clearly identifiable fixed function; they are uniquely plastic, what Bødker calls "the clay of computing" (Bødker, 1999a). In general they may be said to extend the *internal plane of action,* that is, the ability to manipulate internal representations through *imaging & imagining*.

G, H

Goal. The cognitive component of activity. A more or less distinct, conscious, cognitive representation of the desired future result of activity. Goal-images are formed from various components – image, verbal-logical *etc*. Goals may be

accepted in advance, or formulated and specified during activity. Sometimes the goal is very ambiguous during the preliminary stages of task performance; goals may be modified or even entirely transformed during the course of activity. Conscious awareness of the goal of action is a fundamental tenet of AT. The goal of activity is embodied in the active search for a required outcome.

Human Algorithm - see **Algorithm**.

I

Ideal. A term used to denote those things objectively existing in the world which are non-material, but which are produced from the material by human activity, such as word meanings, rules and norms of behaviour, *etc.*

Image. Images are formed during activity, with the act of perceiving being considered as an active process (c.f. Gibson, 1979). The image can be viewed as (a) a tool for understanding reality, *i.e.* as a cognitive function and (b) as a means of regulating activity, that is, as a regulative function. The most significant component of the image is the goal; the goal appears as an image of a future outcome. Comparison of actual outcomes during execution of a program of task performance with the image (influenced by other functional blocks in the self-regulation model of activity) is used to adjust the program of task performance and reassess strategies.

Imagining and Imaging. Imaging is the ability to form and manipulate internal representations of objects directly perceived by the senses; these are primary images. Primary images are determined by, but are not a direct copy of, external information, as they are also affected by subjective factors. Imagining is this visualizing ability exercised in the forming and manipulation of internal representations of objects retrieved from memory or never directly encountered through perception of the external world. These secondary images can be classified as either a) reproductive, *i.e.* directly derived from memory or b) productive or creative. Both abilities constitute elements of the *internal plane of actions.* The manipulation of images is performed through different mental actions, where the image is the object of action. Internal manipulation of the image is easier in the presence of some external functioning model of the imaged object, and in this way computer artifacts can extend the ability to manipulate images on the internal plane of action. It is important to note that the mental actions involved in internal imaging also have a motor component; micro-movements of the eyes and limbs always accompany the process of imaging. Visual perception performs the leading role in imaginative reflection; the leading role in the formation of conscious concepts is taken by the verbal-logical process. The interaction of thinking and imagination is present in activity performance. The **operative image** refers specifically to the image produced during task performance and used to guide actions. The operative image is affected by factors such as *set* and what are perceived as the most significant aspects of the task, and can change quite quickly. Operative images are contrasted with **conceptual models,** which are multidimensional reflections of reality described in sensory-perceptual, symbolic and verbal languages, but in which imaginative processes are dominant.

Conceptual models are characterized by informational redundancy, and are relatively constant over time, and change more slowly than the operative image.

Individual Style of Performance. Activity strategies derived from idiosyncratic features of personality.

Implementation. Stabilising the shared means of work in collaborative activity through communicative, instrumental and scripted coordination. See (Bardram, 1998).

Internal plane of action (IPA). Term used (in Kaptelinin, 1996b, derived from work of Ponomarenko) to denote the general human ability, developed usually in the early school years, to manipulate internal images of external objects. This ability is referred to by Bedny as *imaging* and *imagining*. Roughly corresponds to the cognitive science usage of 'mental models' in 'working memory'. One of the most powerful attributes of computer artifacts is their extension of capabilities of the IPA through the formation of new *functional organs*.

Internalisation *(aka interiorisation)*. The formation of internal, mental processes with ideal objects (symbols) based on external processes with material objects; the process through which objective, external actions are transformed into (Vygotsky, Early Leont'ev), or provoke and affect the formation of (late Leont'ev, SSAT), idealized, internal actions. Internalisation is key aspect of cultural-historical and AT viewpoints on phylo- and ontogenesis, initially formulated as a consequence of Vygotsky's analysis of the tool-mediated nature of human labour activity. The classic Vygotskian example is the transition from external, social, speaking to inner, individual, verbal thinking via the stage of egocentric speech. It should be noted that (in contradistinction to Piaget's formulation of the idea) this is considered as the transition from the *inter*psychological to the *intra*psychological regulation of behaviour through sign mediation. There are numerous approaches within CHP and AT to studying and theorizing the process of internalisation. All agree that the structure of inner, psychological actions can be usefully compared to that of external, instrumental actions, and that the higher psychological functions have at least part of their origin in practical activity.

J, K, L

Learning. From the systemic-structural point of view, *learning* is characterized as a movement from preliminary, through intermediate, to finalized strategies of action. *Errors* often signify the transition from one strategy to another - in fact they should be seen less as problems and more as iterations toward an adequate structure of activity. AT offers several theories of learning, including those of Gal'perin, Landa, and Bedny. Instruction can lead to learning, as outward instruction becomes transformed into self-instruction during dialogue then self-instruction through monologue (egocentric speech) leading to the formation of strategies of internal self-regulation through verbal thinking actions.

M

Meaning. "Meanings interpret the world in the consciousness of man" and are "the object world's ideal form of existence… as they have been brought forward from the total societal praxis" (Leont'ev, 1978). Meanings are thus an essential component of human consciousness, existing in concepts that are objectified in action schemes, social roles, norms and values. Meanings arise as referents in linguistic interaction. The objective meaning of things in the world is developed over the history of human interaction with the objective world; such generalized conscious objective meaning is contrasted with subjective *personal sense*. AT identifies two main types of meaning. **Object Meaning** describes the network of feelings and experiences that individuals associate with particular objects in particular situations through their experience of interacting with them during the performance of a particular action. **Categorical** or **Idealized Meaning** is an objective property of signs, that is it has a socio-historical character as part of the verbal categories mastered in ontogeny; it is relatively stable and independent of specific situations. Through the process of collective, social activity, object meaning can become transferred into categorical meaning.

Morphological Analysis. The description of activity as a structured system of *actions* and *operations*. A fundamental principle of activity theory is the unity of cognition and behaviour (Bedny, Karwowski, & Bedny, 2001). The structure of activity during task performance is understood as formed from a logically organized system of external-behavioural and internal-mental tool-mediated actions and operations, a structure which is continually changing in response to internal and external conditions. In *SSAT* morphological analysis refers to the structural description of human activity. The principal units of morphological analysis are *activity*, *actions*, *operations* and *members of algorithm*. Morphological analysis consist of four stages which are iterative or recursively connected a) qualitative description b) algorithmic analysis c) time-structure analysis d) quantitative (task complexity) analysis. Stages may be abbreviated or omitted according to the purpose of the study. Morphological analysis using action as a primary analytical unit focuses on the interconnectedness of, and transition between, mental and motor actions. Structural analyses of activity can provide insights into how external tools such as controls, displays, screens, instructions *etc.* interact with subjects' internal tools such as conceptual models, skills, knowledge *etc.* (Bedny & Karwowski, 2004a). This approach allows comparisons between the physical and logical configuration of the equipment in use (using descriptions developed from the objectively-logical perspective) and the temporal, spatial, and logical organization of subjects' (real or idealized) actions.

Motive. Leont'ev (Leont'ev, 1978) defined motive as a *need* which finds an *object*. That is, when a being in a need state comes into contact with an object that is perceived as having the potential of satisfying that need, the person is motivated to engage in activity involving exploratory or transformative goal-oriented actions with that object. In this sense, motive is the energetic component of activity. The vector motive→goal is what gives activity its purposeful and directed character; motivation ensures that the individual expends energy in the transformation of an object, through actions guided by conscious goals. Individual's motives may be categorized into two groups 1) **sense formative motives** which are relatively stable and determine a person's general motivational direction; they are connected with personality and general character traits; 2) more flexible and unstable

situational motives which are connected with immediate ongoing activity and the solving of specific tasks. The content of situational motives, their relative weighting and place in the hierarchical organization of motives can change in response to task characteristics, temporal stage of task performance, and informational feedback about task solution. For any individual subject involved in a task, the level of motivation will be directly related to subjectively relevant task conditions, such as their perception of task difficulty. **Motivation** is considered as the source of energy that drives *activity*. Motivation in general includes a hierarchy of individual motives, which may be conscious, semi-conscious or even sometimes unconscious. Motivation is always connected with emotions, and the level of motivation determines the energy expended toward attaining the *goal*. A person's motivation during task performance is always closely linked to the personal significance or *sense* that the activity has for them.

N

Needs. All human activities begin with human needs – which by definition have both biological and cultural components. The most basic needs are associated with self – food, shelter, family/social – and also include the need for self-recognition, feelings of worth, and concerns for the community/society within which a person functions. Needs do not directly generate activity, they create dispositions directed toward need satisfaction. Activity is derived from the situation where a person images or imagines specific objects that can satisfy their need. Such images become *goals* which arouse *motivation*.

O

Object. The object of *activity* is that which is modified and explored by a subject according to the *goal* of activity. Modification or exploration include not only physical transformation, but also the classification of objects according to required goals, the discovery of features of the object that correspond to goal of explorative activity, and so on. Objects may be either concrete (material) or abstract (*ideal*). Ideal objects are *e.g.* signs, symbols or images, and their constitution as entities transformed by the subject in accordance with goals. In activity, initial, intermediate, and final states of objects may be distinguished.
In some (cultural-historical) interpretations of activity theory the term object is used - in a very loosely defined sense that roughly corresponds to the English word objective – to represent the association between a *motive*, a *goal* and a material or ideal object.

Objectification. (Russian *Objektivirovanie*, German *Vergenstandlichung*). The process through which the active forces and capabilities of humans become inscribed into those objects in the world that are incorporated into, or result from, human activity. Through work activity, humans actively remake the physical world, investing objects in that world with *meaning*, creating our own 'human reality', *i.e.* the world of culture. It is the process of objectification that both gives rise to, and embodies in artifacts, the *ideal* aspects of material reality, that is, meanings. Objectification is not necessarily, or even predominantly conscious, although it can be. In art, and through design and production processes, people may consciously strive to objectify certain meanings, knowledge, practices and

norms in the artifacts they create; they invariably also unconsciously objectify many aspects of their own practice and its cultural-historical context. Thus, the design and production process always involves the objectification and transmission of cultural values.

Operations. Those aspects of actions which are shaped and directed by the immediate conditions in the (internal and external, material and ideal) environment of activity and which determine the mode of action. Operations are therefore the non-conscious or automatic aspects of actions; they can be derived from conscious actions through repetition; this is the process of *automatization*.

Orienting Basis. The orienting basis of actions and activity is mainly provided by perceptual, sensorimotor, mnemonic and other *operations* triggered by concrete material conditions. See also *orienting reflex.*

Orienting Stage of Activity. In *self-regulation* models, that aspect or stage of activity which precedes executive action and is subsequently affected by evaluations of the outcomes of executive action. The orienting stage of activity is principally concerned with creating a dynamic reflection of the current situation, is gnostic and exploratory in nature, and involves both conscious and unconscious processes.

Orienting Activity. The term orienting activity is used to refer to those types of activity in which the *orienting stage* predominates and in which little or no executive action is involved. In orienting activity, the main goal is to create and maintain a reflection of the current situation, as in tasks involving vigilance, monitoring, *etc.*

Orienting Reflex. The orienting reflex is a largely physiological phenomena involving external movements (turning the head, *etc.*), and internal changes (*e.g.* in heart or respiration rate, brain activity). The orienting reflex underlies the *orienting basis* of operations and plays an important part in the functioning of the involuntary aspects of the *orienting stage of activity*.

Outcome, Result. The actual result or output of activity. Ongoing comparison of actual result and goal (desired result) during activity performance provides feedback for self-regulation.

P, Q

Personality. The totality of qualities and traits, as of character or behaviour, peculiar to a specific person. The main components of personality are 1) stylistic qualities of mental actions 2) personal ideology, interests, desires, values *etc.* 3) knowledge, skills and habits 4) biological factors. The interaction of these components determines stable individual social orientation as well as the developmental phenomenology of individual personality. The relation between the components determines specific development of *abilities* and *character*. In AT, personality is presented as a system of hierarchically organized substructures. These substructures are organized into a holistic system that determines the specificity of personality. An individual's substructures, especially high level

substructures such as *social orientation* or *goal orientation* can be altered over time, through personal development.

Psychophysiology. Physiological psychology; the branch of psychology concerned with the physiological bases of psychological processes. Studies interactions between the mind and body by recording how the body is functioning and relating the recorded functions to behaviour, affect and cognition.

R

Reflection. One of the basic epistemological assumptions of *dialectical materialism* is that sense perceptions are the means by which humans develop a more or less accurate reflection of an actual and objectively existing material world. In AT, sense reflection is seen as an active and socially-mediated process involving selective attention dependent on the subject's goal and motivation, and personal and cultural history. In its most basic and general sense, reflection is seen simply as what happens when two entities interact; the state of each is changed by the interaction, and this changed state is, for each, a reflection of its interaction with the other. "Psychic reflection develops with the appearance and evolution of the nervous system and brain, through which the higher nervous conditioned reflex and psychic activity is exercised, securing the behavioural orientation and regulation of a subject-organism in the environment. The psychic reflection of men and animals has two sides: 1) content and 2) form, *i.e.*, the mode of existence, expression and transformation of this content. Human knowledge differs in quality from the psychic reflection of animals because it is social by nature" (Frolov, 1984).

