02 INFORMATION ABOUT PRINCIPAL INVESTIGATORS/PROJECT DIRECTORS(PI/PD) and co-PRINCIPAL INVESTIGATORS/co-PROJECT DIRECTORS

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PI/PD Name: Carolyn P Rose

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.
Race Definitions:
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Black or African American. A person having origins in any of the black racial groups of Africa.
Native Hawaiian or Other Pacific Islander. A person having origins in any of the original peoples of Hawaii, Guam, Samoa, or other Pacific Islands.
White. A person having origins in any of the original peoples of Europe, the Middle East, or North Africa.

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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)
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- ☐ Visual Impairment
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- ☒ None

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PI/PD Name: Stephen A Weimar

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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- ☐ Mobility/Orthopedic Impairment
- ☐ Other
- ☒ None

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List of Suggested Reviewers or Reviewers Not To Include (optional)

SUGGESTED REVIEWERS:
Not Listed

REVIEWERS NOT TO INCLUDE:
Not Listed

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 04-23

NSF 06-535 **04/25/07**

FOR NSF USE ONLY

NSF PROPOSAL NUMBER

FOR CONSIDERATION BY NSF ORGANIZATION UNIT(S) (Indicate the most specific unit known, i.e. program, division, etc.)

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SHOW PREVIOUS AWARD NO. IF THIS IS
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☐ AN ACCOMPLISHMENT-BASED RENEWAL

IS THIS PROPOSAL BEING SUBMITTED TO ANOTHER FEDERAL AGENCY? YES ☐ NO ☒ IF YES, LIST ACRONYM(S)

NAME OF ORGANIZATION TO WHICH AWARD SHOULD BE MADE

Carnegie-Mellon University

AWARDEE ORGANIZATION CODE (IF KNOWN)

0001057000

ADDRESS OF AWARDEE ORGANIZATION, INCLUDING 9 DIGIT ZIP CODE

5000 Forbes Avenue
WH 405
PITTSBURGH, PA 15213-3890

NAME OF PERFORMING ORGANIZATION, IF DIFFERENT FROM ABOVE

PERFORMING ORGANIZATION CODE (IF KNOWN)

ADDRESS OF PERFORMING ORGANIZATION, IF DIFFERENT, INCLUDING 9 DIGIT ZIP CODE

IS AWARDEE ORGANIZATION (Check All That Apply) (See GPG II.C For Definitions)
☐ SMALL BUSINESS ☐ MINORITY BUSINESS
☐ FOR-PROFIT ORGANIZATION ☐ WOMAN-OWNED BUSINESS

☐ IF THIS IS A PRELIMINARY PROPOSAL THEN CHECK HERE

TITLE OF PROPOSED PROJECT **Increasing Helping Behavior in Collaborative Problem Solving in the Virtual Math Teams Environment**

REQUESTED AMOUNT	PROPOSED DURATION (1-60 MONTHS)	REQUESTED STARTING DATE	SHOW RELATED PRELIMINARY PROPOSAL NO. IF APPLICABLE
$ **606,669**	**36** months	**01/01/08**	

CHECK APPROPRIATE BOX(ES) IF THIS PROPOSAL INCLUDES ANY OF THE ITEMS LISTED BELOW

☐ BEGINNING INVESTIGATOR (GPG I.A)
☐ DISCLOSURE OF LOBBYING ACTIVITIES (GPG II.C)
☐ PROPRIETARY & PRIVILEGED INFORMATION (GPG I.B, II.C.1.d)
☐ HISTORIC PLACES (GPG II.C.2.j)
☐ SMALL GRANT FOR EXPLOR. RESEARCH (SGER) (GPG II.D.1)
☐ VERTEBRATE ANIMALS (GPG II.D.5) IACUC App. Date _____
☒ HUMAN SUBJECTS (GPG II.D.6)
Exemption Subsection _____ or IRB App. Date **Pending**
☐ INTERNATIONAL COOPERATIVE ACTIVITIES: COUNTRY/COUNTRIES INVOLVED (GPG II.C.2.j)
_____
☐ HIGH RESOLUTION GRAPHICS/OTHER GRAPHICS WHERE EXACT COLOR REPRESENTATION IS REQUIRED FOR PROPER INTERPRETATION (GPG I.G.1)

PI/PD DEPARTMENT
LTI-HCII

PI/PD FAX NUMBER
412-268-6298

PI/PD POSTAL ADDRESS
5000 Forbes Avenue

Pittsburgh, PA 15213
United States

NAMES (TYPED)	High Degree	Yr of Degree	Telephone Number	Electronic Mail Address
PI/PD NAME **Carolyn P Rose**	**PhD**	**1998**	**412-268-7130**	**cprose@cs.cmu.edu**
CO-PI/PD **Gerry Stahl**	**PhD**	**1993**	**215-895-0544**	**Gerry.Stahl@drexel.edu**
CO-PI/PD **Stephen A Weimar**	**BA**	**1980**	**215-895-0236**	**steve@mathforum.org**
CO-PI/PD				
CO-PI/PD				

CERTIFICATION PAGE

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 debarment and suspension, drug-free workplace, and lobbying activities (see below), as set forth in Grant Proposal Guide (GPG), NSF 04-23. Willful provision of false information in this application and its supporting documents or in reports required under an ensuing 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. Conflicts which cannot be satisfactorily managed, reduced or eliminated must be disclosed to NSF.

