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co-PRINCIPAL INVESTIGATORS/co-PROJECT DIRECTORS**

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PI/PD Name: Gerry Stahl

Gender: Male Female
Ethnicity: (Choose one response) Hispanic or Latino Not Hispanic or Latino

Race:
(Select one or more)
 American Indian or Alaska Native
 Asian
 Black or African American
 Native Hawaiian or Other Pacific Islander
 White

Disability Status:
(Select one or more)
 Hearing Impairment
 Visual Impairment
 Mobility/Orthopedic Impairment
 Other
 None

Citizenship: (Choose one) U.S. Citizen Permanent Resident Other non-U.S. Citizen

Check here if you do not wish to provide any or all of the above information (excluding PI/PD name):

REQUIRED: Check here if you are currently serving (or have previously served) as a PI, co-PI or PD on any federally funded project

Ethnicity Definition:

Hispanic or Latino. A person of Mexican, Puerto Rican, Cuban, South or Central American, or other Spanish culture or origin, regardless of race.

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PI/PD Name: Robert Craig

Gender: Male Female
Ethnicity: (Choose one response) Hispanic or Latino Not Hispanic or Latino

Race:
(Select one or more)
 American Indian or Alaska Native
 Asian
 Black or African American
 Native Hawaiian or Other Pacific Islander
 White

Disability Status:
(Select one or more)
 Hearing Impairment
 Visual Impairment
 Mobility/Orthopedic Impairment
 Other
 None

Citizenship: (Choose one) U.S. Citizen Permanent Resident Other non-U.S. Citizen

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PI/PD Name: Curtis LeBaron

Gender: Male Female

Ethnicity: (Choose one response) Hispanic or Latino Not Hispanic or Latino

Race:
(Select one or more)

American Indian or Alaska Native

Asian

Black or African American

Native Hawaiian or Other Pacific Islander

White

Disability Status:
(Select one or more)

Hearing Impairment

Visual Impairment

Mobility/Orthopedic Impairment

Other

None

Citizenship: (Choose one) U.S. Citizen Permanent Resident Other non-U.S. Citizen

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PI/PD Name: Leysia Palen

Gender: Male Female
Ethnicity: (Choose one response) Hispanic or Latino Not Hispanic or Latino

Race:
(Select one or more)
 American Indian or Alaska Native
 Asian
 Black or African American
 Native Hawaiian or Other Pacific Islander
 White

Disability Status:
(Select one or more)
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 Visual Impairment
 Mobility/Orthopedic Impairment
 Other
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PI/PD Name: Tamara R Sumner

Gender: Male Female
Ethnicity: (Choose one response) Hispanic or Latino Not Hispanic or Latino

Race:
(Select one or more)
 American Indian or Alaska Native
 Asian
 Black or African American
 Native Hawaiian or Other Pacific Islander
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COVER SHEET FOR PROPOSAL TO THE NATIONAL SCIENCE FOUNDATION

PROGRAM ANNOUNCEMENT/SOLICITATION NO./CLOSING DATE/if not in response to a program announcement/solicitation enter NSF 00-2					FOR NSF USE ONLY	
NSF 00-17			09/01/00		NSF PROPOSAL NUMBER	
FOR CONSIDERATION BY NSF ORGANIZATION UNIT(S) (Indicate the most specific unit known, i.e. program, division, etc.)						
REC - RESEARCH IN TEACHING & LEARNIN						
DATE RECEIVED	NUMBER OF COPIES	DIVISION ASSIGNED	FUND CODE	DUNS# (Data Universal Numbering System)	FILE LOCATION	
				007431505		
EMPLOYER IDENTIFICATION NUMBER (EIN) OR TAXPAYER IDENTIFICATION NUMBER (TIN)		SHOW PREVIOUS AWARD NO. IF THIS IS <input type="checkbox"/> A RENEWAL <input type="checkbox"/> AN ACCOMPLISHMENT-BASED RENEWAL		IS THIS PROPOSAL BEING SUBMITTED TO ANOTHER FEDERAL AGENCY? YES <input type="checkbox"/> NO <input checked="" type="checkbox"/> IF YES, LIST ACRONYMS(S)		
84600555						
NAME OF ORGANIZATION TO WHICH AWARD SHOULD BE MADE			ADDRESS OF AWARDEE ORGANIZATION, INCLUDING 9 DIGIT ZIP CODE			
University of Colorado at Boulder			East Campus - Room 481, Campus Box 572			
AWARDEE ORGANIZATION CODE (IF KNOWN)			3100 Marine Street			
0013706000			Boulder, CO. 803090572			
NAME OF PERFORMING ORGANIZATION, IF DIFFERENT FROM ABOVE			ADDRESS OF PERFORMING ORGANIZATION, IF DIFFERENT, INCLUDING 9 DIGIT ZIP CODE			
PERFORMING ORGANIZATION CODE (IF KNOWN)						
IS AWARDEE ORGANIZATION (Check All That Apply) (See GPG II.D.1 For Definitions) <input type="checkbox"/> FOR-PROFIT ORGANIZATION <input type="checkbox"/> SMALL BUSINESS <input type="checkbox"/> MINORITY BUSINESS <input type="checkbox"/> WOMAN-OWNED BUSINESS						
TITLE OF PROPOSED PROJECT ROLE Preproposal: The Role of Computational Cognitive Artifacts in Collaborative Learning						
REQUESTED AMOUNT \$ 0		PROPOSED DURATION (1-60 MONTHS) 36 months		REQUESTED STARTING DATE 04/01/01		SHOW RELATED PREPROPOSAL NO., IF APPLICABLE
CHECK APPROPRIATE BOX(ES) IF THIS PROPOSAL INCLUDES ANY OF THE ITEMS LISTED BELOW						
<input type="checkbox"/> BEGINNING INVESTIGATOR (GPG 1.A.3)			<input type="checkbox"/> VERTEBRATE ANIMALS (GPG II.D.12) IACUC App. Date _____			
<input type="checkbox"/> DISCLOSURE OF LOBBYING ACTIVITIES (GPG II.D.1)			<input type="checkbox"/> HUMAN SUBJECTS (GPG II.D.12)			
<input type="checkbox"/> PROPRIETARY & PRIVILEGED INFORMATION (GPG II.D.10)			Exemption Subsection _____ or IRB App. Date _____			
<input type="checkbox"/> NATIONAL ENVIRONMENTAL POLICY ACT (GPG II.D.10)			<input type="checkbox"/> INTERNATIONAL COOPERATIVE ACTIVITIES: COUNTRY/COUNTRIES _____			
<input type="checkbox"/> HISTORIC PLACES (GPG II.D.10)			<input type="checkbox"/> FACILITATION FOR SCIENTISTS/ENGINEERS WITH DISABILITIES (GPG V.G.)			
<input type="checkbox"/> SMALL GRANT FOR EXPLOR. RESEARCH (SGER) (GPG II.D.12)			<input type="checkbox"/> RESEARCH OPPORTUNITY AWARD (GPG V.H)			
PI/PD DEPARTMENT ICS/Computer Science, Campus Box 430			PI/PD POSTAL ADDRESS University of Colorado at Boulder			
PI/PD FAX NUMBER 303-492-2844			Boulder, CO 803090430			
			United States			
NAMES (TYPED)	High Degree	Yr of Degree	Telephone Number	Electronic Mail Address		
Gerry Stahl	Ph.D.	1993	303-492-3912	gerry.stahl@colorado.edu		
Robert Craig	Ph.D.	1976	303-492-6498	Robert.Craig@colorado.edu		
Curtis LeBaron	Ph.D.	1998	303-492-7488	curtis.lebaron@colorado.edu		
Leysia Palen	Ph.D.	1998	303-492-3902	palen@cs.colorado.edu		
Tamara R Sumner	Ph.D.	1995	303-492-2233	sumner@colorado.edu		