Regulation (of behaviour). Se also *self-regulation of activity*. The regulation of behaviour is seen as the maintenance of behaviour within parameters that are directed toward goal achievement. The regulation of behaviour can be achieved by two methods: reactive, *i.e.* behaviour regulation in response to external stimulation; and regulation by goal-direction, where the need to achieve a specific goal requires certain action within limits that are set in relation to the goal. Both types of regulation require that the subject is motivated.

Routinization. Stabilising shared means of work in collaborative activity through communicative, instrumental and scripted coordination. See (Bardram, 1998).

S

Self-Regulation (of behaviour). In general cybernetic terms, self-regulation is an influence on a system, derived from the system itself, which acts to correct its behaviour or activity; it is an intrinsic self-organizing property of the system itself. In human *activity theory*, **psychological self-regulation** refers to the adjustment of action during activity performance through comparison of the goal with the actual outcome. This is a non-homeostatic, goal-directed, multi-level process with both conscious and unconscious aspects and external (exteroceptive) and internal contours (Bedny and Karwowski, 2004b) which includes both cognitive (informational) and motivational (energetic) components. The conscious aspect of self-regulation is visualized as a recursive loop process which draws on updated

input information during task performance to evaluate interim or final results, using subjective standards of success and admissible deviation in relation to the goal, as a basis for making decisions about, carrying out, and correcting programs of action. The models developed by G. Z. Bedny (Bedny and Meister, 1997 pp. 50-94) and others in systems-cybernetic AT portray (conscious) self-regulation primarily as information-processing, rather than the motivational or volitional process proposed by Kuhl and others. **Physiological self-regulation** is based on homeostasis, that is involves measures to reduce the discrepancies between the actual and optimal states of the system. It is mainly automatic, and, in contrast to psychological self-regulation, its processes are completely predetermined.

Sense, Personal Sense (Russian: *Smysyl*). Personal sense is a pre-logical function referring to the individual's reflection of those general meanings of the objective world which are principally acquired during social learning/acculturation. In the process of social learning, individuals acquire not only the meanings of different artifacts, situations *etc.*, but also emotional evaluations of situations. Personal sense is the realization of meaning in a subject's life activity, in relation to their needs and motives. Personal sense determines the significance of any situation for the individual, and as such is closely connected with both their general and situation-specific motivation.

Set. Concept developed by Soviet psychologist D. N. Uznadze (1886-1950) that denotes a subjects' readiness or disposition to perceive or handle situations or interact with objects. Set may be more or less conscious, and is connected with the previous experience of the subject. Set has three components which taken together determine the way an individual will act in relation to an object or situation 1) cognitive components that determine readiness to comprehend and perceive others 2) emotional-evaluative components consisting of the subjects' sympathies or antipathies toward different objects 3) behavioural components that are considered as a readiness to act in a particular way toward a set of objects.

Social Interaction. (In Russian: *Obshenie*). Specific activities with an array of features that emerge during the joint performance of activities. Social information may be communicative, informative, and include intimate interpersonal relationships. Social interactions shape social behaviour and socialize the personal disposition of individuals – here norms, rules and standards are significant. Social interaction may also be considered as a social-perceptual program, where interpersonal cognition and perception are significant. Social interaction plays an important part in shaping the individual personality. Meaning and personal sense are a crucial aspect of social interaction, affecting, and being affected by, *e.g.* the subject's interpretation of observation of the behaviour of others.

Societal. (In German: *Gesellschaftlich*). Denotes the specifically human, cultural-historical form of social organization. Used by Holzkamp to distinguish human social behaviour, rooted in historically formed societies with distinct cultures, and animal social (*Ger: sozial*) behaviour, rooted in biological evolution (See Tolman, 1994). It is important to emphasize this distinction when considering the specifically human ("higher") psychological processes which arise in social interaction in a societal setting; subjective interests are formed by history and culture, and *subjectivity* as a category is both scientific and political.

Strategy. A plan for goal achievement that is responsive to external contingencies as well as the internal state of the system. In systemic-structural activity theory, strategies are those systems of actions that subjects can call upon during task performance. A strategy is the method of taking into consideration input information during planning and the process of achieving a goal. Strategies exhibit plasticity and variability of means, that is, use of the term strategy implies the capacity to change a program of performance based on task outcomes, changing external conditions and internal states. Strategies are thus less specific and stable than plans. From a systemic-structural point of view, *learning* can be characterized as a movement from preliminary, through intermediate, to finalized strategies of action. The notion of *action* and strategies of action acknowledge that learners can be empowered to change the task environment as well as their own behaviour - not simply adapting but also modifying the task situation. *Errors* often signify the transition from one strategy to another - in fact they can be seen less as problems and more as iterations toward an adequate structure of activity.

Subject. In activity theory, the subject of any activity is the individual, or group of individuals engaged in that activity. However, as human beings that are the subjects of activity are formed *as* subjects by their involvement in the production and reproduction of *societal* formations, cultural-historical *subjectivity* is a complex category that is both scientific and political.

Subjectivity and **Intersubjectivity**.

Sublation. (*German: aufheben*). Term coined by Hegel, and later used in dialectical materialism, to signify how the original thesis and antithesis are still present (*lit.* "stored away") in the newer, higher form that has resulted from their transcendence in development. Connects with the notion of "negation of the negation" to show how the dialectical components of earlier stages of development are preserved in present and future formations (*lit.* "lifted up"). This can be visualized as an ascending spiral model of development, with each higher loop reflecting features of those below it.

System. *Lit.* an assemblage of inter-related parts comprising a unified whole. In activity theory, an **organized system** is one where changes in any one element of the system affect the whole system but not other individual components. A **structural system** is one where changes to individual elements change the system, its elements, and the relations between them. All structural systems, which include human activity, can be dynamic and develop over time. See also *functional systems*.

Systemic-Structural Activity Analysis, Systemic-Structural Analysis of Activity, SSAA. Decomposition of the structure of a system of activity into hierarchically related units of analysis – task, action, operation and function block – which represent different levels & stages of description linked in a loop structure: each stage and level of analysis informs the other, building a holistic picture of the structure of activity. Bedny (Bedny and Karwowski, 2003b, Bedny *et al.*, 2001b, Bedny and Meister, 1997, Bedny and Harris, 2005) defines 4 stages of activity analysis: (a) qualitative description, (b) algorithmic analysis, (c) time structure analysis and (d) quantitative analysis. Each stage involves a series of

qualitative and quantitative procedures, and each stage consists of separate levels utilizing distinct languages of description and units of analysis. According to the analytical requirements, analysis at different stages and levels will focus on either morphological (structural) or functional aspects of the system of activity under study.

Systemic-Structural Activity Theory, SSAT, *sometimes aka.* **The Systemic-Structural Theory of Activity, SSAT.**   A modern synthesis of AT that is specifically oriented toward the analysis and design of human learning and work activity (*e.g.* in human factors/ergonomics and HCI) developed by G. Z. Bedny (Bedny and Meister, 1997, Bedny and Karwowski, 2003b). Integrates aspects of cultural-historical psychology, general activity theory and the systems and cybernetic approaches in AT associated with Anokhin, Bernshtein, Konopkin, Uznadze's theory of *set* and other concepts in Soviet psychology, and others with Western information-processing cognitive psychology. Provides a detailed, multi-stage, multi-level methodology, with action as the major unit of analysis, and activity and tasks as the objects of study.

Systems Science & Cybernetics. (*Syn.* (General) Systems Theory, Systems Research). Focuses on the study of complex, adaptive, self-regulating systems. Distinguished from the analytic approach by its emphasis on the interactions and connectedness of system components. Systems theorists consider that the organization of complex and diverse systems can be described by general concepts and principles independent of the specific substrate in which they are embodied. Many of the concepts of system science (*e.g.* information, control, feedback, communication) are shared with cybernetics, "the science of communication and control in the animal and the machine" (Wiener, 1948, now extended to include: in society and individual human beings). In the US, cybernetics grew out of information theory (Weaver and Shannon, 1949) and engineering control systems (Trask, 1971). In the USSR, early systems thinking developed within psychophysiology. Western systems theory has focused more on the structure of systems and their models, whereas cybernetics has focused on system functionality. Modern, "second-order cybernetics" (Heylighen and Joslyn, 2001), examines how observers construct models of the systems with which they interact.

T

Task. The task is a basic component of activity, defined as a situation requiring achievement of a goal under specific conditions. A goal embedded in certain conditions is a task. Tasks always involve goal-achievement and motivational forces. AT views the task partly as a problem-solving process – all human activity can be seen as a continuing attempt to solve or accomplish various tasks. The task may also be more narrowly defined as a situation that requires the discovery of the unknown based on what we already know – often when the method to solve the problem is also unknown.. The task is a (sub) set of human actions that can contribute to a specific functional object and, ultimately, to the output goal of a system. The **basic elements of a task** are an initiating stimulus, the required response, and the overall organizing goal. Any task involves requirements and conditions. **Task conditions** include interacting situational elements, rules and alternatives for situational transformation. **Task attributes** include complexity,

subjective difficulty, and significance. Each task in the work process is regarded as a situation-bounded activity which is directed to achieve a goal under given conditions. Any task includes both the subject's activity and the material components of task, with all the elements of activity during task performance being organized by the task goal. It is only when the objectively given or subjectively formulated requirements of the task are accepted by the subject as a desired future result that they become the goal of task. Whatever is presented to the subject for the performance of the required actions constitutes the conditions of the task. **Task conditions** include the subject's past experience and such material components as instructions, means of work in given conditions, raw material and input information. These conditions also determine the possible constraints on activity performance. The raw material, or input information, is considered to be the object of activity. What is actually achieved (finished product, output) is the result of activity. The vector motive→goal determines the directedness of activity during task performance.

Task performance involves some initial situation, a transformed situation, and a final situation. The elements of any task situation possess meanings that can change as the situation is transformed. Any situational transformation is evaluated by the subject as having a positive or negative value, relative to both the final outcome of the program of performance, and in relationship to the general rules or norms relating to activity performance in a situation. The relationship between these two methods of evaluation will very, as when a strategy for achieving a successful outcome may be evaluated as positive even though it conflicts with rules or norms regarding *e.g.* efficiency.

Task structure includes requirements that help to specify the goal. These may be external, in the form of instructions or commands, or, as in creative task performance, generated by the subject. The task is also structured by the relationship between task requirements and initial task conditions. Task requirements and task conditions can vary according to their mode of presentation, and in some circumstances may contradict each other, causing *breakdown* in activity and initiating *defensive* or *expansive learning*.

Temperament. In AT, an individual's temperament is understood as determining the pace, speed, rhythm and intensity of their psychic processes and states. These dynamic features of personality are jointly determined by the structure of personality and events in the psychological or physical environment – that is, temperamental features are adapted to prevailing conditions and overt behaviour is attributable to both innate features **and** situationally induced states. There are 3 major, interconnected components of temperament 1) general psychological activation 2) motor activation and 3) emotionality. Temperament affects the individual style of performance but does not *predetermine* individual mental abilities. Temperament can be related to qualitative features of the neural system: strength, mobility, dynamics, and lability. The psychological characteristics of temperament can be formulated as 1) sensitivity (alertness to various stimuli) 2) reactivity (emotional intensity) 3) flexibility (adaptation to changes in the environment) 4) rigidity, extroversion/introversion and neuroticism (Bedny and Seglin, 1999a). Temperament renders more or less likely the development of certain features of character.

U, V, W

Unit of Analysis. The basic observable entity being analysed by a study and for which data are collected in the form of variables. In AT, units of analysis are unified components into which the whole is divided, in order to studying those components and their integration into the dynamic whole. Various units of analysis have been developed and used within the *activity approach*. In Vygotsky's *Cultural-Historical Psychology* the main unit of analysis was word meaning. In Leont'ev's general activity theory, object-oriented action was used as a basic unit. In *Cultural-Historical Activity Theory* (CHAT), the principal unit of analysis proposed is the *activity system*; this has latterly been extended to comprise "networks of activity systems". In systemic-structural activity theory (SSAT), the main object of study is human work *activity*, which is principally analysed as activity during the performance of some specific *task*. The principal unit of analysis for the morphological analysis of activity is the (mental or motor) *action*, which may be further decomposed into *operations*. When undertaking functional descriptions of activity, *function blocks* may be used for either macro- or micro-analysis, according to the focus of the study. In SSAT, meanings and signs are treated as the psychological products and tools of mental actions, but not as units of analysis.

X, Y, Z

Zone of Proximal Development, ZPD. A concept formulated by Vygotsky to indicate that aspect of the child's socially-mediated learning where there is a marked difference between their independent problem-solving ability and what they are able to achieve in collaboration with a teacher or more knowledgeable peer. In developing an alternative to summative assessment, Vygotsky asserted that evaluating the child's performance "in" the ZPD (*i.e.* when performing collaborative problem-solving) can serve to indicate their true "learning potential", providing a useful guide for instructional design (Vygotsky, 1930-5/1978, pp. 84-91).