Drug Free Work Place Certification

By electronically signing the NSF Proposal Cover Sheet, the Authorized Organizational Representative or Individual Applicant is providing the Drug Free Work Place Certification contained in Appendix C of the Grant Proposal Guide.

Debarment and Suspension Certification

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

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 ☒

By electronically signing the NSF Proposal Cover Sheet, the Authorized Organizational Representative or Individual Applicant is providing the Debarment and Suspension Certification contained in Appendix D of the Grant Proposal Guide.

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 of Lobbying Activities,'' 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 **Leslie A Rhodes**		**04/24/07**

TELEPHONE NUMBER	ELECTRONIC MAIL ADDRESS	FAX NUMBER
412-268-8746	**lrhodes@andrew.cmu.edu**	**412-268-6279**

*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.

Increasing Helping Behavior in Collaborative Problem Solving in the Virtual Math Teams Environment

On-line learning promises a significant broadening of educational opportunities – although this dream is yet to be made a reality. The long term goal of the proposed work is to replicate the impact of local, on-campus programs targeting increased college preparedness and college success of minority and low income students in a freely available, on-line learning environment. Our proposed solution is to develop a technological augmentation to available human support in a lightly staffed environment as well as deploying conversational agents that are triggered by important conversational events and that have the ability to elicit valuable collaborative behavior such as reflection, help seeking, and help provision. This proposed project brings together a team with expertise in both technological development and careful experimentation both in the lab and in the classroom, a track record for large scale deployment of educational materials, a solid foundation in significant results from prior work on which the proposed research builds in on-line learning.

Intellectual Merit: The proposed research attempts to understand how to structure interactions among peer learners in online education environments to address existing problems. The proposed project seeks to enhance effective participation and learning in the Virtual Math Teams (VMT) online math service by designing, developing, implementing, testing, refining and deploying computer-supported tools to support facilitation in this lightly-staffed service. The key research goal is to optimize a design and implementation of dynamic interventions for supporting collaborative problem solving that will maximize the pedagogical effectiveness of the collaboration by eliciting behavior that is productive for student learning in collaborative contexts according to our own previous research, as well as that of others. Where such support has already proven successful in lab and classroom studies, a major thrust of the current proposal is to understand how the characteristics of the on-line Virtual Math Teams environment necessitate adaptation of the approach in order to achieve comparable success in this environment.

Broader Impact: We are working towards deepening understanding of the pedagogical and technological features that make on-line education in general, and collaborative learning in particular, effective. If we can further understand the causal connections between interaction and learning, then we can wield technology in ways that achieve maximal cognitive and social benefits for on-line learners. To the extent that we are successful, our research will help realize the promise of on-line learning. Expensive instructors and content providers will continue to develop instructional materials and act as moderators to the extent that resources allow. Their resources can be stretched by means of reporting technology that quickly and effectively assists them in identifying the teams that are in most need of their involvement. Fellow students will support each other in dealing with their struggles with the materials. Inexpensive software agents will aid human facilitators in matching students who can help each other as well as in offering help to structure their collaborative learning conversations to make them more effective.

Integration of Research and Education: Students in Computer Supported Collaborative Learning courses taught at Carnegie Mellon University and Drexel University by two of the PIs will be directly impacted by the research. Teams of students from the two universities will work together in distributed teams to prototype dynamic collaborative learning support interventions using the tools provided by the Carnegie Mellon team, which will then be pilot tested in Drexel's Virtual Math Teams environment. Thus, students in the courses will not only benefit by learning about the findings from the research, but they will also actively participate in the research.

Integrating Diversity: Success in mathematics is the key to advancement of disadvantaged minority students. This project seeks to address the racial achievement gap by providing extra support to those in greatest need in a freely available service.

TABLE OF CONTENTS

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

*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.