CERTIFICATION PAGE

Certification for Principal Investigators and Co-Principal Investigators:

I certify to the best of my knowledge that:

- (1) the statements herein (excluding scientific hypotheses and scientific opinions) are true and complete, and
 (2) the text and graphics herein as well as any accompanying publications or other documents, unless otherwise indicated, are the original work of the signatories or individuals working under their supervision. I agree to accept responsibility for the scientific conduct of the project and to provide the required progress reports if an award is made as a result of this proposal.

I understand that the willful provision of false information or concealing a material fact in this proposal or any other communication submitted to NSF is a criminal offense (U.S.Code, Title 18, Section 1001).

Name (Typed)	Signature	Social Security No.*	Date
PI/PD Gerry Stahl		*ON FASTLANE SUBMISSIONS* SSNs are confidential and are not displayed	
Co-PI/PD Robert Craig			
Co-PI/PD Curtis LeBaron			
Co-PI/PD Leysia Palen			
Co-PI/PD Tamara R Sumner			

Certification for Authorized Organizational Representative or Individual Applicant:

By signing and submitting this proposal, the individual applicant or the authorized official of the applicant institution is: (1) certifying that statements made herein are true and complete to the best of his/her knowledge; and (2) agreeing to accept the obligation to comply with NSF award terms and conditions if an award is made as a result of this application. Further, the applicant is hereby providing certifications regarding Federal debt status, debarment and suspension, drug-free workplace, and lobbying activities (see below), as set forth in Grant Proposal Guide (GPG), NSF 00-2. Willful provision of false information in this application and its supporting documents or in reports required under an ensuring award is a criminal offense (U. S. Code, Title 18, Section 1001).

In addition, if the applicant institution employs more than fifty persons, the authorized official of the applicant institution is certifying that the institution has implemented a written and enforced conflict of interest policy that is consistent with the provisions of Grant Policy Manual Section 510; that to the best of his/her knowledge, all financial disclosures required by that conflict of interest policy have been made; and that all identified conflicts of interest will have been satisfactorily managed, reduced or eliminated prior to the institution's expenditure of any funds under the award, in accordance with the institution's conflict of interest policy. Conflict which cannot be satisfactorily managed, reduced or eliminated must be disclosed to NSF.

Debt and Debarment Certifications

(If answer "yes" to either, please provide explanation.)

Is the organization delinquent on any Federal debt?

Yes

No

Is the organization or its principals presently debarred, suspended, proposed for debarment, declared ineligible, or voluntarily excluded from covered transactions by any Federal department or agency?

Yes

No

Certification Regarding Lobbying

This certification is required for an award of a Federal contract, grant, or cooperative agreement exceeding \$100,000 and for an award of a Federal loan or a commitment providing for the United States to insure or guarantee a loan exceeding \$150,000.

Certification for Contracts, Grants, Loans and Cooperative Agreements

The undersigned certifies, to the best of his or her knowledge and belief, that:

(1) No federal appropriated funds have been paid or will be paid, by or on behalf of the undersigned, to any person for influencing or attempting to influence an officer or employee of any agency, a Member of Congress, an officer or employee of Congress, or an employee of a Member of Congress in connection with the awarding of any federal contract, the making of any Federal grant, the making of any Federal loan, the entering into of any cooperative agreement, and the extension, continuation, renewal, amendment, or modification of any Federal contract, grant, loan, or cooperative agreement.

(2) If any funds other than Federal appropriated funds have been paid or will be paid to any person for influencing or attempting to influence an officer or employee of any agency, a Member of Congress, an officer or employee of Congress, or an employee of a Member of Congress in connection with this Federal contract, grant, loan, or cooperative agreement, the undersigned shall complete and submit Standard Form-LLL, "Disclosure Form to Report Lobbying," in accordance with its instructions.

(3) The undersigned shall require that the language of this certification be included in the award documents for all subawards at all tiers including subcontracts, subgrants, and contracts under grants, loans, and cooperative agreements and that all subrecipients shall certify and disclose accordingly.

This certification is a material representation of fact upon which reliance was placed when this transaction was made or entered into. Submission of this certification is a prerequisite for making or entering into this transaction imposed by section 1352, title 31, U.S. Code. Any person who fails to file the required certification shall be subject to a civil penalty of not less than \$10,000 and not more than \$100,000 for each such failure.

AUTHORIZED ORGANIZATIONAL REPRESENTATIVE	SIGNATURE	DATE
NAME/TITLE (TYPED) Laurence D. Nelson, Director, OCG		08/31/00
TELEPHONE NUMBER 303-492-6221	ELECTRONIC MAIL ADDRESS Larry.Nelson@colorado.edu	FAX NUMBER 303-492-6421

*SUBMISSION OF SOCIAL SECURITY NUMBERS IS VOLUNTARY AND WILL NOT AFFECT THE ORGANIZATION'S ELIGIBILITY FOR AN AWARD. HOWEVER, THEY ARE AN INTEGRAL PART OF THE INFORMATION SYSTEM AND ASSIST IN PROCESSING THE PROPOSAL. SSN SOLICITED UNDER NSF ACT OF 1950, AS AMENDED.

THE ROLE OF COMPUTATIONAL COGNITIVE ARTIFACTS IN COLLABORATIVE LEARNING AND EDUCATION

PROJECT SUMMARY

This project builds on cognitive science theories of the role of artifacts in learning, understanding and working. It also adapts methods of human interaction analysis – based on detailed study of digitized video recordings – to the investigation of the use of computer-based simulations and communication media in collaborative learning settings. It thereby develops and tests a methodology for the field of CSCL (computer-supported collaborative learning).

This methodology allows researchers to investigate sessions of collaborative learning by describing interactions of participants with artifacts, expressed through discourse patterns and social practices. Specifically, computer support systems are also conceptualized as artifacts, so the methodology includes assessment of how particular software systems are adopted and whether their designs are effective in usage. In contrast to prevailing methodologies for educational technology that are based on psychological theories of individual learners, this methodology is grounded in social theories of human interaction and is therefore especially suited to the support of collaborative learning.