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Appendices

Appendix 1: The Computer Creative Agreement

Note: Referenced in Chapter 4, §4.3.5.1. This research agreement was created in September 2000. It was presented to participants at the beginning of each phase of field study, all participants being asked to read and sign a copy. The original text as used in the longitudinal field study is reproduced below; a slightly amended version was used in Phase 2.

The Computer Creative Agreement

Computer Creative is an experimental course. All of us involved in running it would like to learn as much as possible from our successes and failures during the course. This will help us improve the design of future courses, and the computer hardware and software that we use together. To do this we need your help.

This means that we will ask you to cooperate with us in helping us to make a record of the course. We will be asking you to take part in interviews and questionnaires, and to allow us to take photographs and make audio and video recordings of you while you work. We may also wish to use special software to record your activities with the computers.

The record that we make together will be used as part of a scientific research project being undertaken by Steven Harris as part of his work at the University of Glamorgan, and may be published in academic journals. It will also be used to show other teachers and learners around the world what we are doing.

In return for your help with this research, we make you a number of promises:
- **We will respect your privacy – we will not use photographs of you or publish your name without your consent.**
- **We will not publish personal or private information about you, such as your address, under any circumstances.**
- **We will keep you informed about the progress of the research, and make any publications arising from the research available for you.**
- **We will make sure that these research activities do not affect your enjoyment of the course.**
- **We will always welcome your comments and suggestions about the research, and do our best to respond to what you tell us. You will be able to contact us personally, or by telephone, post or email, at the following addresses:**

Nicola Shelswell   *Steven Harris*
Centre Manager   *School of Computing*
The Open Learning Centre   *University of Glamorgan*
Pontypridd   *Pontypridd*
Wales   *Wales*
CF37 2SN   *CF37 1DL*
01443 407863   *01443 483210*
N.Shelswell@pontypridd.pontypridd.ac.uk   *srharris@glam.ac.uk*

I understand that by signing this form I am giving my consent to take part in the research project of which the Computer Creative is a part, subject to the conditions set out in this form.
Signed …………………………………………………………………..
Name (Block Letters Please) ……………………………………….……
Date ………………………………………………………………….……

Appendix 2: Sample of Longitudinal Study Field Notes

Note: Referenced in Chapter 4, §4.4.1.1. The following samples of field note entries represent the early, middle, and closing stages of the longitudinal field study reported in Chapters 5, 6 & 7. They were compiled using the methods described in Chapter 4, §4.4.1.1. Participant codenames are as set out in Table 5.2, Chapter 5. Spelling and grammatical errors are retained from the originals.

Session Number 16

Date	Wednesday 11th October 2000				
Time	9am to 12.30 pm				
Location	Open Learning Centre, Mill Street, Pontypridd				
Room	Workshop 3				
Tutors	SRH, T				
Total learners	10	Male	4	Female	6
Names	DH; BD; DK; WH; DC; CP; MM; SM; PR; NE.				

I arrive a few minutes before the start and busy myself setting up the VCR and TV. First to arrive are NE and SM, and they have a bit of a short gossip and a laugh together before others arrive. Once again AH and SC don't attend, leading me to discuss with Nicky asking them to leave the course - T comments that they are in a 'vicious circle, where they feel out of their depth so don't attend, making them more out of their depth.' We resolve to invite another lady, VB, to join the course, as she has expressed enthusiasm, and T rings her right away, arranging for her to start next week.

By now everyone has arrived, and after a quick round of the room to see that everyone has some clear goals for the session, let them get on with it.

PR has started to tell me about something she has in mind to do, but I am able to give her little attention, not even really registering what she is trying to tell me. I give PR a book *New Ideas in PhotoShop* to look at, asking her to mark pages that she finds inspiring. I say that I will get back to her, but then DC arrives, late, and the next time I look they are DCp into working together. DC has also been looking at the book, and begins ranting on about how she wants to 'stretch a rabbit and make it snap back'. I get a little exasperated and ask her to keep on the track of the thing that she is doing. PR shows me a few pages that she has marked, and we discuss the use of graphics programs to combine photographic images together - she likes the camels with wheels, and especially a 'dripping, pouring' landscape. I counsel her to think about subtle effects, telling her that that is what I especially admire. I then leave the two of them to get on with whatever they are doing, feeling a little guilty, but don't manage to get back to them before the end of the session.

Next significant interaction is with WH. He is exuded a very lugubrious, rather depressed atmosphere this morning. He has once again plonked himself at 'his' computer, and is laboriously working with PSP, building on the [rather over-complex] storyboard that he and LR created in the previous session. We have a friendly talk, and he essentially tells me that he wants to carry on alone, working away steadily toward his goal. I agree that this is fine, but check back on him at regular intervals. Each time I do he tells me that he has 'made a major cock-up but is back on track now' - he seem to quite relish the pain! I sit down with him again and do some work rearranging his layers - what is immediately evident to me is that his illustration bears very little resemblance to the storyboard. WH still seems to be having some difficulty with the idea of layers - probably explained by forgetting during his absence on holiday. As usual, he wants things explained in a way that is not at all clear - what is it he asking from me? His usual vigour is lacking, and I sense a new vulnerability in him. It reminds me of what he said in the previous session, when I was explaining about storyboarding - 'stupid me, I should have known about this after 30 years in the business' - maybe retirement (and is it possible bereavement - must ask about this in his interview if I can) has left a big void in his life.

DK is working on his own on one of the really slow machines. I ask him if this is all right, and he declares himself happy. But he then presents me with a problem - he is trying to do a save as operation on an image, and it stubbornly fails to work the way he (or I) expects. A real

breakdown here, and I can't solve it either - we must try to identify what is going on, and why. Anyway, he finds a way to move forward, seems to want little attention. I sit NE next to him, and he occasionally helps her during the session.

NE, for the first time takes charge of her own learning today. She sits herself down at a machine, and when I ask her she declares that she is going to search the Internet for a better image of Les Dawson, whose picture she has been using in her work with PSP. I spend five minutes with her showing her how to use Google. When I return, some twenty minutes later, I see that she needs more coaching in using a text-based interface. Although she reads reasonably well, she does not seem to be able to interpret the short synopses by the links, and isn't differentiating between relevant and non-relevant results. I try to show her how to quickly explore some of the sites, but the idea of following clues doesn't appeal to her at all - she begins to get disheartened. I then put in the url for AltaVista, get to the image search page, and we get a very good response - the first 10 or so images returned are good ones. I leave her for a few minutes to sort out which one she wants. When I return she has chosen an excellent B & W shot. We capture it to the desktop, and then she opens it in PSP, crops it and saves it to her floppy.

I then go off for a while, having quickly got her started with Animation Shop. At some point T goes to work with her, and I am drawn to the corner by laughter and whoops of delight. NE has been drawing direct to the frames, and has produced a little animation of a bear, whose legs move about in a highly comical fashion. She appears to be hugely delighted with herself, and with the reaction she has produced in T. T comments to me later 'for someone who says she can't draw, she did pretty well'.

All through the session CP works quietly by herself. She is methodically developing her technique in Animation Shop. She is painting direct to frame, iteratively increasing the complexity of what she is doing. Every so often she prints out the animation as a series of frames, and this seems to be helping. She is working with lively nature imagery, and is showing a distinct style. By the end of the session she seems to have exhausted that strain of enquiry, and returns to using PSP, building up a photomontage that she intends to animate. Although I don't notice, when I check back with her she tells me that DK has been helping here. (It is very interesting now how teaching/learning situations are happening that we tutors have no part in or knowledge of. This is very much in accord with Papert and Resnick, and speaks well for the Piaget/constructionist thread we are following.) At the end of the session, CP once again rushes off without saving her work - I try to save it around the network (which is flaky today, she is on a machine on the cross-linked hub) and succeed in crashing the application and losing the work. This may produce an interesting interaction when I next see her; I hope that she will be able to quickly reproduce what she is doing!

DH and BD spend the session very productively. They are working up their storyboard design in PSP an AS. The only time I have much to do with them is to look at what they are doing and suggest some refinements midway through the session. It is immediately evident that they have both found a real strength - their animation work is by far and away the most advanced in terms of applying the animation principles I outlined in my talk a few sessions before. There is a huge contrast in BD's success in this with his difficulties with still image creation (perhaps he is more comfortable with time-based media because of his experience with music? Are there affinities between creative approaches to media types?). DH is confident and self-assured, and the two of them seem to be a very successful team.

Partway through the session, when everyone comes back from tea break (might be interesting to map who goes where with who - as Tim Robins suggested, what element of the learning is taking place externally?) I do a short section of teaching. First I draw their attention to the book full of examples, then show them two Aardman animated Peter Gabriel videos. Everyone seems to really enjoy them, except WH, who sits there stony - faced, and to my mind disapproving. I conclude the showing by telling everyone that we can do any of the techniques they have seen 'right here in this room', which gets a murmur of approval.

During the first part of the session SM finishes her 'shell lady' image. I help her to put a few finishing touches to it, using the technique of adding a shadow to unify the picture elements. SM is very proactive, carefully monitoring what I do, giving me little verbal clues in a display of intelligent communication that belies her cultural overlay (what I mean is that I am increasingly realising, that despite the fact that she is extremely awkward socially, she is very powerful in creative terms). We print out the finalised image on photo paper, and it looks good. I playfully observe that it looks like a postcard, and this leads us into making it into one - I go find one, SM measures it, we translate that into the print dimensions and I add some text to the image. The result is excellent, and SM carefully cuts them out and stores on in hers and one in MM's folder.

After this, I get SM started off with Animation Shop. She is keen to do some more photo realistic work, and we collaborate on a composition using the picture tube in PSP. After some rudimentary instruction she begins to animate it, and quickly gets some really lifelike motion - unfortunately the session ends before she can do much, but it promises great things.
MM is sitting next to her, working on an animation, but without a storyboard. She is making a short about a plane crash, and breakdown occurs for her several times when inserting frames. AS insertion is counter-intuitive because it inserts before the selected frame rather than after. However, she makes strong progress once I have helped her over this. During the course of my interactions with SM and MM I suddenly reflect on how much I am learning, and how much they are teaching me - the classroom hierarchy is definitely under subversion!

Session Number 45

Date	Wednesday 31st January 2001				
Time	9am to 12.30 pm				
Location	Open Learning Centre, Mill Street, Pontypridd				
Room	Workshop 3				
Tutors	SRH, T				
Total learners	11	Male	5	Female	6

[Entered by keyboard in the UOG office later the same day.]
I arrive early and set about installing VR Toolbox on our fastest machine. Then I begin to rearrange the room, ready for BD's filming, as people begin to arrive. A very busy and chaotic session follows; I don't even have time to make notes, although I do take a number of photographs. [It should be noted that the photos act as a valuable *aide memoir*, prompting recollections.] Consequently, this account will not necessarily give events in the order they occurred in.
WE is among the first to arrive, I take this as a good sign. JH doesn't appear until well into the session, but I do overhear him saying to T that he is in the process of rearranging his schedule so that he can be more punctual – hopefully this too is a sign of early engagement with the learning, but time will tell. T follows up on our chat of yesterday by spending much of the session working with JH, using PSP and AS. T also confirms that VB will definitely not be attending any more sessions, due to transport difficulties, and we discuss whether we might be able to get someone to finish her animation, and also award her some accreditation.
[Entered by keyboard in the UOG office next morning.]
I have one major exchange with JH – he has brought in a digital camera to show me, a very nice, though rather old, Canon. I admire it, thinking that it is a lovely tool for him to have – then he asks me how much I think it is worth. He tells me that he makes his living 'buying and selling', and that the camera is in an Internet auction on Yahoo! 'up to £220' at the moment, and that he has another, better one at home. I ask him where he got it from, and he avoids the question, which makes me feel very uneasy. Still, he works well throughout the session, and by mid-morning he has produced a small animation clip, combining drawing and photography, of a 'stick man' moving across our workshop and sitting down in an empty chair – a nicely imagined and executed piece of work. T and I ask the group to gather round while he 'premieres' it, to much acclaim.
At the same time, BD has a clip to show, close-ups of his 'band' performing. He has spent all morning working, with WE as his teammate. BD sets up his camera, stage and puppets, at first with some difficulty, as he is still obviously unwell. I then quickly brief WE, sketching out the rudiments of video capture, which she seems to grasp straight away. She then becomes the computer operator. The pair of them seem to get on well, in a very businesslike fashion, and get a lot of work done in very short order. The only difficulty encountered is that the ATI capture software crashes several times, forcing a reboot of the system, for no immediately apparent cause – although I suspect that we are filling up the HDD now, and overlong access times might be hampering the streaming. Toward the close of the session, when they have finished filming, I prompt them to complete the task by recompressing the clips and exporting them to another machine on the network, ready for editing. BD, normally so sharp, can't recall how to do this [to be fair, it is a task that he would normally do with Leighton, who doesn't attend on Wednesdays] so I demo the procedure to him and WE, at the same time giving another potted explanation of

codecs. They then carry on with this until the end. WE leaves telling me that she's 'really enjoyed herself'.