Increasing Helping Behavior in Collaborative Problem Solving in the Virtual Math Teams Environment

1. Vision

American children are in the middle of a group of 38 countries in terms of science and math education, far behind such countries as Singapore, Korea, Hong Kong or Japan (Mullis et al., 2000). On-line learning promises to address this problem by providing free or inexpensive education for the masses – quality educational opportunities available to all people, but especially those who are in the greatest need – although this dream is yet to be made a reality. The ultimate goal of the proposed work is to replicate the impact of what are normally local, on-campus programs targeting increased college preparedness and college success of minority and low income students, such as the Professional Development Program (PDP) (Treisman, 1985), in a freely available, on-line learning environment. We focus on middle school math since middle school is a pivotal time when students, especially girls, begin to lose confidence in and interest in math (Callahan & Clements, 1984; Dossey, Mulis, Lindquist, & Chambers, 1988; Brandon & Newton, 1985), and we target the well established Virtual Math Teams (VMT) online math service at http://mathforum.org/vmt as a venue for broad dissemination because of its strategic location in an on-line math service that reaches millions of students per week. Furthermore, we focus on eliciting proof-like explanations from students, since this is an important skill connected with a deep understanding of math concepts, and which continues to be a struggle for students throughout their school years. In supporting collaboration, we focus on eliciting productive helping behavior, which we have observed to mediate learning in prior studies with this age group and domain content area (Gweon et al., 2007) as well as studies with older students (Gweon et al., 2006). This proposed project brings together a team with expertise in technological development, careful experimentation in the lab and in the classroom as well as insightful ethnographic research in real on-line learning environments, a track record for large scale deployment of educational materials, and a solid foundation in significant results from prior work on which we build in the areas of computer supported collaborative learning and tutorial dialogue systems.

The purpose of this project is to enhance participation and learning in the Virtual Math Teams (VMT) online math service by designing, developing, implementing, testing, refining and deploying computer-support tools to enhance facilitation that is available to support students in this lightly-staffed service. One key research goal is to optimize the design and implementation of dynamic collaborative learning support agents that will participate in VMT chat sessions in order to maximize the pedagogical effectiveness of those interactions. Prototype dynamic support agents have already yielded positive learning effects in pilot evaluations in lab (Wang et al., 2007) and classroom studies (Kumar et al., 2007) in the domains of science and engineering respectively, and a recent pilot evaluation shows promise with middle school kids learning about fraction arithmetic. Another key research goal is to develop technology for monitoring collaborative behavior and automatically generating reports for human facilitators to allow them to quickly identify teams that require more attention. Our recent work on automatic collaborative learning process analysis from collaborative learning discussions between college age students (Donmez et al., 2005; Wang et al., 2007c, Rosé et al., to appear) provides a foundation for this. In our proposed work we will carry this further by identifying which conversational events are most indicative of a need for support in interactions involving middle-school kids, who are far less sophisticated in their communication skills and thus struggle with different issues in collaborative contexts. This will be accomplished through close collaboration among CMU, Math Forum and VMT researchers.

As a starting place, we will begin this process by integrating our research findings and infrastructure from our prior work in the areas of computer supported collaborative learning and tutorial dialogue systems. We will also pilot our integrated VMT environment as soon as possible in order to collect the most realistic development data so that our plans for our continued collaboration can be strongly influenced by observations of interactions in the exact environment where we will do our most important work towards a significant impact in the long run. In our exploratory data analysis we will take

a qualitative approach so that we can get a firm handle on important contextual variables that we will take into account in our subsequent experimental work, in line with methodology proposed in (Design-Based Research Collective, 2003).

Our main research objectives include:

(1) Integrating and then extending the technical infrastructures created in the prior work in the area of Computer Supported Collaborative Learning at Carnegie Mellon University and Drexel University, which includes an elaborate environment for coordinating math teams and supporting their joint problem solving efforts as well as tools for automatic collaborative learning process analysis and for building collaboration support agents that can be triggered by this analysis.

(2) Conducting a series of investigations into the causal connections between conversational processes and learning as well as the causal connection between automatic interventions and collaborative behavior across multiple settings, including lab and classroom studies as well as investigations in the on-line VMT environment. This series of controlled and naturalistic observations will culminate in a large-scale summative evaluation in the on-line VMT environment.

In addition to producing new knowledge in the research area of Computer Supported Collaborative Learning, the results of this research will permanently extend the capabilities of an existing on-line math community, making it a more valuable resource beyond the end of the proposed research funding.

2. Building a Foundation by Integrating our Prior Work

Our research goal is supporting productive collaborative learning discussions in a computer-mediated environment in "the wild", specifically supporting students in working together in pedagogically effective ways. Researchers have examined the mechanisms by which human tutors are so successful at teaching and motivating children as a model of successful education (Bloom, 1984; Cohen, Kulik & Kulik, 1982). Unfortunately, it is not practical to provide every student with a human tutor. While there is a shortage in terms of the resources to provide each student with their own tutor, there is no lack of children in need. While the help students are capable of offering one another is not perfect, there is evidence that it is effective in spite of the errors students make when helping each other (Gweon et al., 2006), and possibly even because of these errors (Piaget, 1985; De Lisi & Goldbeck, 1999; Grosse and Renkl, submitted). If we can harness the potential of state-of-the-art technology for automatically filtering collaborative learning discussions that we have developed in our previous work (Donmez et al., 2005; Wang et al., 2007c), and we can use this automatic analysis to trigger interventions that support students in helping each other learn together (Gweon et al., 2006) using tutorial dialogue and intelligent tutoring technology as in (Wang et al., 2007; Kumar et al., 2007), we could move towards a solution to our nation's educational problems in a cost effective, practical manner. In this section we describe how we integrate elements from our previous work into a technical foundation as well as a foundational instructional approach that we build on and extend in our proposed work.