The project studies how a small group of middle school students learns to use a computer simulation of rocket launches as a tool for scientific knowledge-building. As the project goes on, this simulation is incorporated into an on-line environment for knowledge-building. The research methodology is then adapted for virtual collaboration and provides formative evaluation for the computer simulation, the collaboration software and the classroom pedagogy. The goal is to have the students treat the simulation as more than a video game, the communication medium as more than a chat room for unreflective opinions and the curriculum as more than a series of isolated exercises. The project aims to understand in a detailed way how the artifacts participate in deeper collaborative knowledge-building processes.

The proposed project fits in ROLE's quadrant 2 because it builds bridges from the cognitive sciences and human interaction analysis to research on learning. It also fits in quadrant 3 because it extends an existing research base to support specific educational approaches within CSCL.

The interdisciplinary project team includes faculty and students from cognitive science, communication, computer science and education. They have conducted a number of pilot studies to explore various aspects of the project and they bring together the necessary mix of backgrounds. In particular, the team consists of researchers who have conducted pioneering work in human interaction analysis, CSCL theory and design of computational media. The project synthesizes this work to produce a much needed methodology for the design and development of computer support for education, grounded in an expanded theoretical understanding of the role of computational cognitive artifacts in collaborative learning.

TABLE OF CONTENTS

For font size and page formatting specifications, see GPG section II.C.

Section	Total No. of Pages in Section	Page No.* (Optional)*
Cover Sheet (NSF Form 1207) (Submit Page 2 with original proposal only)		
A Project Summary (not to exceed 1 page)	1	_____
B Table of Contents (NSF Form 1359)	1	_____
C Project Description (plus Results from Prior NSF Support) (not to exceed 15 pages) (Exceed only if allowed by a specific program announcement/solicitation or if approved in advance by the appropriate NSF Assistant Director or designee)	7	_____
D References Cited	4	_____
E Biographical Sketches (Not to exceed 2 pages each)	6	_____
F Budget (NSF Form 1030, plus up to 3 pages of budget justification)	0	_____
G Current and Pending Support (NSF Form 1239)	0	_____
H Facilities, Equipment and Other Resources (NSF Form 1363)	0	_____
I Special Information/Supplementary Documentation	0	_____
J Appendix (List below.) (Include only if allowed by a specific program announcement/ solicitation or if approved in advance by the appropriate NSF Assistant Director or designee)	_____	_____
Appendix Items:		

*Proposers may select any numbering mechanism for the proposal. The entire proposal however, must be paginated. Complete both columns only if the proposal is numbered consecutively.

THE ROLE OF COMPUTATIONAL COGNITIVE ARTIFACTS IN COLLABORATIVE LEARNING AND EDUCATION

PROJECT DESCRIPTION

Motivation

Much of the focal activity in school and work centers around physical and/or symbolic artifacts. Increasingly, these are “*computational cognitive artifacts*,” that is, computer-based systems such as *simulations* or conferencing *media* that extend our ability to visualize, analyze, communicate and learn. Astrophysicists, for instance, model on mainframes phenomena that cannot otherwise be studied under controlled conditions; science students use computer simulations to observe idealized interactions. The Web was originally created for physicists to share the latest theories of subatomic matter; knowledge-building environments like CSILE (Scardamalia & Bereiter, 1996) are now being developed to let students collaborate on theories of everyday observable phenomena.

Recent trends in the cognitive sciences stress the central role that artifacts play in modern human cognition. The literature in CSCL (computer-supported collaborative learning) picks up on this view and relates it to learning in social settings. There are many suggestive remarks about the cognitive function of artifacts in writings from anthropology (Donald, 1991; Geertz, 1973; Hutchins, 1996; Hutchins, 1999; Hutchins & Palen, 1998; Suchman, 1987), cultural psychology (Bruner, 1990; Cole, 1996; Engeström, 1999; Norman, 1993; Vygotsky, 1930/1978), philosophy (Gadamer, 1960/1988; Hegel, 1807/1967; Heidegger, 1927/1996; Husserl, 1936/1989; Marx, 1867/1976; Wittgenstein, 1953), CSCL (Bereiter, 2000; Ehn, 1988; Keil-Slawik, 1992; Koschmann, 1999; Roschelle, 1996; Stahl, 2000b), cultural theory (Bakhtin, 1986; Benjamin, 1936/1969; Hall, 1996; Heidegger, 1935/1964; Wenger, 1998) and communication and social theory (Bourdieu, 1972/1995; Giddens, 1984; Habermas, 1981/1984; Lakoff, 1987; LeBaron & Streeck, 2000; Streeck, 1996). However, *there is no cohesive account of how people acquire understanding of the meaning of new artifacts or develop the skills required in using them effectively*. We are therefore studying the texts referred to in the preceding citations as a preliminary to the proposed project. Based on these texts and empirical classroom evidence, the project will try to formulate the needed cohesive account.

Methodological extensions to conversational analysis developed in the past decade provide a promising access on a micro-ethnographic level to the processes involved in learning to use artifacts, including computational cognitive artifacts. The adoption and use of artifacts in collaborative settings takes place within complex interactions involving: (i) artifacts that have affordances, (ii) people who bring perspectives to bear, (iii) social practices reflecting various cultures and (iv) discourse patterns or mini-genres. The conversation analysis approach grounds its interpretation of these interactions in evidence of how the participants take each other’s utterances (Heritage, 1990). It thereby provides access to actual phenomena of learning as they unfold (typically recorded on digitized video to allow for detailed study). A very different view of learning emerges from this approach than that provided by comparing results on pre- and post-tests to infer that specific facts or skills were somehow acquired by individuals. There have been scattered attempts by other researchers in CSCL and CSCW (e.g., Bødker, 1996; Roschelle, 1996; Suchman & Trigg, 1991) to use video analysis, and we will be incorporating and extending their work within our project.

The field of CSCL holds great promise for the future of education with its dual emphasis on collaboration and computational artifacts; both of these potentially overcome the limitations of the unaided individual mind. But *there is today no adequate methodology* – grounded in theory and research – *for the design of CSCL artifacts*. Current assessment of educational technology relies on either pre/post testing of individuals or coding of isolated statements – both of which systematically exclude evidence of the interaction processes by which collaborative knowledge is socially constructed. The proposed project brings together experienced researchers in micro-ethnography, collaborative learning and computational support. Focused on empirical study of middle school science education, this project will develop,

investigate and assess a much needed, theoretically grounded, socially-oriented methodology for observing the effects of computational artifacts in the classroom.