On the next machine, up in the corner, is DH [T tells me that he has now negotiated day-release from work to attend the sessions] who is working away on his poster. He has really taken possession of this project, and is determined to finish it and do a good job. During the course of the morning he demonstrates an increasingly sophisticated grasp of the use of vector graphics, creating text on a path several times, which is definitely not an intuitive task in PSP. Interestingly, despite his now excellent facility with the application, he experiences breakdowns – with layers and selections. Each time he calls me over it is because his actions aren't having an effect, twice because he is not operating on the correct layer [it is not active] and once because he has a selection made, and is not aware of the fact. [Perhaps there could be some kind of 'selection meter/indicator' in the interface? The difficulties with layers are perhaps compounded by the fact that vectors are automatically created on their own layer initially. It is quite possible, if the layers palette is not open, to create layers without knowing that you have.] He also does some advanced manipulation with the text tool, reselecting and altering text using the 'loaded cursor' facility [some illustrations needed]. By the end of the session he has produced a 'limited edition' of posters that seem to satisfy all of his design goals, and T takes them off to get them laminated [it occurs to me as I write that it might be good to get them signed – an interesting subject that requires some investigation, in terms of how it might support ownership of projects.

Also working with PSP throughout the session are CP and PC. CP, before the break, quietly paints away, this time using the photo-realistic aspects of the Paint Shop. She employs the picture tube, adds effects, and then frames and reframes the whole composition. She is very thoroughly exploring, using a markedly different style from anything that she has done before, and the results are stunning. While she is out getting a cup of tea, I look at her printout with SC, who has just arrived. We agree together that it is excellent, and I print another copy, on photo paper and at high quality, which I give to CP when she gets back. As usual, she manages to be appreciative and dismissive at the same time, simply popping it into her binder.

Later in the session I ask CP to help with some photography. I quickly show her the VR software and explain the concept of a Pano. We set up the camera; I take the first shot and leave CP to do the rest. [There is an interesting intervention from PC to inform us that if we need 12 pictures around the circle they must cover 30 degrees each – he's quite interested, whereas, as always with CP, I feel like I've dragooned her a bit.] When we upload them to the machine it is soon apparent that she hasn't really seen the principle of what we're trying to do, or wasn't very engaged with it. I don't say anything, but just go on to use the software to stitch them together. Then, when we are at the adjustment stage, I ask CP to take over – probably a bit unfair really, as the nudge process is very tedious. Next thing I know, she is making one of her now famous fast exits - 'got to catch my bus'. I say goodbye, then go over to look at the work in progress. She has been adjusting the fit in the wrong direction, and has maoved the tiles of the image away from each other. I set to to put it back together again, and stay for a while after the session has ended, producing a QTVR pano file. I hope that this will form a starting point for a discussion with her about the process when I see her next.

PC, on the other side of the room, continues to work on his accreditation material, but with a marked change of attitude. Yesterday's slightly dreary exercise is now in a process of change. He has drawn a collection of vector shapes as required, then manipulated them into the outline of a [military] tank. He is now creating a whole landscape around it – using the picture tubes – with beautifully realistic and deatiled grass, sky and clouds. As the object under construction becomes more 'real', he seems to get more and more involved with it. As we near the end of the session he begins to carefully colour sections of the tank itsel with gradients and patterns. The contrast between the hard edges of the vector shapes and the bitmap elements is exquisite.

[There is no doubt that PSP is undergoing a revival in the group, and that what started out as prompting by T to fulfill accreditation criteria is providing a great framework for creativity. This bodes well for our consideration of the educational aspects of the programme, and especially how to integrate fulfillment of the academic and adminstrative criteria into such an open fraamework. There is little doubt in my mind that time, familiarity with the surroundings and the cohesion of the group is a very large factor here – I can't imagine these activities being able to take place two months previously. Later the same day I have a long discussion with Geoff about the transferability of these approaches to the HE environment, and it prompts me to reflect that physical, administrative and attitudinal factors are the biggest barriers here. A lot of it is to do with letting people feel safe and belonging; that simple, yet something that does not happen anywhere on the UOG campus!]

DC and PR are, as usual, hard at work, and the end still doesn't appear to be in sight, as they are now adding an entirely unscripted episode to their movie! However, PR has resolved the frame size issue, and they work very quickly and productively this morning. Their only incidence of breakdown is one that, on reflection, has occurred quite often. AS2 has a quirk when inserting frames, as by default it does it before the selected frame, rather than after. This produces orientation difficulties, as already created frames can get bounced to the 'end' of the 'reel', and then need to be moved back again. A simple enough action, but this undermines the whole 'left to rightnesss' of the interface metaphor. [Must explore whether this has been rectified in version 3, I think it has. Things are slightly confused as I have not yet managed to upgrade all the machines.] SM's catch phrase for the day is "can we just scrap it?". She is growing increasingly frustrated with the difficulties of synchronising her soundtrack to her visuals. This is exacerbated by her desire for perfection, and although each time she suggests that we could scrap it she is smiling, she is only half joking. She and D work on the film all the way through the session, with a number of periods of lengthy rendering operations. When I ask D how it is going, he says 'don't ask' with a wry expression. I determine to make it a priority to help them break through this impasse at the earliest opportunity. On the up side, SM is very sociable with the others during this session, and she, D and CP spend quite a lot of time chatting.

And so to SC . She arrives during the morning break, around 10.30, having rung in earlier to let us know that she will be late. This is great, as only I am in the room when she arrives. I ask her what she wants to do – and she is keen to carry on programming. I explain to her that, as far as possible, I would like her to continue exploring on her own, and that I don't want to 'teach' her programming, or impose my own ideas. She is very responsive to this. I tell that she is the pioneer for the group, and that I hope that she will assist me in introducing the others to Logo, and she readily agrees. She is eager to get going again, and quietly gets on with it, following her strategy of reading and printing the help files [remarkable and unique!]. She calls me over once or twice during the session. What is really significant her is that this is not in the first instance because of breakdowns related to the programming itself, but rather to the operation of the prpogramming environment. She asks me why her function won't run, and it is because she has not compiles it – an operation that involves highlighting the relevant lines in the text editor window, the choosing run from the Go menu. If you haven't done this the error message is 'Logo doesn't know what *function name* is', which , to me anyway, actually seems pretty helpful – the metaphor in use is of input as conversation or notification. Once she is established in the appropriate practice again, she sets to learning how to use variables. At this point she asks me to intervene again, but it is more to see what she has done than to put her right. The Logo explanation and demonstration of variables is pretty good, and I try to support it by emphasising variables as containers – I grab the rubbish bin, and work through the procedure [I am using terms loosely here, must clarify and standardise] that she has written in terms of putting content in the bin, and then adding to it. Once again I notice that DC is following all this, fascinated, and I determine to open up the programming activity to the group as soon as possible. As the session draws to a close, SC makes a most remarkable request: would it be possible for her to do some programming in her class at Beddau? [SC also attends classes in IT at the Beddau outreach centre, taught by rachel Houghton.] I am so pleased I nearly fall over! SC tells me that she is 'showing everybody what to do anyaway' in that class, and would rather be doing something more interesting. Rachel is in the office – I pop in to see her and she agrees that it would be fine by her. I quickly copy the installers for Mach Learning turtles to a blank CDR and entrust it to SC . The only question mark is whether the manager of the Beddau centre, who is apparently very proprietorial about his equipment, will allow her to install it. Rachel assures that she will do her best to expedite the arrangement.

Session Number 66

Date	Wednesday 28 March 2001				
Time	9am to 12.30 pm				
Location	Open Learning Centre, Mill Street, Pontypridd				
Room	Workshop 3				
Tutors	SRH, T				
Total learners	12	Male	6	Female	6
Names	DK; DH; PC; MM; BD DE; (very late) DE Evans. DC; WE; SM; CP; PR; SC . Visitor: PB				

Main points, typed in office later same afternoon:

- I get confused about views in UVS. Work through break on additional clip for DC. BD, when asked about watching me work says "I'm finding it very interesting".
- DC took manual home to read, says "now at least I know what all the buttons do". Tells me that the way to see how the movie is gioing is to move 6to 'finish' mode and drag the scrollbar through – this works great! also seems to greatly reduce rendering time.
- We have trouble with sound playback on the machine we are working on (must produce a schematic of the room) as media player is 'bust'. However, plays back fine through UVS – we need to go to another machine to see the final product.
- Synchronisation is getting easier, better with more practice – and I'm finally getting familiar with the modal interface of UVS.
- DC still displays some confusion about versions and views – and so do I, compounding hers. Together we begin to understand the difference between 'storyboard' and 'finish' mode – only in the latter can one see the whole picture.
- SC and SM sit together throughout the session and work with Logo. At one point, immediately after the tea-break, SM leaves us for a while and I sit with SC and work. They have become slightly frustrated by not being able to fill shapes they have drawn with self-written functions. The setfc command only appears to apply to the rect and oval functions. I go through this with SC, then get hooked and quickly explore a number of other things as she looks on, including point, which is a bit flaky, and tprint, which does what CP had been looking for – writes text in the turtle window. SM rejoins us and we together work through giving a shape drawing function a list of attributes: x, y position, width, height. I leave them to it, and by the end of the session, with some collaboration with T, they have written a function which writes SC directly to the screen in filled in blocks of colour. They're well pleased with themselves.
- At the end of the session DH tells me that he has worked through all the links in his website, checking for dead links. He has culled all the dead ones, and declares his Star Wars pages "ready to go on the Web".
- PB comes to the session today, arriving at the start of tea break. I ask her to circulate when the students come back, next time I see her she is sat next to CP, which is where she remains for the rest of the session. She helps CP to work on her graphics accreditation materials, using PSP7 to do node edits on vector graphics. I am unclear how much CP enjoys this (will ask her next time I see her) but it is clear that PB enjoys it thoroughly! After the session she is full of how she has "found the right analogy" for layers by comparing the background to "the table top, that you pile stuff up on, and nothing can go under it or else it falls off". Hmm…she doesn't do any ethnographic observation at all, just gets pulled in to the class. This is slightly unexpected to me, but I reflect that PB's self-image has taken a lot of damage lately, and just let things go on, I'm too busy elsewhere anyway.
- MM enacts another 'I want to be on my machine' sketch again – but as he wants to do scanning anyway I direct hime toward the appropriate seat. The technician (Steve E) is there when the group arrive, delving in to why some CD-writers don't work – with no success – but the result is that a CD of MM's comes to light, with some dodgy files on it. As soon as he sits down at the machine with the scanner he tries to open a file from the CD – and crashes the machine instantly. He comments to me "that's that auto run". He then goes on to try to scan the image he has brought I - a collage – at 1200 dpi, which makes the scanner literally groan with pain.

[stuff added by dictation later that same day - in fact at night. Not corrected]

OK, some random things I remember about day's session. The first as my delight of once again same chance to working together programming in logo. He really is a good thing to say the way that logo is spreading spontaneously around the class. I also remember right at the beginning of the session, zero either in a very extrovert mood by untrained or joshing with myself and CP. The two of the she had a joke together, I think of my expense, and fell about laughing at 930 in the morning! DK was very quiet during the session, he seems to be quite taking quite seriously by injunction to put a bit more research into his presentation on their stuff. He had some kind of a long string of text file, looked like he had been extracted from some kind of chat line, and he was

editing out all kinds of we had: escape characters from it, getting to the pain of the interesting stuff which was a discussion about maps to. DK really intrigues me, he seems quite unflappable, mostly because he's very quiet. In this respect he reminds me of my friend Phil, is always managed to the topping situations by never saying very much. All be really intrigued to see what DK comes up with, as with no set the date of his presentation for two weeks hence.

A one point when I was sitting around the machine with DC and BD, BD started to begin to get really irritated with DC. This was really what precipitated my head long intervention into their project, I had our hopes that BD would be out to cope with it, which seemed to find its limits. I have to say DC has only been a great factor helping me develop our personal limits of patients over the years! Any way the end it was mostly me working with your application, with DC making some very useful and supportive marks, and BD just pretty passively watching. He did once or twice intervened suddenly to tell me that I was about to go wrong or are clicked on the wrong thing, and his intervention revealed just how closely he was watching what was going on. It was a little easier to communicate with DC today, mostly because we were all looking intently at the same interface. Her mode of communication is very elliptical, as she which speaks from an internal knowledge of the subject she's talking about in this case her animated film, and she doesn't do any hand holds to climb into her internal world. This gives a very misleading impression of her, because she really is quite keenly intelligent and very highly focussed. Because of a method of communication she gives the impression that she has come believe me out to lunch! As I did take this her remember what people first tell me about DC two years ago began to teacher-people were within the centre were very quick to classify her as mentally ill.

PR seem to be working very fluently with multimedia builder, although we've didn't really get much chance to talk to her about it. Right at the end of the session she called me over, to show me the work she had been doing with the photographs we had taken of the book of cover. She had taken a small flame that was that the centre of the book cover, and turned it into a dancing living flying very effectively. She had done this using Animation Shop., and I'm not really sure she we are to imported directly into multimedia builder, I certainly hope so. DE came in very late on in the session, only about 20 minutes before the end. He sheepishly explains that he had to attend it some kind of appointment at the local Social Security. This apparently was also the destination of CW who didn't appear.