2.1 Technological Foundation

For a technological foundation, the CMU team brings to the project much prior work developing and evaluating tutorial dialogue technology that can be used to deliver interactive support (Rosé et al., 2001; Gweon et al., 2005; Rosé et al., in press; Rosé et al., 2005; Kumar et al., 2006; Wang et al., 2006), prior work developing automatic collaborative learning process analysis technology that can be used to trigger interventions (Donmez et al., 2005; Wang et al., 2007c), other language technologies research related to text classification (Rosé et al., 2003; Rosé et al., 2005-b), robust analysis of explanations (Rosé, 2000; Rosé et al., 2002; Rosé & VanLehn, 2005) and dialogue analysis more generally (Rosé et al., 1995; Arguello & Rosé, 2006), as well as early work on design and evaluation of adaptive

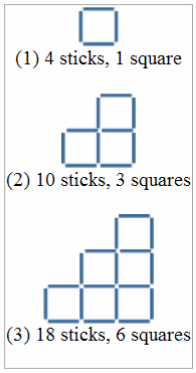
collaborative learning support (Gweon et al., 2006; Wang et al., 2007; Kumar et al., 2007) and investigations of group composition and gender effects in collaborative learning in an intelligent tutoring environment (Gweon et al., 2005b; Gweon et al., 2007).

The Drexel team brings the existing Virtual Math Teams (VMT) environment (http://mathforum.org/vmt). The Virtual Math Teams (VMT) project within the Math Forum uses peer collaboration in small student teams to enhance learning and participation in math discourse. Small groups of students are invited to chat rooms (see description of the Collaborative Environment in Section 3.1) where they discuss carefully designed math problems or math micro-worlds. VMT mentors are typically not present in the chat rooms, but they provide asynchronous feedback to the student groups upon request. We proposed to augment this environment with automatic, dynamic collaboration support. Math Forum and VMT staff will be involved at all stages of designing, developing, implementing, testing, refining and deploying these computer-support tools in close collaboration with researchers from Carnegie Mellon University. VMT researchers have extensive experience exploring the effectiveness of these materials for stimulating productive collaborative learning interactions. For analysis of collaborative discussions, VMT researchers have used a variety of methods that we will draw upon in our proposed work for on-line and off-line analysis of the learning and collaboration that takes place in the VMT-Chat environment, including statistical analysis of coded chats, ethnographic observation of participation and interaction analysis (adapting ethnomethodologically-informed conversation analysis to textual chat). A large number of studies of VMT chats are already available, including (Cakir *et al.*, 2005; Sarmiento, Trausan-Matu, & Stahl, 2005; Stahl, 2006a, 2006b, 2006c, 2006d, 2006e; Strijbos & Stahl, 2005; Wessner *et al.*, 2006; Zemel, Xhafa, & Cakir, 2005); see http://www.mathforum.org/vmt/researchers/publications.html for a more complete list.

2.2 Math Forum Materials

VMT Spring Fest

Here are the first few examples of a particular pattern or sequence, which is made using sticks to form connected squares:



N	Sticks	Squares
1	4	1
2	10	3
3	18	6
4	?	?
5	?	?
6	?	?
...	...	...
N	?	?

1. Draw the pattern for N=4, N=5, and N=6 in the whiteboard. Discuss as a group: How does the graphic pattern grow?
2. Fill in the cells of the table for sticks and squares in rows N=4, N=5, and N=6. Once you agree on these results, post them on the VMT Wiki
3. Can your group see a pattern of growth for the number of sticks and squares? When you are ready, post your ideas about the pattern of growth on the VMT Wiki.

Figure 1 Example Math Forum Problem: The Sticks Problem

Selecting appropriate materials to stimulate productive collaborative conversations is essential to fostering the success of collaborative learning. Since the goal of much collaborative learning is to stimulate higher order thinking, typical tasks used in studies of collaborative learning are open ended problems with multiple possible solutions, especially ones with many trade-offs rather than right versus wrong solutions, or highly interpretative problems such as case study analysis. We draw from resources designed by The Math Forum, which has been providing a successful, highly popular online community and digital library for K-12 students, teachers and others for over a decade (Renninger & Shumar, 2002). Although the Math Forum works closely with school districts and teachers, its central focus is on providing informal learning experiences, by developing challenging, non-traditional math problems for students to think about and by collecting student responses. Although it has collected some of these responses into math books on algebra and geometry, it mainly organizes these responses as a digital library. In its various services (see Section 6 on Partnerships and http://mathforum.org for more details), the Math Forum facilitates interactions among students, teachers, pre-service teachers, volunteer mentors and paid staff.