Pilot Studies

We have conducted three pilot studies to explore a methodology for studying the adoption and use of computational cognitive artifacts in settings of collaboration and education:

- (a) A scientist mentors a small group of middle school students conducting a project using *SIMROCKET*, a computer simulation of rocket launches. Micro-ethnographic analysis of this three-hour interaction highlights successes and difficulties the students encounter in learning to use the simulation as an experimental tool, in negotiating goals for investigation, in coordinating data collection, in analyzing results and in drawing rigorous conclusions. We track the development of individuals' theories and the gradual adoption by the group of the scientist's systematic approach and of his comparatively precise formulations. At the same time, we observe how various proposals by individuals are negotiated and taken up within the group. We watch artifacts (the simulation, instruction page and data sheet) become meaningful and cognitively effective through their integration within gradually adopted social practices (taking and sharing data; computing results; deducing conclusions) and discourse patterns (stating hypotheses; presenting evidence; arguing for theories; referencing artifacts).
- (b) *WEBGUIDE*, a knowledge-building environment for discussing topics via the Web, is used in a middle school environmental science class and in college seminars on CSCL (Stahl, 1999b). This software is being revised and extended in response to the findings of its use in such settings. *WEBGUIDE* goes beyond similar discussion-based systems by supporting the representation and development of personal and group perspectives (Stahl, 1999a). Eventually, we will use it to facilitate and scaffold a group of students to use a simulation like that in (a) within an on-line, purely computer-supported interaction.
- (c) *JIME*, a Web-based journal for interactive media in education, conducts group reviews of submitted articles on-line, and then includes an edited version of the review discourse with the published article (JIME, 1996-2000). We are currently analyzing the on-line review discussions to draw conclusions about how the journal software and practices might be improved. This study provides an example of how to analyze on-line discourse, extending the methods of conversation analysis.

Research Project

We propose to replicate our pilot study of *SIMROCKET* more rigorously and under varying conditions. We will improve the technical recording conditions to produce a higher quality record for transcription and analysis. We will use different teachers with different styles and different groups of students at somewhat different ages. The *SIMROCKET* simulation and its supports (e.g., a spreadsheet for data analysis) will be modified. For instance, students may be empowered to construct rockets with different selections of characteristics.

As is clear from our pilot studies, simply sitting students in front of a computational artifact will not automatically build knowledge. The teacher, curriculum and established social practices play essential roles, which will be investigated in the project. For instance, in the *SIMROCKET* pilot we observed the teacher repeatedly modeling patterns of behavior, analysis, questioning and articulating. The students were observed gradually adopting some of these. The enormous complexity of the challenge to middle school students presented by a simple simulation becomes increasingly clear as one carefully studies their activities in transcribed video segments.

Later in the project we will move from face-to-face to virtual collaboration. Without the detailed study of the face-to-face interactions it would be impossible to design effective online scaffolding. We will adopt our methodology to observe the new interactions associated with new computational artifacts like *WEBGUIDE*. Our pilot studies of online collaboration indicate that much of the analysis of interaction in

video transcripts can be adapted to online logs, although with changes in the execution and meaning of turn-taking and other features.

This project will produce a methodology for observing the understanding, adoption and use of computational cognitive artifacts – that is, a methodology for studying collaborative learning and for studying the effectiveness of software supports. Specifically, the project will analyze at a micro-ethnographic level how middle school students adopt scientific practices in the use of computational cognitive artifacts. How does the understanding, adoption and use of such artifacts take place within the development and interplay of culturally regulated social practices and discourse patterns? And then how do these artifacts function within cognitive and collaborative activities as evidenced in behavior and speech? The project will also explore how Web-based media can support such learning in formal settings of collaboration. It will contribute a methodology that spans face-to-face synchronous and on-line asynchronous interaction. Such a methodology is desperately needed in order to make significant and systematic progress in CSCL as a research field.

Theoretical Framework

We start from three principles enunciated by Vygotsky (1930/1978; 1934/1986):

- (1) *Mediated cognition*. Modern adult human cognition is thoroughly mediated by physical and symbolic artifacts such as tools and words. We extend this to the use of computer-based artifacts like simulations and discussion media.
- (2) *Social cognition*. Meanings and practices are first established interpersonally and may then be internalized in individual minds. We take advantage of this by analyzing the interpersonal interactions, which are largely observable to the trained analyst as well as to the participants.
- (3) *Zone of proximal development*. A student learns most productively when guided somewhat beyond his or her current skill level by peers or a mentor. We use this principle to design experimental situations in which a small group of students is challenged to engage in a scaffolded scientific task.

We conceptualize our subject matter as the process of “*knowledge-building*” (Bereiter, 2000). This is an active collaborative learning process in which a small community constructs *conceptual* meaning. For instance, in pilot study (a) the participants come to understand the effect of different variables upon future rocket launches; in study (b) students develop interpretations of texts; and in study (c) reviewers build a consensual critique of an article. The process of collaborative knowledge-building is interpersonal and observable – primarily through analysis of the discourse through which it takes place.

Collaborative knowledge-building involves an interplay between individuals and the group, with individuals contributing from their personal perspectives and the group accepting these contributions in its own way (Stahl & Herrmann, 1999). This perspective-taking and perspective-making unfolds in the observable world of signs and artifacts, such as spoken utterances and external memory devices (Boland

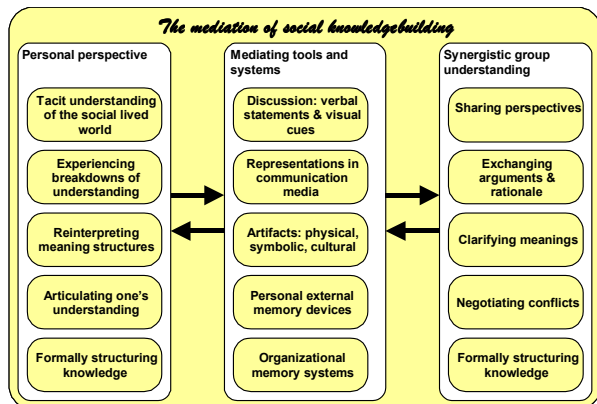


Figure 1. A theoretical framework for analyzing the mediation of social knowledge-building.

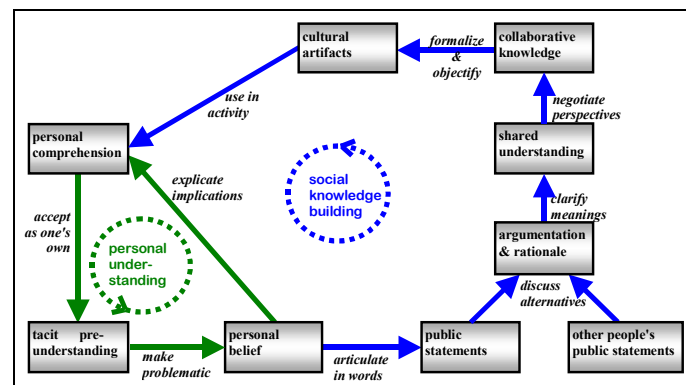


Figure 2. A prototypical cycle of social knowledge-building activities.

& Tenkasi, 1995). The physical and symbolic artifacts mediate between personal and group understandings (see figure 1).