So I had an interesting talk with PC at the start of the session, he had loaded in a new 3D package and has been busy creating wire frame models. He told me that he had had some success importing into Poser they had a problem because he was all "hollow". I really couldn't understand what he meant, say had to demonstrated to me in Poser. In fact what he had created was a large rectangle there was extremely dint of 3D shape that didn't have a playing surface upon it, so as effectively as a PC said "a huge picture frame". However is obviously very near, very quickly his goal of being out to create planes in his pose a set up the wall rotate in relation to all the other objects. I really can't keep up with a mature man, and I can't wait to see what things he produces. I only hope they did doesn't go rejected on by PR on grounds of the aesthetics of the thing, but anyway we shall say. I think there is the potential in the collaboration of the two of them to produce something really outstanding..

Appendix 3: Extracts from Interview Transcripts

Note: Referenced in Chapter 4, §4.4.1.2. The following extracts from interview transcripts provide examples of formal and informal interviews with learners. Spelling and grammatical errors are retained from the originals.

3a. Example of Formal Interview Transcript

Interview number:	4
Date:	16/10/00
Time:	17.40
Location:	Interview room, Open Learning Centre
Informant Name:	DH
Gender	Male
Interviewer:	SRH
Audio Tape Number:	1 Side B
Transcribed:	30/11/00 – 14/12/00

[As the interview begins, DH sits back and relaxes.]

[SRH does the usual six week review preamble]

SRH: The first thing that we hope that you would do is convey ideas and opinions clearly to one other person. Do you think you've been doing that?

DH: Yeah, yeah. Me and Byron have been working really well, you know, ah, I mean it literally took the both of us to come up with this idea [refers to animation of solar system], you know, and actually bring to progressing – we haven't quite finished but em, but it was em – I won't say massive but bigger than it really started with. Yeah, we've done alright you know. We've been looking out for each other and talking about it. When we've made mistakes we've just gone back and erase it and start again, you know…

SRH: How about working with other people?

DH: I've got to be truthful, I think it's really difficult 'cause on one other occasion you've had me and another person that haven't really known a lot about …erm…the actual computer program itself. And actually trying to do something when two people don't really exactly know what they're doing…it's alright if one knows what they're doing cause they can show the other person how to do something. And then you can go on from there. Once you know how to work erm [hesitates] the computer program you're alright. But if you get two people together that don't really know it's practically – you're working at say one percent.

SRH: Who were you working with before? Was it Sian?

DH: I think it was. I mean, no disrespect to her, I mean, you know, I mean, I, I didn't know any more than she did. That's what made it worse, cause to start with I was finding it quite difficult to use the Paint Shop Pro program. Now actually, funny enough, working with er Byron em… we're actually getting through it a lot, lot quicker. Now I'm even picking up a lot more. I know that sounds daft but… he's got a computer at home so he knows a lot of it anyway. So he's saying to me, you know, you do it yourself. I'll go through it with you, you do most of the computer work, even though we'll discuss it together. Em, and if I've made any mistakes he's been able to tell me exactly where I've been going wrong.

[…concludes review…]

SRH: What do you like most about the course?

DH: Erm – I think it's great. It's a nice friendly course, it's… erm, a lot of helpful people. You know, if you don't know how to do something just ask, and if they know how to do it they'll give you a hand. Erm…considering I've never done anything like this before, cause I've never really classed myself as artistic in any way erm, I am , I am thoroughly enjoying it. I've got to be truthful, I was a bit nervous at first, specially when , you know like, I thought we had to start drawing things and stuff like that. Erm…no, I don't feel too bad now, I feel alright.

SRH: Wasn't it you who did a load of sheets full of drawings the other night?

DH: [laughs] Yeah it was! [laughs] They weren't much good, but funnily enough Byron knew exactly what they were. When he could understand them all that was…

SRH: I understood them too…so what is good? Good is what does the job. So what do you like least about the course? Is there anything that's made you feel bad?

DH: No, I'd say it was just that at the beginning, the first few weeks, erm, trying to get used to the Paint Shop Pro knowing what, like, each tool did – up the left hand side [refers to default interface layout] you know – er, was very difficult for me. I mean, I just didn't understand one thing from the next. To be truthful I didn't really have a clue what I was doing, erm, even though I was just trying to mess about with it, you know like we were all told to. That's why I said I thought it would be easier if erm, I mean it would only take two or three pages of erm…like they do with the other programs. Just a small generalisation of what they actually do rather than people having to read a whole manual. You know, if everybody had a copy of that, if they weren't sure they could just simply look into that little copy, em, see what symbol is which, and then determine from there where they're going. I think that would have been a lot esier fir, not everybody, but most people who haven't had anything to do with Paint Shop Pro at all. That was my only quarrel. Now I'm getting to know it a little bit more, I'm not too bad. But I think there's still one or two things on that, you know, I probably don't know or haven't even used…

SRH: What do you hope to get out of the course?

DH: Erm… I've got to be truthful, when I first started I didn't really have any expectations of where it was gonna lead at the end, because I mean I didn't really - I'd been told what the course was about a little, but erm I wasn't quite too sure myself, cause I'd never, you know even heard of it you know. I know of animation, stuff like that, but I'd never worked with it before, neber even seen it apart from watching a cartoon on the TV. Erm, so I didn't really know what to expect. I just wanted to try and learn something and improve my skills working on a computer. Now I'm, I gotta be truthful, now I'm enjoying myself, erm, I would like to be able to get some form of qualification at the end of it, and I was thinking well, depending on how I feel at the end of the course, if I've enjoyed the whole course, I think I can improve even more, I would like to go on, erm, further, and do some more. Maybe at the Arts College or something. Anyway, that's a decision I'd have to leave until, you know, more towards the end of the course.

I mean. I've gotta be truthful, I was supposed to be on a different course to start with. I was supposed to be doing computer engineering…erm, cause that'd been my main priority for over a year – well just under a year cause I'd just missed out last year. […]That's what I originally wanted to do. And then I was told about this. I said, yes, I don't mind doing this course, you know it sounds very interesting, I've never done anything like it before. I gotta be truthful, I will try my hand at anything new., erm, and see how it goes from there. But I was hoping to do the computer engineering at the same time….

[…]

I'm dyslexic, so my English ain't that…I say my English, my spelling's terrible, my English isn't too bad now. Working with computers, again I've found that's, that was a help. You know, I'm just trying to – I'm desperate to actually get one in the house. And I've heard that, er, if you can get, er, the report, saying that you're dyslexic, there are ways of going round and getting a computer. Well I wasn't quite sure there was, otherwise I would have got one a long time ago…

[…]

SRH: Do you feel that you're a creative person?

DH: Erm…when it come to putting things on paper I would say no, but in other ways I was. I mean I was ok with, you know, doing things like silkscreen printing, pottery, I mean I done all them things, I done photography for a while. I can say I can be fairly creative in those sorts of areas, but not when it came to drawing, painting, things like that. I was always actually terrible, to be truthful. I, I can be creative, put in the right environment. But under other environments…

SRH: Did you find…did you have something happen at school?

DH: Well, to be truthful, I mean, my school was not very good at all. There was only two, what you can call your duffer's classes, there was only two, two of those classes in my high school, and they didn't pay any attention to us at all. Erm, I mean, when it came to the arts classes it was a case of, you know, 'there's a bunch of pictures, just colour em in'. That was it. That's about as far as art ever went. You never got to draw anything yourself, you know, you never had to paint anything yourself, it was all practically done for you. All you had - you know whatever it was you wanted to paint or colour in it was there done for you. Literally what child – kids of three or four years old are doing. Colouring colouring books.

SRH: This was…how old were you then?

DH: That was from when I was eleven right up till – well I left school when I was fourteen, I was only going once a week, erm, and most, most of the classes were pretty much like that, I mean even the English classes…erm it was a case of play on a computer playing computer games. It's

not as if we were doing anything constructive on the computer. […] It was only until the very last year that one teacher – and it was our maths teacher – turned round and said to us that erm as far as he's concerned – I mean he just come in and said as far as he's concerned we're not stupid. Even when everybody has just literally left us to do our own thing practically for, nearly five years. And if we wanted to he would teach us all maths, even though we had to learn near enough five years worth of work in six months, he would teach us it. He said well, you're good enough to do it. He said anyone that doesn't want to learn, leave my class now and I'll always mark you here. Well, as it happened, one feller left. But the rest, I mean there was only about 10 or 11 of us in the class anyway, so it wasn't too hard to teach individually if you had to, erm and he stuck us all in for our City & Guilds and it was at the time level, this class now was level three. Em, and every single one of us passed. Erm, I mean out of the whole school, I mean even those who were in the higher classes that done that particular exam that year, I was the only one, funny enough, to get a distinction. I had a hundred percent. And I've always's been chuffed at that. But it just, it proved to me, that if somebody puts a load of time and effort in, and is with a taecher, then I don't think anybody's stupid, it's just a piece of, you know…

SRH: Do you think you're good at using the computer?

DH: [BREATHES IN] Em, I've certainly got a little bit more practice, or, a lot more practice. I am, I am getting there. Erm, I'm not too bad, no. […] I wouldn't class myself as hopeless. I mean, I know my general way around the computer now, [indistinguishable] the files back and forth, and even swapping one file into another file, just about getting the hang of that now.

SRH: Do you enjoy working as part of a team?

DH: Yeah! […] I mean I don't think I dislike that anyway, as I say I am quite a people person, I do find I work better, erm, when it comes to stuff like this anyway. I would work better in a group than I would on my own. In fact I think the result would be a lot, lot better.

SRH: How do you feel about the room?

DH: Well my only complaint there would be is concern about, a lot of the time we have to work in pairs, since what, I'd say the second week. It's very, very cramped. It wouldn't be so bad if the computers were maybe spaced, could be spaced out a little, erm I mean, I think we've got what, ten computers up there? Erm, there's only a maximum of what, 15 or 16 of us in the class anyway… even if it was a case of taking say the two older computers , putting one new one in there so the others could move over a little, and then using the opposite side of the room […] I mean it's alright if you're working individually, you've got plenty of room. But if you're working, you're trying to get two people here, two people here, two people there…

SRH: About the computers themselves and the equipment generally…

DH: Yeah, I think they're alright. Well they're the best computers I've worked with that's ceratin [laughs].

SRH: [Say a little bit about the software] paint Shop Pro for instance?

DH: [At first] I found it quite difficult, myself. I didn't have a clue at all what I was doing or what anything did. Erm…like I say, I mean it was a case of learning a little bit off my own back and then having other people show me or give me a bit of advice. That I found, you know, very helpful. Erm, and I got a lot further in it. There is I mean, any work that…

SRH: But if you'd been left to your own devices?

DH: No, I think I'd have still been there, you know, by now, still playing around with the same old things, trying to do the same old work, er, not really having a clue how to do anything else. Erm, erm, I'd have, I gotta be truthful I think I'd have got a bit disheartened and ended up turning around and saying I don't think it's for me.

SRH: Some people would say that they can design software that you can just sit in front of, and it will show you how to do it. Does it seem like that to you?

DH: No, I would say , it's, no.

SRH: How about Animation Shop?

DH: Yeah, I'd say AS is fairly straightforward. Erm…yeah, in fact yeah I would, even with, all the stuff at the top, all the toolbars and things, even that's straightforward as well. I mean, I've been doing things like inserting extra frames, stuff like that, and I haven't found any problem at all, erm, I don't think byron has either. I think that's a lot, lot more straightforward than the Paint Shop Pro programme.

SRH: But it does a lot more…

DH: Yeah.

3b. Example of Informal Interview Transcript

Date:	07/02/01
Time:	11.30 am – 12 noon
Location:	Workshop 3, Open Learning Centre
Informant Name/s:	DC, PR
Gender	Female
Interviewer:	SRH
Audio Tape Number:	3 Side A
Transcribed:	07/02/01
Subject:	Layers in Paint Shop Pro 6/7

[DC and PR are engrossed in working on their animation project. They have a multilayer – about 16 – image open in Paint Shop Pro 7. They are executing a very complex routine that involves cut and paste operations to Animation Shop 3, toggling different layers' visibility before copying them. A kind of onion-skinning that they have developed to a high art.]