An example problem is displayed in Figure 1 above. In the VMT environment, students work in small groups on the same problem over 3 sessions. In the first session, they work out solutions to the problem. In between the first and second sessions, students receive feedback on their solutions. In the second session, students discuss the feedback they received on their respective solutions and step carefully through alternative correct solutions. In that session and the subsequent session, they also discuss additional possible ways of looking at the problem including variations on that problem in order to take a step back and learn larger mathematics principles that apply to classes of problems rather than individual problems. Although the problem provides the opportunity to investigate multiple possible solutions and to engage in deep mathematical reasoning, our finding from analysis of chat logs where students have worked on this and other problems is that students tend to jump to finding one solution that works rather than taking the opportunity to search for alternative solutions. The moderator plays an important role in stimulating conversation between students, encouraging knowledge sharing and probing beyond a single acceptable solution. Thus, we plan to model our dynamic support agents after successful group moderators using a similar data driven process that was used to develop the CycleTalk tutorial dialogue agents (Rosé et al., in press; Kumar et al., 2006), patterned after successful human tutors (Rosé et al., 2005) supporting learning in the same environment that the chat agents now participate in.

2.3 Tools for Building Dynamic Collaborative Learning Support

What the CMU team brings in terms of technological infrastructure are tools for automatic collaborative learning process analysis to trigger dynamic support in the midst of ongoing collaboration and tools for quick authoring of conversational agents to administer the interactive support. Note that both of these tool sets were developed under the NSF funded Pittsburgh Science of Learning Center (PSLC) as enabling technology projects. Whereas in the PSLC this work can support classroom studies in designated LearnLab courses (which do not include any courses using Math Forum materials), that center does not fund work in on-line learning communities, classroom studies in other classrooms, or lab studies. Thus, the proposed work will take resources developed in one NSF funded context, and extend the impact to a new and significantly broader context.

As part of a collaboration with the Knowledge Media Research Center in Tuebingen, Germany, we have developed a proof of concept for fully automatic collaborative learning process analysis (Donmez et al., 2005). We refer to this coding scheme, developed by Weinberger & Fischer (2006), as the Weinberger and Fischer coding scheme. This coding scheme was developed for the purpose of addressing the question of how computer-supported collaboration scripts could foster argumentative knowledge construction in online discussions. Argumentative knowledge construction is based on the idea that learners acquire knowledge through argumentation with one or more learning partners, by better elaborating the learning material and by mutually refining ideas. Argumentative knowledge construction must be evaluated on multiple process dimensions. Thus, the Weinberger and Fischer coding scheme has five process dimensions. These dimensions are derived from different theoretical approaches and focus

on specific conceptualizations of argumentative knowledge construction, and are supposed to be independent from each other. The main concepts are (1) epistemic activity, formal quality regarding argumentation, which differentiates in the (2) micro-level of argumentation and the (3) macro-level of argumentation, and (4) social modes of interaction. Independent of these dimensions, the segments have been coded whether they were or were not (5) a reaction to a previous contribution.

Each dimension offers a different perspective on the nature of the contribution, often drawing upon information of a different nature from the other dimensions, and thus offers evidence of the generality of our approach. For example, the Micro and Macro dimensions each characterize different aspects of the linguistic structure of the contributions whereas the Social Modes and Reaction dimensions focus on different types of social conventions and relational styles conveyed in and encoded in contributions. Automatic application of coding schemes such as this one make it possible to automatically detect dysfunctional communication patterns within running discourse. For example, they make it possible to determine whether participants are acknowledging each other's contributions, and considering them adequately without either giving in too quickly or rejecting each other's views out of hand. A major focus of our work has been increasing classification accuracy on low frequency events, since many times very infrequent events are nevertheless important to recognize with a high degree of accuracy because they are indicative of particular types of trouble.

The second technology provided by the CMU team is an infrastructure called TuTalk to support quick authoring of dialogue agents (Gweon et al., 2005; Jordan et al., 2007). This work includes 1) tools for non-technical users to author dialogue specifications for particular student exercises and 2) a backend system for supporting full spoken or text-based dialogue behavior that follows the authored specifications. In our prior work we have explored strategies for supporting the development of language understanding interfaces by non-linguists (Rosé & Hall, 2004; Rosé, Pai, & Argeullo, 2005). TuTalk provides a suite of corpus organizational tools to help authors prepare their corpus data in preparation for authoring using what we refer to as the InfoMagnets interface (Arguello & Rosé, 2006b). The TuTalk authoring interface is then used for finer grained processing, such as shifting topic segment boundaries and labeling more detailed utterance functionality, as well as authoring templates used for generating dialogue behavior. These tools were used to build the dialogue agents used in the successful classroom studies reported in (Kumar et al., 2006) in one week.