The social perspective of our theoretical framework provides conceptual unity to the project. We are interested in supporting collaborative knowledge-building, seen as a social process. Our methodology is designed to analyze that process as it displays itself intersubjectively. We view our computational artifacts – simulations and media – as components and facilitators of the social process underlying educational practices.

Educational Technologies Used and Developed

Computer and network technology allows us to design new mediating artifacts that can support collaboration and knowledge-building by extending cognitive powers (to imagine, analyze, express) and by facilitating collaboration (virtual, asynchronous, non-linear, persistent, perspectival, personalizable, creating complex and evolving communities) (Stahl, 1999a; Stahl, 2000a). But this potentially limitless transformation of knowledge-building requires an understanding of various activities and social processes in collaborative learning. Figure 2 provides a model of a prototypical process of knowledge-building that reflects our initial understanding (Stahl, 2000b).

Ideally, we would like to support each activity in this social knowledge-building cycle. To that end, we have developed a number of software prototypes that provide designed media for asynchronous discussion and knowledge-building. As indicated in the table, they support many of the activities identified in our models:

<i>Knowledge-building activities</i>	<i>Forms of computer support</i>	<i>Prototype systems</i>
articulate in words	discussion forum	DYNACLASS
discuss alternatives	personal & group perspectives	WEBGUIDE
argumentation & rationale	argumentation graph	INFOMAP
clarify meanings	interactive glossary	DYNAGLOSS
negotiate perspectives	negotiation support	WEBGUIDE
formalize and objectify	interactive bibliography	DYNASOURCE

During the life of our project we will integrate versions of SIMROCKET into WEBGUIDE. We will extend WEBGUIDE to include useful features of the other prototypes. We will also incorporate student scaffolding – such as that used in the KIE/WISE project (Cuthbert, 1999) – based on our analysis of the role of the mentor in our studies of students interacting face-to-face.

Project Team

The project team builds on three unique research strengths:

1. The Center for LifeLong Learning and Design (L³D) at the University of Colorado at Boulder (CU) specializes in developing computer support for collaborative learning. The Center is part of the Department of Computer Science as well as the Institute of Cognitive Science. Stahl, Sumner, and Palen are faculty at L³D with joint appointments in computer science and cognitive science. They have designed, implemented and studied the adoption of numerous computational artifacts and digital communication media.
2. The Communication Department at CU has brought together a group of researchers who specialize in micro-analysis of communicative interactions. Professors LeBaron and Craig are leaders of this group, which includes faculty and students from Education and Linguistics as well as Communication. The group has held collaborative data sessions for several years, usually every other Wednesday.
3. The Problem-Based Learning Institute (PBLI) at the Medical School of Southern Illinois University studies collaboration within the long-established PBL approach to medical education implemented there. This approach stresses collaborative learning in small groups. Koschmann is a researcher at

PBLI and a leader in the field of Computer-Supported Collaborative Learning, having organized the first two international conferences on CSCL in North America (CSCL '95 and CSCL '97) and edited two major books on the field (Koschmann, 1996; Koschmann et al., in prep).

These three groups were brought together two years ago when Koschmann spent a year at L³D and taught a seminar on CSCL. He was active in the data sessions organized by the Communication Department, and initiated a number of on-going collaborations among the three groups.

Stahl combines his backgrounds in cognitive science, philosophy and computer science to look at collaboration simultaneously from the perspective of social learning theory and from that of practical issues of technological support. He is developing a theory of collaborative knowledge-building that stresses the long-range potential of CSCL to open new cognitive possibilities, so that virtual groups can construct deeper knowledge structures than have been possible in the past. He has also designed, implemented, and field-tested Web-based systems for supporting collaborative online discussions from personal and group perspectives. He conducts seminars on CSCL, trying out the software to be used in the proposed project. He is the Program Chair of the next international CSCL conference.

Craig has developed a meta-theory of communication theory as a form of professional discourse. His research also focuses on student discussion in university-level critical thinking courses. Thus, he has looked at the collaborative knowledge-building process on the level of professional communities as well as that of groups of college students, using micro-ethnographic analysis of discourse and of social practices.

Koschmann has explored collaborative learning and CSCL at both theoretical and practical levels. He has written on the prominent theoretical frameworks for CSCL (from Dewey, Piaget, and Bakhtin to situated cognition and activity theory). He has also engaged in micro-ethnographic analysis of episodes of collaborative problem-based learning, in order to understand how best to conduct PBL sessions.

LeBaron is an authority on the use of human interaction analysis and micro-ethnography to study language usage and social interaction. He uses video analysis to get at detailed social interactions that generally go unnoticed but may play important tacit roles. For instance, he has studied the use of bodily gesture and physical space – dimensions usually excluded from computer-mediated interaction. An innovator of the micro-ethnographic methodology, LeBaron organizes an annual national workshop on “Language and Social Interaction.”

Palen currently studies the use of computational artifacts (like groupware calendar systems and wireless telephony) in collaborative settings. She has also used micro-ethnography methods to study the construction of shared meaning and collaborative knowledge through discourse and non-verbal interaction.

Sumner conducts research in scholarly discourse and how it can be supported with computer technology. A founder and co-editor of the on-line *Journal of Interactive Media in Education*, she is currently analyzing the discourse structure of on-line reviews of submitted articles. She previously developed distance education curriculum at the Open University in England.

An important part of the team will be **undergraduate and graduate students** and other colleagues. The project will hire several students. They will be recruited from the departments of Education, Communication and Computer Science. The following will likely be involved: Alena Sanusi, a communication student with strong background in linguistics and conversation analysis; Elizabeth Lenell, an education student specializing in CSCL, also with strong background in linguistics and conversation analysis; Leo Burd, a computer science student with experience in technology adoption in schools in impoverished areas. Other students will be involved through L³D's Undergraduate Research Apprenticeship Program, related student projects in various classes, relevant dissertation topics, and participation in seminars that are studied within the project. It is anticipated that the proposed project will significantly increase interdisciplinary contact among researchers – both faculty and student – at CU.

Another important part of the team will be **teachers and middle school students**. The project will start by working with the teachers who were involved in the *SIMROCKET* pilot project at Platt Middle School in

Boulder. Three teachers there work as a collaborative team to teach two classrooms in a very project-oriented way.