SRH: When you're working with layers do you find it easy, difficult, are you getting used to it?
PR: Getting used to it.Like we were sying earlier on, in the beginning we didn't really know what we were about. Now we're getting to know what's available to us…
DC: And what we can do with it.
PR: What we can do with it.
SRH: When you're working with the layers, do youhave a picture in your mind of what is going on?
PR: Yes.
SRH: Can you describe that to me at all?
PR: Well, it's like a book almost. It's like a book. Like, em, you can choose whatever pages you want, and you can alter those pages to suit yourself, to get the effects that you want.
SRH: When you say it's like a book, do you have a picture of the book in your mind? Is it lying down closed, or…
PR: Yeah, yeah you do. Like now we're working , like planets [refers to animation work in progress], different types of planets…
DC: Yes. For example we're moving the clouds in front, and behind.
PR: We can move the mist, either behind the planet, in front the planet, take the colour out a little to make it look more sort of pink, and misty…so yeah, you are thinking about it like a book aren't you. Like pages.
DC: Like the acrylic…not the acrylic, those see-through papers [laughs] I can't thiink of the right word.
SRH: Acetate.
DC: Acetate.
SRH: Do you think that you've learned how to use layers by doing it, or by being told about it?
PR: Oh, doing it. Definitely. Mind you, having said that, I'm saying doing it, but you need the guidelines to be able to do it. Like, you find out things by accident, but it makes sense, more sense, when you've been told what's available to you and how they work. Then you sort of…
DC: Talking about it, with layers, the old way, of flicking through the pages [gestures like a thumb-flicking animation book, card shuffle] that's what makes me understand it.
SRH: So if I asked you to explain to someone who had never seen them before, how to use layers, how do you think you would start?
DC: I'd do it with papers.
PR: Yeah…I would take them through it on the computer first, and try to explain how I see it.
SRH: What would you say is the most common mistake or problem you have when you're using them?
PR: Ah, yeah, to me, I dunno about DC, It's that you've gotta go on the right – like if you're picking – say you've got 12 layers, which we have, and you want to use, say, 3 of them, you've gotta make sure that you only open those three. You've gotta cross all the others off, so's that when you're copying them, you're only merging those 3. Cause, otherwise…well that's what we were making mistakes with in the beginning. Cause we were saying 'how did we do that?' It was because we'd had them…
DC: Where did that [indistinguishable] come from! [laughs]

PR: Yeah, we had the wrong sort of pages open then, like. Or we hadn't closed down pages.
SRH: Right, OK. So the problem is making sure that you've got the right layers selected in the layer palette?
PR: Yes.
SRH: And what about changing their order in the stack? Is that something you do much now?
PR: We, well we're doing it…
DC: All the time.
PR: …we're doing it now, we're putting the mist behind, the mist in front…
DC: And upgrading colours [gestures indicate the transparency control]
PR: …and that's not difficult, once, you know,once you're shown, that's not really difficult.
SRH: Great. Could you think of any way that the layers could be improved?
PR: Improved?
SRH: Yeah, can you think of anything that would make them easier to use?
PR: I suppose…em…you know when you're dragging up [indicates moving a layer up the stack using the mouse] I suppose, if it was like say, do a double-click, and then take it to the top and just do a click and fetch it to the top, rather than dragging it up…
SRH: OK. You don't like the dragging?
PR: Well, cause sometimes you let it go in the wrong place, and then you're looking for it again.
SRH: How about you DC?
DC: If we named them [indicates stack of layers in palette, all with default names provided by the software] this would make an improvement. Except ther's two of us and we remember where things are. But otherwise it would be better to name them.
[This is something I've advised them to do and they never do, perhaps why DC brings it up.]
There are two of us here and I know, what's on number 3, what's on number 12, and the next one, I know which one we're working on. But if somebody else came along now, instead of me, they wouldn't know what we've done or why we're doing it.
SRH: So, why haven't you named them?
DC: Because, there are the two of us.
PR: I suppose if you were sort of, like you say, in some places, where a girl will come behind you on the same project, it would be different. But because we're just working on this one project, we don't feel the need to.
SRH: Great. Thank you.

Appendix 4: Examples of Completed Breakdown Pro-Formas

Note: The design & use of BDPFs is described in §5.2.2.3, Chapter 5.

Figure A1: Examples of completed BDPFs.

Appendix 5: Additional Materials from the Usability Evaluation

Note: These additional usability evaluation materials are referenced in §7.1, Chapter 7. Table A1 shows estimated values for the frequency and neccessity of tool use. Figure A2 charts the relationship between need and usability; Fig. A3 that between use neccessity and usability.

Table A.1: Estimates of frequency & necessity of tool use.

Tool	Frequency of Occurrence in Field Record	Estimated Need to Use
Animation Shop	542	4
ATI TV	228	3
Bryce	16	1
Cakewalk	12	1
Camcorder	180	3
Cool Edit Pro	213	4
Cool3D	27	1
Digital cameras	309	3
Dreamweaver	85	2
HP ScanJet	190	3
Internet Explorer	521	5
Logo	265	3
Nero Burning Rom	190	5
Notepad	290	4
Paint Shop Pro	573	5
Painter 3D	4	1
Poser	280	1
PowerPoint	365	3
Printers	565	5
Sound Recorder	42	2
Ulead Video Studio	410	3
Volume Control	205	5
VR Worx	98	1
WinAlice	194	5
Windows Explorer	322	5
Word	464	5

Notes:

1. Approximate values for the frequency with which applications were used during the longitudinal study were established by the following method: (1) the use of NVivo (qualitative analysis software, see http://www.qsrinternational.com/) to count direct references to individual tools in the text archive (§4.4.1.1); (2) a subsequent manual search for indirect references to individual tool use in the field note record; (3) merging the results from steps 1 & 2 to produce an intermediate count of the use frequency of individual tools; and (4) adjustment of the intermediate count in the light of further manual searches of the interview data and other data sources (see §4.4.1.2, 4.4.1.4). Stage 4 aimed to compensate for "selection bias" in the observation data due to the focus on incidences of breakdown and the researcher's involvement with teaching during the course, both of which resulted in some tools being disproportionately featured in the field note record in relation to their overall frequency of use.

2. The criterion *Need* evaluates the extent to which study participants were required to use the application in order to carry out *Computer Creative* course activities & tasks. Scores for need were allocated at 5 levels, as follows:
   1. Little or no requirement to use the tool
   2. Many alternative tasks & tools
   3. Task optional, but only tool for task
   4. Few alternatives to using the tool
   5. No viable alternative to using the tool
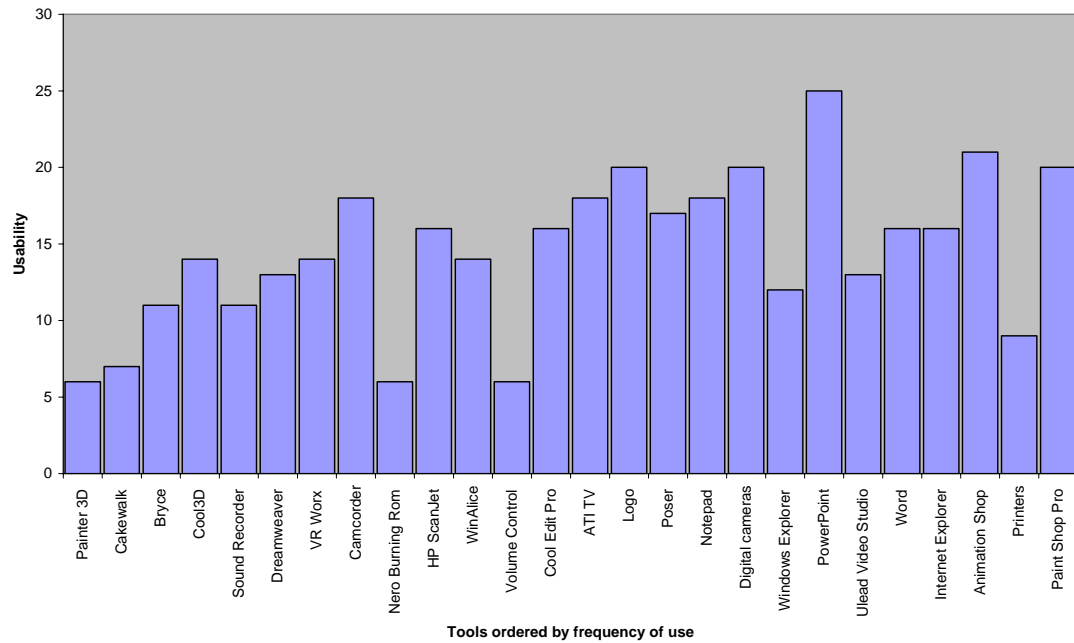
Figure A2: Estimates of the relationship between use frequency and usability in the longitudinal study. Tools ordered by use frequency, most frequently used to the right.
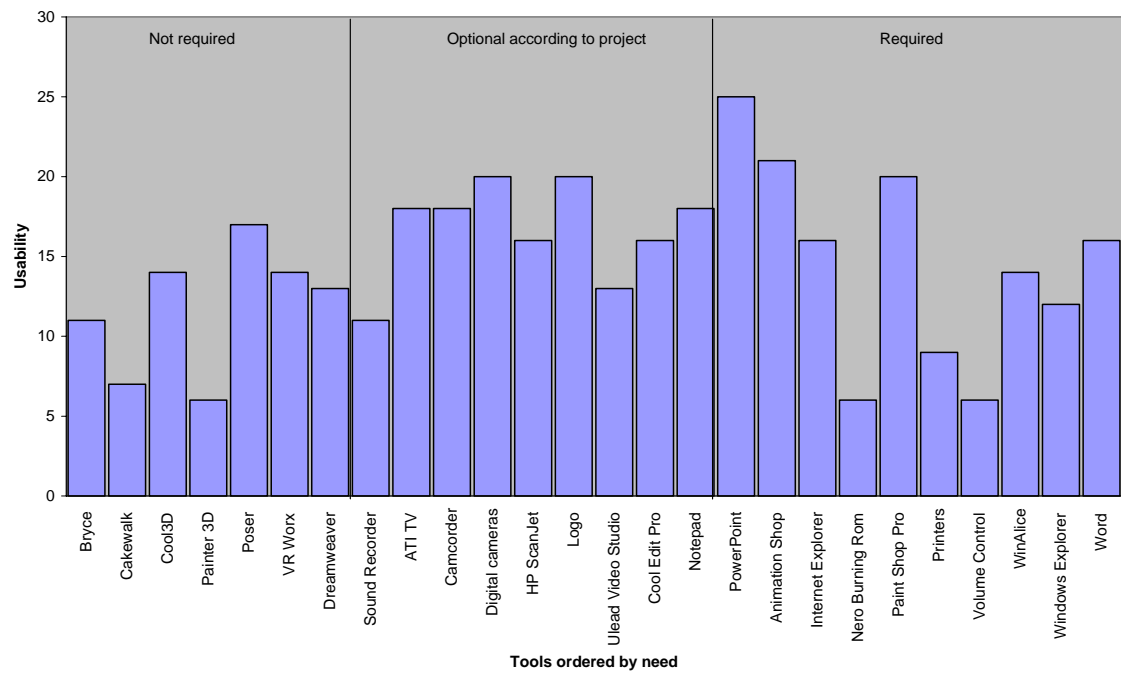
Figure A.3: Estimates of the relationship between use necessity and usability in the longitudinal study. Tools ordered by need, most required to the right.

Code No.	Code	Category	Code Applied	Code Occurrences % (N = 120)

Appendix 6: The BDPF Coding Scheme

Note: Referenced in Section 7.1.3.3, Chapter 7.

6a. Coding Scheme for Breakdowns Pro Forma.

Code	Category	Description/Focusing Query	Notes & References
SUE	Standard Usability Error	Is the error linked to features of the user interface (UI) that can be readily identified as in conflict with usability heuristics: learnability, efficiency, memorability, error avoidance and minimisation, & satisfaction?	Standard usability errors may occur when UI elements are: invisible; arbitrary; inconsistent; unintelligible; impolite; or dangerous (Nielsen, 1994; Norman, 1998; Shneiderman, 1998; Noyes & Baber, 1999).
MAP	Mapping Problem	Is the user unable to correctly determine the relationships between: intentions and possible actions; actions and their effect on the system; actual system state and what is perceivable; perceived system state and needs, intentions and expectations of user? A general category in which some of the following 9 codes may appear as subcategories.	Term used in cognitive science to denote the relationship between two phenomena, e.g. controls and their movement and actions in the real world (Norman, 1998).
SOL	Solidity	Does the virtual object exhibit the appearance of solidity?	Codes derived from studies reported in Leslie, Spelke, Baillargeon *et al* summarized in (Pinker, 1997; Plotkin, 1998; Nørager, 2004). The perceptual attributes listed are postulated as providing input for pre-conscious categorisation of perceived phenomena, one basic distinction being that made between objects (passive, to be acted upon) and actors (autonomous, animated – to be reacted to). In (Bærentsen, 2000; Bærentsen & Trettvik, 2002; Nørager, 2004) the contradiction of pre-conscious categorizations of UI elements by their ensuing behaviour is hypothesized as a persistent cause of interaction breakdown.
PER	Persistence	Does the virtual object appear to survive once instantiated, especially after becoming hidden?	
CON	Continuity	Does the virtual object exhibit continuity of its boundaries and attributes, especially when partially occluded?	
LAUN/ SUPP	Launching/ Supporting	Does the object appear to conform to perceived gravitational constraints, such as contact being necessary for support? When one object strikes another, does it move? Does the virtual object display *any* attributes of causal sequentiality?	
OCC	Occlusion	Does the virtual object survive partial or total occlusion unchanged?	
NUM	Number/Subitizing	Does the interface present more items to be enumerated than can be handled by the user's subitizing capacity (+ 4or 5)?	
ONE	Uniqueness	Does the virtual object currently being worked with exhibit and maintain a unique identity?	