While our previous work developing dialogue agents has focused primarily on tutorial dialogue for individual learning, here we expand our scope to cover tutorial dialogue for collaborative learning. Thus, here the purpose of the dialogue agents is not to lead one student to reflect on a past decision or come to a specific conclusion. Instead the dialogue agents will seek to direct the interaction between students, offering instruction only as a last resort. Building on work reported in (Rosé & Torrey, 2005), we seek to build dialogue agents that are effective at eliciting elaborated explanations from students in the context of the help seeking and help giving interactions with other students in order to implement dynamic support interventions.

3. Building on and Extending the Technological Infrastructure

3.1 Collaborative Environment

The Math Forum and its Virtual Math Teams Project will collaborate with CMU personnel under this grant towards designing, developing, implementing, testing, refining and deploying of the computer-support tools that are part of this grant. In particular, the VMT-Chat environment will be available as a test-bed for collecting data about the performance of these tools. VMT staff will be involved in assessing the results of the use of these tools through close analysis of selected excerpts from this chat log data. The free VMT service currently consists of an introductory web portal within the Math Forum site (http://mathforum.org/vmt) and an interactive environment called VMT-Chat. VMT-Chat includes the VMT Lobby, where people can select chat rooms to enter, and a number of math discussion chat rooms, that each include a text chat window, a shared drawing area and a number of related tools (for a more detailed description of the environment and how it is used, see (Stahl, 2006). The environment is

available as Open Source, so that (1) it can easily be extended for this project and (2) the results of this project can easily be made available to other researchers.

VMT-Chat includes the VMT Lobby – where people can select chat rooms to enter (see figure 2) – and a number of math discussion chat rooms – that each include a text chat window, a shared drawing area and a number of related tools (see figure 3).

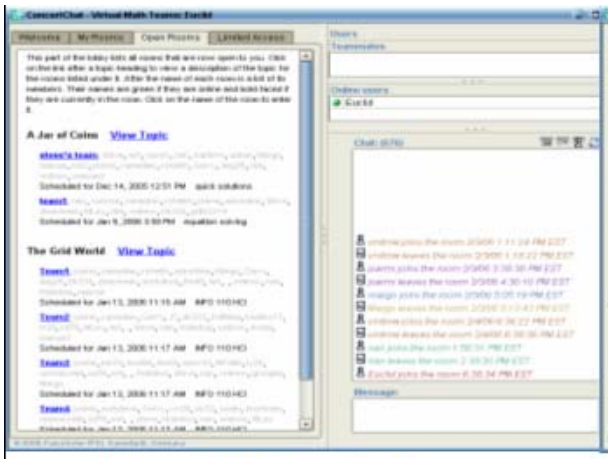


Figure 2. The VMT Lobby.

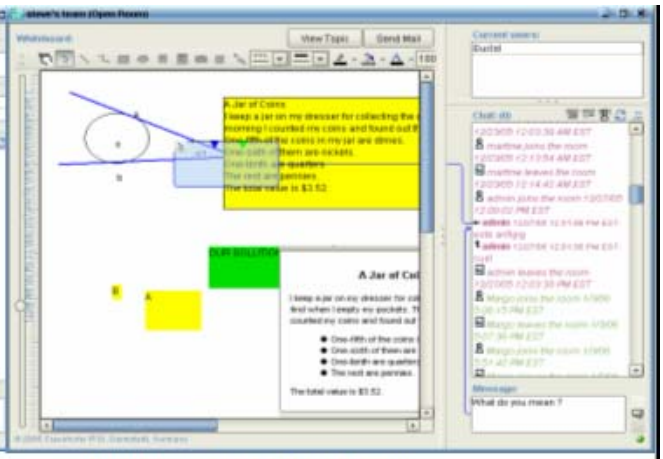


Figure 3. A VMT chat room.

Three types of rooms can be created in the lobby:

a. *Open rooms*. Anyone can enter these rooms and participate in the discussion – see Figure 1, where open rooms are listed under math problems or topics.
b. *Restricted rooms*. Only people invited by the person who created the room can enter.
c. *Limited rooms*. People who were not originally invited can ask the person who created the room for permission to join.

Such flexibility allows the VMT service to be used in a wide range of ways and in limitless combinations and sequences:

1. For instance, teams of students from the same classroom might first use the VMT environment to work together on a series of Problem of the Week (PoW) problems during class time, allowing them to become familiar with the system and build collaboration skills in a familiar social setting.
2. Later they could split up and join groups with students from other schools to explore more open-ended mathematical situations.
3. As they become more advanced users, they can create their own rooms and invite friends or the public to discuss topics that they themselves propose.