Method of Investigation and Assessment

We adopt a recent tradition of human interaction analysis (Jordan & Henderson, 1995) that we refer to as “micro-ethnography.” This methodology builds on a combination of conversation analysis (Sacks, 1992) and context analysis (Kendon, 1990). An integration of these methods has only recently become possible with the availability of videotaping and digitization that records interpersonal interactions and facilitates detailed analysis. It has been successfully applied to diverse concerns, such as police brutality (Goodwin & Goodwin, 1994), criminal recidivism (LeBaron & Hopper, 1997), medical education (LeBaron & Koschmann, 1999). Micro-ethnography as we use it can be described as one discernable area of emphasis within the field of language and social interaction. Presently, micro-ethnographic research involves (1) a specific setting, or research site; (2) a detailed analysis of both audible and visible micro-behaviors, which are to be understood in terms of their embeddedness within the particular social and material environment; (3) a recognition that culture is a product and a process of naturally-occurring communication, experienced by participants who at the same time make it available for empirical study and interpretation; (4) a displayed awareness of sociopolitical concerns that are in some way addressed, consistent with the notion that societal macro-structures are embodied and sustained through moment-to-moment, face-to-face interaction; and (5) a noteworthy use, perhaps dependence, upon recent technologies, whereby analysts may look and sometimes see anew the orderly performance of social life.

Faculty of the Communication Department who specialize in studies of human interaction regularly host a series of interdisciplinary micro-ethnographic data sessions. Over time, these meetings have involved faculty and students in Communication, Linguistics, Education, Speech Language & Hearing Sciences, Computer Science, and other fields. Participants meet informally to share recordings of human communication (video, audio, field notes, etc.) for group discussion. The recordings are drawn from ongoing research projects, and often are presented during exploratory or early phases of data collection and analysis. Short data segments, usually accompanied by written transcripts, are observed repeatedly and discussed. One important goal of data sessions is to generate insights, grounded in close observation from a variety of analytical viewpoints, that will be useful in the particular research project from which the data have been selected. A second, perhaps equally important goal is to cultivate observational and analytical skills among an interdisciplinary community of researchers involved in empirical studies of human interaction.

We will build on this approach and on the expertise and methodology which has evolved through these data sessions. We will conduct our own data sessions for project staff, working intensively with our data. We have already begun a series of sessions to collaboratively analyze our SIMROCKET pilot study data. After producing a log of the three hour student/teacher interaction, we selected 24 moments (segments averaging a minute) to digitize, transcribe, post on the Web and discuss. These moments cover many themes for analysis relevant to the proposed project.

The method of micro-ethnographic analysis provides a built-in evaluation process for the project. By videotaping our sessions of students working with artifacts, we will derive a formative evaluation of the learning facilitated by the artifact. By the end of the project, we will be able to compare in a detailed and documented way how well our revised versions of SIMROCKET and WEBGUIDE perform as compared to how they worked in the pilot studies and in earlier phases of the project. In addition, we will evaluate how successful we were in the course of the project in developing, formulating and applying this methodology for studying the educational role of cognitive artifacts and for assessing the ability of students to adopt the computational artifacts into their collaborative learning.

Contribution to NSF ROLE Goals and Potential Impact

Recent research on learning and on technology in education – as surveyed in the *Report to the President* (Panel on Educational Technology, 1997) and in *How People Learn* (Bransford et al., 1999) – stresses the potential of innovative constructivist educational approaches to foster deep understanding. The latter

document, for instance, argues that key learning processes are “affected by the degree to which learning environments are student centered, knowledge centered, assessment centered, and community centered” (Executive Summary). It also concludes that computer technology “has great potential to enhance student achievement and teacher learning, but only if it is used appropriately” (Ch. 9).

Our project proposes to investigate at a detailed level the key learning processes in a student-centered, knowledge-building, problem-based, collaborative-community learning environment – whether computer-supported or not. We hypothesize that *collaborative learning* has a great potential to foster deep knowledge-building when it brings together the perspectives of multiple students in a productive way. However, this requires a more detailed understanding of how collaborative knowledge-building processes work. We further hypothesize that *computer support* has the potential to facilitate collaboration by removing communication limitations and by helping to manage the complexity of ideas and interactions. However, this requires carefully designed knowledge-management applications tuned to the needs of collaborative learning.

We believe that a collaborative approach to learning and computer support in education can have a transformative impact if adopted in a fundamental way rather than being merely integrated into schooling focused on individual learning. Collaborative learning should take advantage of the social origins of all knowledge and should foster integration of multiple perspectives. Computer support can facilitate the complex interactions needed for productive collaboration by providing appropriate external memories and communication media that allow participants to interact without, for instance, always going through a teacher. Our project will increase our understanding of the social origins of knowledge and develop a methodology for assessing the role of computational cognitive artifacts in supporting collaborative knowledge-building.

While ROLE projects related to neuroscience may focus quite literally inside the head of an individual learner, this project will look outside at the social interactions through which knowledge is constructed and shared – and at the same time evidenced – in educational settings. The project is situated in ROLE’s quadrant 2 because it builds bridges from the cognitive sciences to research on learning and undertakes detailed micro-ethnographic studies of educational environments. It is also situated in quadrant 3 because it is building a stronger research base to support educational approaches (e.g., scaffolded collaborative small groups), curriculum materials (*SIMROCKET* experiments) and technological tools (*WEBGUIDE*) to mediate the learning process. In particular, the project builds on diverse cognitive theories of the role of artifacts and on methods of conversation analysis and micro-ethnography in order to develop and refine new education research and evaluation methods for analyzing the role of computational cognitive artifacts in collaborative learning and education.

Project Cost Summary

The major costs for this project are salary. We have budgeted for 6 months of the PI’s (Stahl) time, 1 month for each of the other faculty, 3 graduate research assistants, 2 undergraduate research apprentices and release time for teachers. The total budget is about \$250,000 per year for three years.

THE ROLE OF COMPUTATIONAL COGNITIVE ARTIFACTS IN COLLABORATIVE LEARNING AND EDUCATION

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<http://www.umich.edu/~icls/proceedings/abstracts/ab70.html>.
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- Streeck, J. (1996) How to do things with things, *Human Studies*, 19 , pp. 365-384.

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- Vygotsky, L. (1934/1986) *Thought and Language*, MIT Press, Cambridge, MA.
- Wenger, E. (1998) *Communities of Practice*, Cambridge University Press, Boston, MA.
- Wittgenstein, L. (1953) *Philosophical Investigations*, Macmillan, New York, NY.

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Professional Appointments

- 1999-present **Research Professor**
Department of Computer Science and
Institute of Cognitive Science, Boulder, CO
- 1996-99 **Post Doctoral Research Fellow**
Center for LifeLong Learning and Design, Boulder, CO

Education

- 1993 **University of Colorado**
Ph.D. in Computer Science
- 1990 **University of Colorado**
M.S. in Computer Science
- 1975 **Northwestern University**
Ph.D. in Philosophy
- 1971 **Northwestern University**
M.A. in Philosophy
- 1973 **University of Frankfurt**
Graduate study in critical social theory
- 1968 **University of Heidelberg**
Graduate study in continental philosophy
- 1967 **Massachusetts Institute of Technology (MIT)**
B.S. in Humanities & Science (Math & Philosophy)

Research Interests

Theory of collaborative knowledge-building, educational technology, computer supported collaborative learning, knowledge-building environments on the Web, digital external memories for groups, situated cognition, social theory, mediation of cognition by cultural artifacts and technology, new forms of computer-mediated collaborative cognition.