A   17

1	SUE	Standard Usability Error	21	18
2	MAP	Mapping Problem	13	11
3	SOL	Solidity	10	8
3	PER	Persistence	24	19
5	CON	Continuity	21	18
6	LAUN/ SUPP	Launching/ Supporting	1	1
7	OCC	Occlusion	5	4
8	NUM	Number/Subitizing	4	3
9	ONE	Uniqueness	21	18
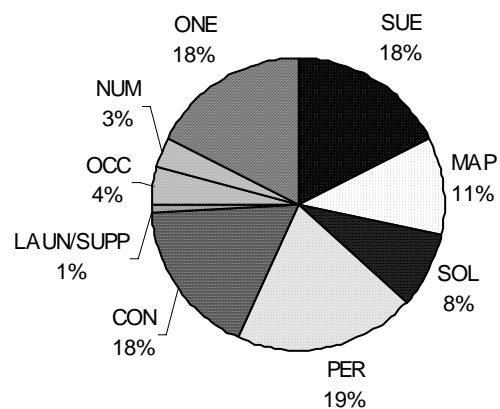
The table and chart show the results of applying the coding scheme to the Breakdowns Pro Forma. The codes were used as a focusing device, reflecting an interpretation of the situations under study. As such, frequency of occurrence serves only as a general indicator of the usefulness of the codes and the concepts they represent as tools to guide analysis of the ethnographic record. N.B. Multiple codes were applied to each Pro Forma - Standard Usability Errors and Mapping Problem generally contained the other codes as subcategories. Inspection of the figures indicates that the bulk of contradiction – based breakdown incidents (codes 3-9) were seen as linked to problems with the persistence, continuity or uniqueness of virtual objects as represented by the interface. The very low incidence of Launching/Supporting categorisations was taken as indicating that this is an unsuitable category for analysis of the BDPF data in its current form.

6b. Application of Coding Scheme to Breakdowns Pro Forma.

Appendix 7: Extract from Whole-Session Transcript, Sub-Group 3 (lines 3-157)

Note: Referenced in Chapter 8

1 **Focused field study, Session transcripts for S & V group**
2 **Transcript WGI_1_01 Total duration 00:10:00.4**
3 T: OK thanks for coming. What we're doing today, is we're
4 doing a project, but we're going to do the project all
5 within one session, because you're all quite experienced
6 now in project work, some of you I think are doing desktop
7 publishing, others making films, others working on Logo
8 projects, and some of you are doing more than one of those
9 things. So you're all getting quite experienced now in
10 project working, would you agree with me? ((general
11 assent))
12 T: So, today we're going to have to work quite fast,
13 whereas you've had several weeks or months previously, to
14 work through your projects, we're going to have to go
15 through as many of the stages of the project as you can
16 manage, all in one session today.
17 T: Erm, so, if we just run through the stages of the
18 project, of project working to remind you, Er, what's the
19 first thing you do when you start a project, what's the
20 first sort of things you do? ((several: get ideas))
21 T: Yeah, yeah, generate an idea to base the project
22 around, and if the ideas don't just come flowing, what can
23 you do to get them flowing? ((several: make lists,
24 wordstorming, brainstorming))
25 T: Yes, erm, so OK you've got some nice ideas all jotted
26 down what do you do next?
27 T: Yes, yes, you can start to organize the ideas a bit.
28 Erm, various methods for doing that, would depend on what
29 kind of project you're working on, what kind of, you could
30 say, artifact you're trying to produce at the end. One way
31 is to connect the ideas together with erm a Spidergram, or
32 sometimes you can call it a Mind Map, erm, we haven't got
33 a whiteboard any more, but, you remember you start off
34 with an idea and then you link it to another idea, and
35 another idea. Can you think of another way of organizing
36 your ideas?
37 P (a learner): Like a list ((general assent))
38 T: Yeah, cause they say some people, their minds work
39 best by being able to connect ideas in this way
40 ((*indicates mindmap*)) things going off in different
41 directions, and other people have the kind of minds where

Appendix 7: Extract from Whole-Session Transcript, Sub-Group 3 (lines 3-157)

Note: Referenced in Chapter 8

```
42   they like to put things in nice, orderly sequence. So
43   you'll have different styles of sort of organizing how
44   you, how you work on your projects. How about these two
45   ((indicates list on large writing pad)) - audience and
46   purpose - do you think they're important?
47   P: Yeah, it's all according what you're gonna do
48   T:  So how well, if you decide on a certain sort of
49   audience, say for a publication, how will that affect how
50   you go about it?
51   ((general suggestions))
52   T:  Different age groups, different parts of society, or
53   maybe people in a different country even, maybe even a
54   different language.
55   T:  And then, when you work on your projects, some of you
56   I think prefer to work alone, and others of you maybe
57   prefer to work with another person, or even with a group.
58   Do you have any preferences
59   P: I like working together, cause I like throwing ideas
60   T:  And then when you work with somebody else, then
61   there's different ways of splitting up the tasks isn't
62   there. Sometimes on a big project it may be more effective
63   to say 'right I'll go and do this, you do that, and then
64   we'll come back together again after and see what we..
65   W: Especially when there's a lot of research to do
66   T:  and yet other times you might like to share the same
67   task, mightn't you, work together doing the same thing,
68   maybe producing a piece of writing,
69   P: Bounce things off each other as well, you might have
70   one idea, then somebody else has got another slant on it,
71   and make it better again, you know, you're not necessarily
72   the be-all of it
73   T:  Yes, because you've all got different things to
74   contribute, different experiences...
75   T:  Erm, yeah, we mentioned research, we'll have limited
76   time today for research, whereas on your other projects
77   you may have spent quite a few weeks on that, but we'll
78   have to be quite quick today, but what sources, where have
79   you gone to find information on your projects?
80   Group: There's books, there's Internet
```

Appendix 7: Extract from Whole-Session Transcript, Sub-Group 3 (lines 3-157)

Note: Referenced in Chapter 8

```
81   T:  So, if you use the Internet or books, what's, and then
82   you find some information, what do you do with it straight
83   away?
84   (Suggestions from group)
85   T:  make notes, yes, that's right.
86   Nicky, So, you've done your research, you've made some
87   notes, you've got some kind of structure already, then you
88   can think about organizing your ideas a bit further,
89   depending on what kind of thing you're trying to
90   produce...
91   T:  You might want to make some sketches, erm, did you do
92   that for Logo, I'm not quite sure what you did
93   (affirmation from group) and you certainly did it for
94   desk-top publishing, didn't you, did laying out plans with
95   where your images were going to go, where the text would
96   go, er, where the headings would be, to get a general
97   overall view of it.
98   T:  Erm, then, probably, you would draft the text. Erm,
99   using your notes and your research, and your original
100  ideas, yeah. That is something you might want to work with
101  somebody else on, some of you.
102  T:  Then, you would get some images, or else create them
103  yourselves. So where, how have you managed to get images?
104  Thinking about desk-top publishing?
105  (Suggestions from group - scan, Internet etc)
106  T:  Erm, and then you put all this together to produce
107  your publication. And then after you've produced it, what
108  do you think you might want to do last of all?
109  (suggestions from group)
110  T:  Yes. You'd evaluate it, and say 'is this what I
111  intended initially, or is it a bit different?' Do you
112  think it's better than what you intended?
113  P: But you do that, you know, as you're planning. You know
114  in your mind what you want it to be, and what the contents
115  are going to be, so you sort of aim, aim towards that. Not
116  evaluate it then, you just know how your project, what you
117  want to get over then.
118  T:  Yes, each step as you go along, you say is this
119  really, is the best way of achieving...
120  P: Like D (another learner) is doing a gardening one, she
121  just doesn't want to write about plants, she wants to
```

Appendix 7: Extract from Whole-Session Transcript, Sub-Group 3 (lines 3-157)

Note: Referenced in Chapter 8

```
122  write about everything to do with gardening, rather than
123  (general discussion of gardening breaks out)
124  T:  So you would think carefully as you're going along,
125  yeah, but there is, I think, a point at the end, when
126  you've finished, you've produced it, then you'd want to
127  look at it and say , if I did this again, is there
128  anything I would do a bit differently, a bit better, or
129  maybe has this turned out a bit better than I was
130  expecting, yeah.
131  T:  So you might want to evaluate what you've produced,
132  but you also might want to evaluate what you did, the
133  process that you went through to produce it.
134  T:  So, what I'd like you to do today is to produce
135  something. I suggest that could be a leaflet, or maybe a
136  small brochure, either for the purpose of advertising, or
137  for information, which is quite similar.
138  T:  And I've suggested some themes, but you're very
139  welcome to choose a theme of your own, and these are the
140  ones I've suggested. If we imagine that Pontypridd was
141  going to have a new department store, a new David Morgan
142  or Howells or Allders or something, erm (jocular comments
143  from group), then perhaps you could produce a leaflet or a
144  small brochure to say what the store had to offer.
145  T:  Another suggestion could be an information leaflet on
146  what to look out for in your home, health and safety
147  hazards, how not to electrocute yourself or fall down the
148  stairs, or whatever.
149  T:  Another one, similar one, would be how to avoid
150  getting food poisoning at home. What to, how to
151  End of Transcript WGI_1_01 Total duration 00:10:00.4
152  Transcript WGI_2_01 Total duration 00:08:20.9
```
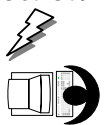
Appendix 8: Time Structure Outline for Sub-Group 3

Notes: Referenced in Chapter 8. Shaded rows indicate beginning of sub-tasks listed in Fig. 8.
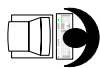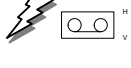
Table A2: Key to symbols used in time-structure outline.
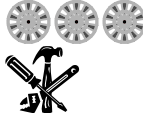
Symbol	Indicates
	Goal-acceptance or formation
	Goal achieved, task or sub-task completed
	Tool-related issues
	Subject/user-related issues
	Breakdown
	Screen-capture data available.

| Line Nos.	Description
3- 201	T sets out instructions for task 'create a publication'
3-16	T sets out general task conditions and precise (sub)-goal – project to be completed in one 2 hour session. *This aspect of goal is not a visual image.*
17-134	T sets out task sub-tasks and goals
20-24	T sets out sub-task 'get ideas'
27-42	T sets out sub-task 'organize ideas'
42-54	T sets out sub-sub-task 'organize ideas according to audience'
55-75	T sets out sub-task 'form groups'
76-88	T sets out sub-task 'research'
86-88	T sets out sub-sub-task 'make notes on your research'
92-98	T sets out sub-task 'make layout sketches/drawings'
99-102	T sets out sub-task 'draft text'
103-105	T sets out sub-task 'get images'
107-109	T sets out sub-task 'produce publication'
111-134	T sets out sub-task 'evaluate project'
125-130	T sets out sub-sub-task 'evaluate what has been produced'
132-134	T sets out sub-sub-task 'evaluate the production process'
135-138	T explicitly defines the overall task goal
140-173	T makes suggestions for publication content
174-181	T explicitly identifies sub-task 'form groups' as first stage of task solution
182-196	T reiterates task stages, in order of intended execution
192	T restates task conditions
201-2	Group formation process. No transcription as separate utterances inaudible in general talk. Groups follow pattern already established by seating positions chosen prior to session. Subtask goal clearly visualized and easily (already) accomplished by all participants.
201-2	T goes to back of room to sit with S and V, establishing this as her primary group affiliation.
203-205	T establishes pencil & paper, dialogue, as primary tools of subtask 'get ideas'
210-216	From this point on transcript focuses on interaction between T, S and V.

A   23

Line Nos.	Description
	T reiterates possible publication topics to S & V. No transcribed dialogue, transition from whole group camera to camera focused on S & V who work at table and PCs in street side corner of room, same wall as door [see plan]
217-218	S proposes leaflet as commonly agreed goal of task. V accepts.
223-291	S, V and T engage in subtask 'get ideas'. S & V discuss ideas
223-226	T proposes Health & Safety, Food poisoning as topics for the leaflet
228	S accepts Health & Safety as topic, tacit acceptance from V follows. This formation of the goal marks the beginning of the sub-task 'get ideas'.
229	T confirms 'health & safety in the home leaflet' as the goal
234	V begins to use pencil and paper as tools mediating his and S's activity in the subtask 'get ideas'. S holds pencil but does not write, *signaling participation in the shared practice.*
262	T leaves group
268	V recalls T to group
248, 280-3	T intervenes to encourage V to write, working toward her *own* session goal 'demonstrate literacy use'.
291-292	V signals end of 'get ideas' subtask, T confirms.
293-393	Sub-task 'research'. PC becomes major means of work, Web browser, Search Engine (text search) main material tools mediating activity. S becomes main tool operative. List artifact created by V also supports activity.
297-300	S encounters some physical/behavioral difficulty in assuming the role as PC operator due to physical environmental (space, configuration) and individual (ambivalent handedness) constraints.
367-379	Breakdown in interaction with Web Browser as S & V wish to use text item on Web page perceived as hyperlink that does not respond to left mouse-click. This slows hitherto fluent interaction with site, as users become unsure how to read the semantic properties of the page. Goal-directed action becomes more exploratory, as users pursue what the page can give them rather than what they purposively seek – page becomes object of actions. On return to group, T confirms non-hyperlink status of (underlined?) text and activity moves forward again.
382-392	T negotiates cessation of sub-task 'research', although S & V have not indicated that they feel the goal has been achieved – the subtask goal is too imprecise to clearly guide activity. The tutor, T, is regulating the activity from the point of view of the task goal 'project to be completed in one 2 hour session'.
393	V confirms willingness to end sub-task 'research'
394-406	T negotiates transition to next sub-task 'get images'. Presence of open browser facilitates this. Here, the goal of T's actions is to move S & V on to next subtask – so T again has an independently formulated goal, that she wishes S & V to adopt.
410-623	Sub-task 'get images'. PC remains major means of work, Web browser, Search Engine (image search) main material tools mediating activity. S remains main tool operative
407-458	Sub-sub task/interim goal 'get image of no smoking sign
407-409	During dialogue with T, V develops initial interim goal for sub-task 'get images' as 'get image of no smoking sign'. At line 407 V' utterance gives evidence of clearly formed mental image of desired future outcome of collective actions.
416	S makes public through dialogue her acceptance of the interim goal for sub-sub task 'get image of no smoking sign'.
425-427	Dialogue between S and T shows S raising concern for 'making it look good' which was not explicitly stated in the task instructions. Indicates S's subjective setting of criteria for success of activity and gives insight into her formulation of the goal which introduces aesthetic aspects not touched on anywhere in the objectively given task conditions.