3.2 Instructional Approach

Our goal is to maximize the benefit students receive from the interactions they have with one another. Not all instructional conversation between learners is equally effective, and often requires some form of support in order to become effective (Stegmann et al., 2004; Rummel et al., 2003). State-of-the-art forms of collaboration support proactively structure collaborative learning interactions using a broad assortment of approaches. Examples of such support includes assignment of students to roles (Strijbos, 2004), provision of prompts during collaboration (Stegmann et al., 2004), design of structured interfaces including such things as buttons associated with typical "conversation openings" (Baker & Lund, 1997), instructions to guide learners to structure their collaboration (Webb & Frivar, 1999), or even various forms of collaboration training (Rummel et al., 2006). These approaches to structuring collaboration play

a role similar to training wheels on bicycles. Just as training wheels allow kids to have the experience of riding a bike before they are ready to do it independently, these forms of collaborative learning support increase the amount of productive collaboration behavior above that of what it would be without the structuring, thus allowing students to collaborate at a higher level than their own collaborative skills would naturally allow. As is well known, however, training wheels must eventually come off. And typically, they are removed by a watchful parent, who may decide after watching their child fall a few times, to put them back on for a time until the child has developed further in their own coordination and balance. In a similar vein, the learning sciences literature tells us that scaffolding should be faded over time (Collins et al., 1991), that over-scripting is detrimental to collaboration (Stegmann et al., 2004), and unnecessary support is demotivating (Dillenbourg, 2002). However, in order to fade collaboration scaffolding as a watchful parent, we must do so using technology that is sensitive to collaborative behavior in the environment. Thus, a major goal of our research is to support collaboration in a way that is responsive to what is happening in the collaboration rather than behaving in a "one size fits all" fashion, which is the case with state-of-the-art static forms of support.

Our instructional approach is modeled after constructivist principles of classroom discourse, such as those advocated in (Chapin, O'Connor, & Anderson, 2003). Webb and colleagues present a series of studies in different educational settings that demonstrate the importance of the depth of instructional explanations, both for the speaker as well as the recipient (Webb, 1991; Webb, Nemer, & Zuniga, 2002). Much research shows the value of drawing out student reasoning in the form of elaborated explanations. In particular, one of the best substantiated educational findings in cognitive science research related to education is the educational benefit of explanation, and in particular, the self-explanation effect (Chi et al., 1989; Chi et al., 1994; Chi, 2000). Nevertheless, previous discourse analyses of collaborative conversations reveal that the majority of conversational interactions between students do not display the "higher order thinking" that collaborative learning is meant to elicit (Webb & Mastergoerge, 2003; Webb, Nemer, & Zuniga, 2002), and we have found this as well in our own observations of collaborative learning, both at the college level (Gweon et al., 2006) and at the middle school level (Gweon et al., 2007).

To begin to move past the traditional one-size-fits-all non-adaptive approaches to collaboration support, we have conducted a series of studies in which we experimentally investigate foundational issues related to the design of dynamic support for on-line collaborative learning (Gweon et al., 2006). These initial investigations demonstrated that explanation elicitation prompts delivered strategically, on an as needed basis, were effective for eliciting explanation attempts as well as increasing learning. In our long term plans in the VMT context, in order to elicit the type of collaborative behavior that leads to more learning, we will use dynamic collaboration support agents based loosely on the style of our previous investigations at the secondary and post-secondary level (Gweon et al., 2006; Wang et al., 2007; Kumar et al., 2007). Our previous success with automating collaborative learning process analysis (Donmez et al., 2005) offers promise that the dynamic support mechanism evaluated using a Wizard-of-Oz setup in (Gweon et al., 2006) can be implemented and deployed fully automatically. We have run two successful pilot studies in which we used dialogue agents to deliver interactive support when triggered by an automatic analysis of the collaborative learning discussions as they unfolded (Wang et al., 2007; Kumar et al., 2007). In both of these successful studies, the fully automatic interactive support lead to significant increases in learning in comparison to a control condition that did not have the interactive support. However, neither of these studies took place in an open web environment such as the Virtual Math Teams environment. Furthermore, the interactive support was focused mainly on eliciting deep reflection, rather than eliciting helping behavior, which is the focus of this proposed work. Thus, there is still much work to do to investigate how best to elevate the level of helping behavior in an environment such as the on-line VMT environment.

3.3 Architecture for Dynamic Collaborative Learning Support

In Figure 4 below is displayed the architecture of the dynamic collaborative learning support system developed at Carnegie Mellon University, and evaluated in the domains of Earth Sciences (Wang

et al., 2007) and thermodynamics (Kumar et al., 2007). In both cases, our finding was that students who collaborated with the dynamic support through intelligent dialogue agents learned significantly more within the same amount of time as pairs who worked together without this support. In this architecture, students communicate with each other and with the intelligent agents through a chat interface. A server coordinator module collected their conversational contributions in order to send them on to other system modules as well as to accumulate a conversational history that was displayed to students in their chat interface. Conversational contributions were first passed to a filter module that applied text classification technology in order to detect important conversational events. These events, when detected, were indicated to an Interaction Module, which then updated it's model of the conversational state. In certain states, a trigger was then sent to the intelligent agent, eliciting it's support in the conversation. The conversational behavior of the agent was tailored according to the specific trigger sent.