Related Publications

- Stahl, G. (2000) Collaborative information environments to support knowledge construction by communities, *AI & Society*, 14, pp. 1-27. Available at: <http://www.cs.colorado.edu/~gerry/publications/journals/ai&society/>.
- Stahl, G. (2000) A model of collaborative knowledge-building, In: *Proceedings of International Conference of the Learning Sciences (ICLS 2000)*, Ann Arbor, MI. <http://www.cs.colorado.edu/~gerry/publications/conferences/2000/icls/>
- Stahl, G. (1999) Reflections on WebGuide: Seven issues for the next generation of collaborative knowledge-building environments, In: *Proceedings of Computer Supported Collaborative Learning (CSCL '99)*, Palo Alto, CA, pp. 600-610. Available at: <http://www.cs.colorado.edu/~gerry/publications/conferences/1999/csl99>.
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Professional Appointments

- 1990- **University of Colorado at Boulder**, Department of Communication;
Associate Professor with tenure
- 1981-1990 **Temple University**, Department of Rhetoric and Communication (Speech before 1988);
Associate Professor with tenure (1984); Assistant Professor (1981)
- 1979-1981 **University of Illinois at Chicago Circle**, Department of Communication and Theatre;
Assistant Professor
- 1975-1979 **Pennsylvania State University**, University Park, Department of Speech Communication;
Assistant Professor
- 1978 (Spring) **University of Wisconsin-Madison**, Department of Communication Arts;
Visiting Assistant Professor
- 1973 (Spring) **American University of Beirut**, Mass Communication Program; Visiting Assistant Professor

Education

- Ph.D. in Communication, Michigan State University, 1976
- M.A. in Communication, Michigan State University, 1970
- B.A. in Speech, University of Wisconsin - Madison, 1969

Research Interests

Professor Craig is a communication theorist with a particular interest in theory as discourse and its role in cultivating reflective practices. His more than fifty academic publications have addressed a variety of research topics and issues in communication theory, including cognitive effects, conversational coherence, strategies and goals in discourse, argumentation, the epistemological foundations of communication as a practical discipline, and the intellectual structure of communication theory as a field. A current project involves close discourse analysis of student discussions in a sample of university-level critical thinking classes. The goal of this research is to describe the meta-discursive vocabularies that student discussants use for managing their interaction, especially the ways in which formal argumentation and critical thinking concepts are adapted and used in practice.

Related Publications

- Craig, R. T., & Sanusi, A. L. (in press). "I'm just saying": Discourse markers of standpoint continuity. *Argumentation*.
- Craig, R. T. (1999). Metadiscourse, theory, and practice. *Research on Language and Social Interaction*, **32**(1), 21-29.
- Craig, R. T. (1997). Reflective discourse in a critical thinking classroom. In J. F. Klumpp (Ed.), *Argument in a Time of Change: Definitions, Frameworks, and Critiques* (Proceedings of the Tenth NCA/AFA Conference on Argumentation, 1997; pp. 356-361). Annandale, VA: National Communication Association.
- Craig, R. T. (1996). Practical-theoretical argumentation. *Argumentation*, **10**, 461-474.
- Craig, R. T., & Tracy, K. (1995). Grounded practical theory: The case of intellectual discussion. *Communication Theory*, **5**, 248-272.

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Education

University of Missouri-Kansas City	Philosophy	B.A., 1972
University of Wisconsin-Madison	Psychology	B.S., 1976
University of Wisconsin-Milwaukee	Psychology	M.S., 1980
Illinois Institute of Technology	Computer Science	Ph.D., 1987

Professional Appointments

Visiting Associate Professor, Institute of Cognitive Science, University of Colorado-Boulder, (1997-1998).
Associate Professor, Dept. of Medical Education, Southern Illinois University (1994-present).
Assistant Professor, Dept. of Medical Education, Southern Illinois University (1988-1994).
Assistant Professor, Computer Science Dept., Southern Illinois University (1988-1992).

Significant Publications

Koschmann, T. (Ed.)(1996). *CSCL: Theory and Practice of an Emerging Paradigm*. Mahwah, NJ: Lawrence Erlbaum.

Koschmann, T., Kuutti, K., & Hickman, L. (1998). The concept of breakdown in Heidegger, Leont'ev, and Dewey and its implications for education. *Mind, Culture, and Activity*, 5, 25-41.

Koschmann, T. (1999, December). Toward a dialogic theory of learning: Bakhtin's contribution to understanding learning in settings of collaboration. In *Proceedings of CSCL'99* (pp. 308-313). Mahwah, NJ: Lawrence Erlbaum.

Koschmann, T. (2000, June). The physiological and the social in the psychologies of Dewey and Thorndike: The matter of habit. *International Conference on the Learning Sciences (ICLS'00)*, Ann Arbor, MI.

Koschmann, T. (in press). A third metaphor for learning: Toward a Deweyan form of transactional inquiry. To appear in D. Klahr & S. Carver (Eds.), *Cognition and Instruction: 25 Years of Progress*. Mahwah, NJ: Lawrence Erlbaum.

Related Publications

Conlee, M., & Koschmann, T. (1997). Representations of clinical reasoning in a PBL meeting: The inquiry trace. *Teaching and Learning in Medicine*, 9, 51-55.

Koschmann, T., Glenn, P., & Conlee, M. (1997). Analyzing the emergence of a learning issue in a Problem-Based Learning meeting. *Medical Education Online*, 2(1) [available at : <http://www.utmb.edu/meo/res00003.pdf>].

Glenn, P., Koschmann, T., & Conlee, M. (1999). Theory sequences in a problem-based learning group: A case study. *Discourse Processes*, 27, 199-133.

Koschmann, T., & Glenn, P. (1999, April). Hypothesis generation within problem-based learning meetings. Annual meeting of the American Educational Research Association, Montreal, Canada.

Koschmann, T., Glenn, P., & Conlee, M. (2000). When is a problem-based tutorial not tutorial? Analyzing the tutor's role in the emergence of a learning issue. In C. Hmelo & D. Evensen (Eds.), *Problem-based Learning: Gaining Insights on Learning Interactions through Multiple Methods of Inquiry* (pp. 53-74). Mahwah, NJ: Lawrence Erlbaum.

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Education

- B.A.** Department of English, Brigham Young University, 1979
- M.A.** Department of Communication, University of Utah, 1983
- Ph.D.** Department of Communication Studies, University of Texas at Austin, 1988

Professional Appointments

- Assistant Professor, Department of Communication, University of Colorado at Boulder (1996 to present).
- Assistant Instructor, Department of Communication Studies, University of Texas at Austin (1992 to 1996).
- Associate Instructor, Department of Communication, University of Utah (1991 to 1992).
- Managing Editor, The National Center for Constitutional Studies, Salt Lake City, Utah (1990 to 1991).
- Technical Writer, Clyde Digital Systems, Orem, Utah (1987 to 1989).
- Teaching Assistant, Department of Philosophy, Brigham Young University (1986 to 1987).
- Writing Instructor, Department of English, Brigham Young University (1986 to 1987).