Line Nos.	Description
436	S's utterance 'we want summat that's in the house' illustrates an aspect of her goal-image and how it is guiding the decision making/search process. This is speech for herself and for the other, regulating the mutual search activity.
444-5	S experiences breakdown in the physical aspects of interaction as her right mouse-click is not captured by onscreen image and thus context menu not invoked.
446-457	T responds to S's breakdown by demonstrating for S the step-by-step physical and logical component of the semi-automated (for her) task 'save picture as'. She also restates general task condition that images should be saved on local hard drive in folder dedicated to this learning group's activities (although she actively reinterprets this as the folder was actually created for a previous learning group, the one followed in the longitudinal study). Illustration of operations in the zone of proximal development?
450	S requests T to articulate immediate goal for next action 'So what do I do now'. Here, cooperative behavior passes from physical and low-level aspects to cognitive aspects of operations in the ZPD.
451-457	T talks S step-by-step through task 'save picture as', deautomatizing, unfolding the mental and motor operations into distinct actions, in the same way an online 'show me' movie might – but this dialogic interaction in the ZPD is both non-intrusively co-occurring and supremely context-sensitive.
459-469	T, S & V negotiate new interim goal. At 462 T articulates task goal as a sign-verbal concept 'smoke alarm'. At 463 new sub-sub-task 'get image of smoke alarm' begins.
463 - 482	Sub-sub-task/interim goal 'get image of smoke alarm'. T signals end of task at 482 with utterance 'right'.
484-487	Goal-setting process for next sub-sub-task requires discussion between S, T & V. List compiled earlier becomes main tool supporting this phase of activity.
488	PC and onscreen browser become object of speech and gestures.
488-494	T fairly precisely articulates the means of production: tools (paper, browser, search engine), division of Labour, procedures for sub-task solution.
494-502	Negotiation of goal between V and T. V appears to have a goal-image but no corresponding sign-verbal information, so cannot articulate his 'inner vision'. Here. A sketch, or a comparative 'looks like' image search might have supported him...
504-554	Sub-sub task/interim goal 'get image of chip pan'
503-504	T formulates 'chip pan' as new sub-sub task goal and S & V signify goal acceptance through verbal utterance.
514-537	Breakdown as S clicks on thumbnail in image search results page but next page downloaded displays IE 'The page cannot be found' message in lower frame of Google image search window. [This is also shown in Screen Capture file 521.mpg as Transana transcript SC_52_1_01]
547-550	V makes joke – signals end of tension over breakdown, end of sub-sub task?
556-594	Sub-sub task/interim goal 'get image of child playing with matches'
556	V initiates sub-sub task with query
594	V signals end of sub-sub task with utterance 'that's alright
600-623	T negotiates cessation of sub-task 'get images' by reviewing progress with S & V. At 623 S signals partial agreement with utterance 'We've got quite a few'.
600-609	T initiates the conscious self-evaluation through dialogue of the results of the sub-task 'get images'. She is offering the practical example of how such conscious self-evaluation works.
624	T initiates sub-task 'make layout drawings'. PC use stops.

Line Nos.	Description
624-626	T reiterates project stages for S and V as a means of initiating the next sub-task
624-707	Subtask 'make layout drawings', lead actor S. Main tools paper, pencil, dialogue.
637	S begins layout activity and talks aloud, marking the beginning of her formation of a more precise goal-image for the sub-task 'produce publication' and the task 'create a publication'
645	T signals that V is engaged in sub-task 'draft text'
645-707	Subtask 'draft text' lead actor V. Main tools paper, pencil, dialogue.
678-673	S & T articulate more precise image-goal for the sub-task 'produce publication'
684-686	T articulates need for more precise formulation of written (sign-verbal?) component of image goal.
687-688	More precise goal allows S to emphatically state her view on the appropriate division of Labour. Confirmed by T as the two seek to regulate V's contribution to the collective activity
691-707	In this passage, where S & V are seated together at table with paper and pencils, S repeatedly passes her hands across the paper as she speaks, gesturally indicating (to herself as much as V) where the different block elements of the page layouts should go. The image-goal is now precise enough for her to implement it directly; At 704, 705, 706, S & V quickly exchange utterances that indicate that they are both clearly visualizing an image in very similar ways- as similar as if they were both actually looking at it. At 707 S identifies that some of the text aspect is not so precisely formulated, and tells V that he must write it down. This seems to be a crucial turning point in the overall joint task solution process.
712-1098	Subtask 'produce publication'
712-802	Sub-sub-task/problem 'insert no smoking picture in publication'
713-716	Breakdown in actions to insert picture of no smoking sign – unable to locate file via Publisher dialogue
718-731	T intervenes to initiate and guide sub-subtask 'name and save publication'
730	SRH initiates recording of screen capture file [H:\DTP_Pilot_Study\screen_capture\522.mpg linked to transcript SC_52_01.]
733	T suggests recommencing sub-sub task 'get image of no smoking sign' as the breakdown in the picture insertion process has lead her to the conclusion that the sub-sub-task goal was not fulfilled, i.e. the image was not saved.
733-756	Reconstruction of sub-sub task 'get image of no smoking sign' leads to information that picture is in fact already saved
753	T's utterance indicates a) evaluation of mismatch between actual result and goal image b) T's perception of the file as an independently existing "thing"
757-764	T encourages S to reconstruct the attempted insertion of the 'no smoking' picture into the Publisher document. This again fails.
765-802	T guides S in using Windows 'Find File' utility to locate no smoking image, that also requires intervention of SRH to solve the problem. Find operation returns many results. At 782-784 T and S report a false positive as they locate the temp file in the cache.
789-802	At 789 SRH makes an intervention (physically takes mouse) which also fails at 798. S retries the insert operation having located the file in the Publisher insert dialogue box and at 802 the operation succeeds, signaled by T's utterance.
802	Sub-sub-task/problem 'insert no smoking picture in publication' finally ends in success
809	PC once again primary means of work. At this point V now sits in front of an active PC (although he does not use it). This may be to signify his inclusion in

Line Nos.	Description
	the computer-based practice.
810-1001 (Phase 1, 810-962, Phase 2, 962-1001)	Sub-sub task/problem 'create a heading'. Two distinct phases differentiated by changes in tool use, goal, strategy and configuration of the collective subject. SRH makes screen capture, [refer to file H:\DTP_Pilot_Study\screen_capture\523.mpg linked to transcript SC_52_3_01]
810-822	S is experiencing minor breakdowns and frustrations attempting to enter and format a heading for the publication. At 819 the interface produces an unexpected result in response to her keyboard input. At 822 V intervenes via an utterance and tapping the onscreen icon to suggest that S should use an alternative strategy – WordArt rather than text. **NB:** This sequence illustrates the computer as *means of work*, as various tools and objects are picked up and created. Note use of same phrase by Korpela *et al* in SJIIS. Used by Engels as synonym for means of production, see http://www.marxists.org/archive/marx/works/1881/05/21.htm
832-836	WordArt becomes primary tool of actions. S and V make the goal-image for the headline more precise, defining both the font style and color in a dialogic exchange supported by the onscreen visualization.
837-865	Sub-sub-sub-task/problem 'choose color' begins with more precise visualization of sub-sub-task 'create a heading' goal.
842-845	Breakdown caused by handling aspects of the application. Neither subject can identify any interface element controlling the color of the WordArt item under creation [see screen dumps]. In fact, the color is controlled via the shading icon, which is a monochrome button that conveys no color information – it is necessary to know this, or use the help to find out.
864-865	Resolution of breakdown by intervention of T – experienced with the application – brings sub-sub-sub-task to end.
866-893	Sub-sub-sub-task 'choose font'. Initiated and led by T. Note functionality of app does not offer preview of font type – choice must be applied then undone or overwritten, as noted by T at lines 870-1. At line 875 T expresses an imprecise goal image for the decision action. At 890-93 S & V terminate the sub-sub-sub-task by agreeing on a decision.
895-962	Sub-sub-sub-task 'define shape'. This is initiated by T at 895, then its termination is negotiated by T between lines 944-960. The failure of this task to produce an actual result that is in line with the goal-image of T (who appears focused on the time element) is construed by T as grounds for abandoning the tool in use, despite the fact that the tool was chosen by V, and appears to be producing results that are within S & V's subjectively acceptable parameters for the evaluation of the activity.
945	T introduces 'sufficiently readable' as a criteria for evaluation of the outcome of activity. At 948-951 V reformulates the goal, attempting to include this new criteria, by T rejects (diplomatically) this image-goal at 952, citing time as the main factor.
955-958	T suggests the adoption of alternative strategy and tool.
961-962	T terminates all activity by instructing S to discontinue tool use and erase all product to date.
962	At this point the sub-sub-task 'create a heading' effectively begins again, using new tools, and led by T. This could be seen as signaling the end of a breakdown – but perhaps it was only a breakdown from the point of view of T! For S and V it signals a change in strategy forced by the external (T) reformulation of the goal in informational terms (readability, time, as new informational elements). Here we see how T's goal for the whole task 'create a publication' is essentially different from that of S and V, and, because of her position of power, T enforces the realignment of S and V's activity with her goal, rather than say, S's ('making it look good', see entry for lines 425-427).

Line Nos.	Description
963-1001	T leads S through actions/operations with tools (mouse cursor, icons, menus, dialogues) and toward objects (icons, menus, dialogues, text frame, heading) step-by-step.
986	T's utterance reinforces 'readable' as a criteria for evaluation and a component of the goal.
1002-1094	Sub-sub task 'enter text'.
1003-1006	T initiates task and attempts to set a clear goal, ('put all that lot in') which she attempts to make more precise by indicating the spatial layout on the screen, touching the screen to illustrate her points. S utterance signals goal acceptance at 1006.
1011-1017	Mismatch between S's perception of the state of the tool in use (text tool cursor set at 36 point) and the actual system state (text tool cursor set at 10 point) pointed out by T.
1031	SRH makes screen capture, [refer to file H:\DTP_Pilot_Study\screen_capture\524.mpg linked to transcript SC_52_4_01]
1036-1040	T recommends the elimination of the percentage information that S and V spent some time researching and recording at lines 349-366. Again, reveals divergences in goal-visualization.
1047-1049	T indicates S (& V's) typographical error, showing how result is guided by collaboration and instruction in the ZPD – S & V could not achieve this level of accuracy without T. This also reflects/reminds us of something of the traditional division of Labour in publishing. Similar interaction between V and S at 1067.
1093-1096	T asks if S & V are happy with the actual result of activity, in the form of the onscreen document. At 1095 S responds by pointing to a section of the document saying 'that don't look together to me' – the actual result does not match with her goal image, and that component of it expressed as 'making it look good'. T replies (*sotto voce,* missing from transcript) 'yes it is' and proceeds anyway.
1099-1101	S and V's dialogue reveals absorption in the task, and the changed nature of subjectivity (one is not so individually self-conscious) in collaborative, creative (co-constructive) Labour.
1075-1096	T attempts to negotiate end of 'produce publication' subtask. Clear disparity between T's goal (finish session within time) and S's goal ('make it look good', see lines 425-427)
1098	T signals end of 'produce publication' subtask with action of sending document to printer
1113-1248	The 'evaluate project' subtask which subsumes the subtasks 'evaluate what has been produced', 'evaluate the production process' , as set out by T in the instructions at the start of the session.
1114-1119	T restates the instructions for the subtask 'evaluate what has been produced' and carefully sets out its components: 'one person from each group show the others what you did ; ...and talk us through it a bit'. She further sets out 'talk us through it a bit' as consisting of the components 'say what you did', 'say how you did it', 'say why you chose to do it like that', 'say whether you were happy with what you did', 'say whether you would do anything differently next time', in that order.
1121-1157	P contributes to the evaluation subtasks on behalf of her group
1158-1187	V briefly contributes to the evaluation subtasks on behalf of his group
1161-1164	V demonstrates the actual outcome of the printing of the publication from one of the room's two printers. The outcome is evaluated as a failure – absence of text due to lack of black ink in the printer.
1168-1187	V attempts to perform the other components of the 'evaluate what has been produced' sub-task. Accomplishes what he sees as the goal in one utterance, lines 1168-1171, which address 'say what you did', and 'say how you did it'.
1176-1180	T attempts to add something to V's account with her knowledge as group member. Here we see again the balancing of T's roles and goals in relation to S and V's activity.

Line Nos.	Description
1190-1248	D contributes to the evaluation subtasks on behalf of her group. She is the most thorough, but has to prompted by T at lines 1238-1239 to discuss division of Labour within group. There is a clear tension between group membership and self-evaluation.
1274-1276	T initiates a new subtask 'collect copies' that wasn't explicitly defined in the task instructions
1276	Transcript terminates