Research Interests

LeBaron studies language and social interaction within institutional and organizational settings. He uses micro-analytic methods (e.g., Conversation Analysis, Micro-ethnography) to examine recordings of naturally-occurring human interaction. He explicates both the vocal and the visible behaviors whereby people interactively create their social identities and pursue their practical goals. Recent research topics include: the strategic use of physical space during a police interrogation; the detection of deception during group therapy sessions; the use of hand gestures to introduce and negotiate new ideas during meetings between professional architects and their clients. For many years, LeBaron's research and teaching has been influenced by emerging computer technologies, which facilitate micro-analysis of videotaped data and creation of multimedia presentations ("movies") to document research findings.

Related Publications

- LeBaron, C. (in press). Technology does not exist independent of its use. In R. Hall, T. Koschmann, & N. Miyake (Eds.), *CSCL2: Carrying Forward the Conversation*. Mahwah, NJ: Lawrence Erlbaum.
- LeBaron, C. & Streeck, J. (in press). Gesture, knowledge, and the world. In McNeill, D., (Ed.), *Review of Language and Gesture: Window into Thought and Action*. Cambridge: University Press.
- Koschmann, T., & LeBaron, C. (1998, July). The complementarity of speech and gesticulation in learner articulation. Paper presented at *Eighth Annual Meeting of the Society for Text and Discourse*, Madison, WI.
- Hopper, R. & LeBaron, C. (1998). How gender creeps into talk. *Research on Language and Social Interaction* 31 (1), 59-74.
- LeBaron, C. & Streeck, J. (1997). Space, surveillance, and interactional framing of participants' experience during a police interrogation. *Human Studies* 20, 1-25.

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Education

- 1998 *PhD, University of California, Irvine*, Information & Computer Science
1995 *M.S., University of California, Irvine*, Information & Computer Science
1991 *B.S., University of California, San Diego*, Cognitive Science

Professional Appointments

- 1998-present Assistant Research Professor
University of Colorado, Boulder, Computer Science Department
Member of the Institute of Cognitive Science and Center for Lifelong Learning & Design
- 1997 Consultant
Sun Microsystems Incorporated, JavaSoft Human Interface group
- 1995 & 1996 Consultant and Intern
Xerox Palo Alto Research Center, Collaborative Systems Area
- Summer 1994 Usability Specialist Intern
Microsoft Corporation, Usability Group
- 1991-1993 Research Associate
The Boeing Company, Flight Deck Research, Boeing Commercial Airplane Division

Research Interests

Human-computer interaction (HCI), computer supported cooperative work (CSCW); social analysis of information technologies, distributed cognition, information technology adoption

Related Publications

- Palen, Leysia (1999). Social, individual & technological issues for groupware calendar systems. *Proceedings of the ACM Conference on Human Factors in Computing Systems (CHI 99)*.
- Hutchins, Edwin & Leysia Palen (1998). Constructing meaning from space, gesture and speech. In L. B. Resnick, R. Saljo, C. Pontecorvo, and B. Burge (Eds.) *Discourse, Tools, and Reasoning: Situated Cognition and Technologically Supported Environments*. Heidelberg, Germany: Springer-Verlag.
- Ackerman, Mark S. & Leysia Palen (1996). The Zephyr help instance: Promoting ongoing activity in a CSCW system. *Proceedings of the ACM Conference on Human Factors in Computing Systems (CHI'96)*, M. Tauber (Ed.), ACM: New York, pp. 268-275.
- Grudin, Jonathan & Leysia Palen (1995). Why groupware succeeds: Discretion or mandate? *Proceedings of the 4th European Conference on Computer-Supported Cooperative Work, ECSCW'95*, H. Marmolin, Y. Sundblad, K. Schmidt (Eds.), Kluwer Academic Publishers, pp. 263-278.
- Grudin, Jonathan & Leysia Palen (1997). Emerging groupware successes in major corporations: Studies of adoption and adaptation. *Proceedings of the International Conference on Worldwide Computing and Its Applications (WWCA '97)*, T. Masuda, Y. Masunaga, & M. Tsukamoto (Eds.), Berlin: Springer-Verlag, pp. 142-153.
- Moran, Thomas P., Leysia Palen, Steve Harrison, Patrick Chiu, Don Kimber, Scott Minneman, William van Melle & Polle Zellweger (1997). "I'll get that off the audio:" A case study of salvaging multimedia meeting records. *Proceedings of the ACM Conference on Human Factors in Computing Systems (CHI '97)*, S. Pemberton (Ed.), ACM: New York, pp. 202-209.

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Education

1982	BS in Earth Science	University of California, Santa Cruz
1985	BA in Computer Science	University of California, Santa Cruz
1992	Masters in Computer Science	University of Colorado at Boulder
1995	PhD in Computer Science	University of Colorado at Boulder

Professional Appointments

1999-present	Assistant Professor, Center for LifeLong Learning and Design, University of Colorado
1996-1998	Lecturer, Knowledge Media Institute, The Open University, United Kingdom
1990-1995	Research Assistant, Computer Science Department, University of Colorado at Boulder
1983-1989	Member of Technical Staff, Hewlett-Packard, Santa Clara, California

Research Interests

Socio-technical Design: technology-use mediation, adaptive structuration, participatory design.

Education and Educational Technology: open learning course design, evolutionary course design, workplace learning, organizational learning, collaborative learning.

Interactive Publishing: learning conversations, community-based publishing, new models of scholarly discourse, knowledge-enriched intranets, digital libraries.

Human-Computer Interaction: work practice analyses, media integration, interaction design.

Related Publications

- Sumner, T. and S. Buckingham Shum, "From documents to discourse: Shifting conceptions of scholarly publishing," *Human Factors in Computing Systems (CHI '98)*, Los Angeles (April 18-23), 1998, pp. 95-102.
- Sumner, T. and J. Taylor, "New media, new practices: Experiences in open learning course design," *Human Factors in Computing Systems (CHI '98)*, Los Angeles (April 18-23), 1998, pp. 432-439.
- Sumner, T. and J. Taylor, "Media integration through meta-learning environments", in *"The Knowledge Web: Learning and Collaborating on the Net"*, M. Eisenstadt and T. Vincent (eds.), Kogan Page, London, 1998, pp. 63-78.
- Sumner, T. R., N. Bonnardel and B. Kallak Harstad, "The cognitive ergonomics of knowledge-based design Support systems," *Human Factors in Computing Systems (CHI '97)*, Atlanta, Georgia (March 22-27), 1997, pp. 83-90.
- Sumner, T. (1995). The high-tech toolbelt: A study of designers in the workplace, *Human Factors in Computing Systems (CHI '95)*, Denver, CO (May 7-11), pp. 178 – 185.