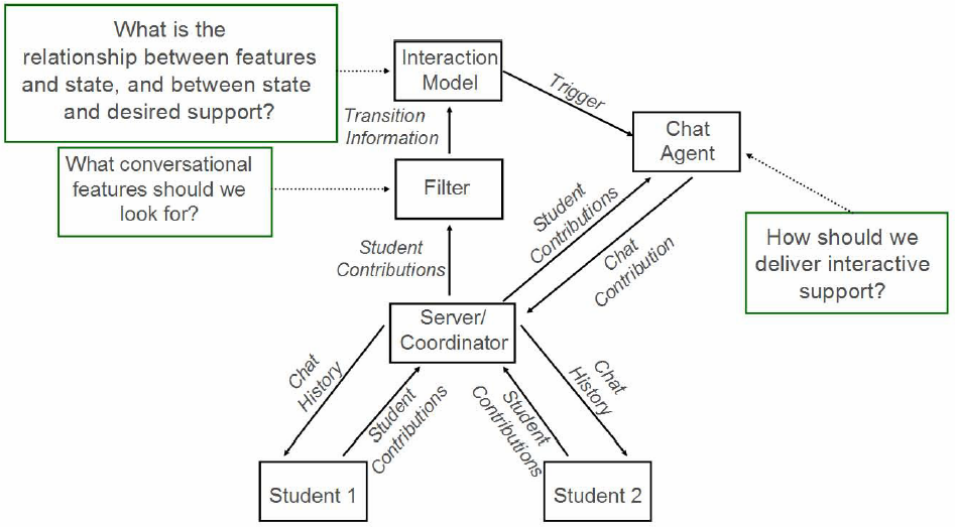


Figure 4 Architecture for Dynamic Collaborative Learning Support

As displayed in Figure 4, this architecture allows for specialization of the design in three main ways. First, the Filter module can be tailored to perform a wide range of types of collaborative learning process analyses. Furthermore, at a more abstract level, the manner in which evidence of individual conversational events in assessing conversational state can be specialized depending upon the assessment approach as well as the model of scaffolding and fading of support in collaborative learning. Finally, the form of the delivered support can be modified by replacing or modifying the intelligent dialogue agents. As part of our iterative development methodology, we will pursue enhancements in all three of these areas. For example, in both evaluations of this architecture, we have used a simple topic oriented filter to detect when important topics are raised throughout the conversation. However, our work on automatic collaborative learning process analysis offers evidence that we can implement much more sophisticated collaborative learning process modeling approaches. As mentioned earlier, we have developed a proof of concept for fully automatic collaborative learning process analysis (Donmez et al., 2005; Wang et al., 2007b). With this proof of concept in mind, we have confidence that we can automate the process of detecting other types of collaborative behavior, such as helping behavior, which is the focus of the proposed work. We have already developed a rudimentary coding scheme for analyzing helping behavior, which we will refine as part of this proposed work (Gweon et al., 2007).

4. Full-Circle Methodology: Exploring the Design Space in Complementary Contexts

We propose to take advantage of the complementary insights we can gain from investigations in various settings, including lab studies, classroom studies, and studies in the Virtual Math Teams

environment. Furthermore, we leverage a broad spectrum of methodologies, ranging from high internal validity studies in the lab and in the classroom, with pre/post test designs to high external validity investigations in the "wild" Virtual Math Teams environment where the same analyses of observable collaborative behavior are possible even with naturalistic, non-controlled observation, but experimental designs are less practical and must be administered with caution because of the way imposing too much control may interfere with the natural working of the community (In Section 4.4, we describe how we will carefully conduct a large-scale summative evaluation at the end of the project in such a way as to avoid interfering with the natural workings of the community any more than necessary.) With respect to analysis of log data, we will also employ a diversity of approaches including formal, quantitative analyses of log data based on categorical coding as well as ethnographic style analyses.

4.1 Illustration of Methodology

As an illustration of our full-circle, mixed-methods approach, we offer an example of how our informal collaboration to date is already yielding synergistic findings. Because our ultimate goal is to achieve success in the "wild" Virtual Math Teams environment, we begin with insights gained from an ethnomethodological analysis of chat logs collected in the Virtual Math Teams environment (Stahl, ???). In one notable chat session, we observed a group of students that was successful at solving problems collaboratively that none of them were capable of solving alone. On close inspection of the chat logs, a student who at first appeared as "the class clown" emerged as a tone setter in the analysis, putting his team mates at ease, and allowing them to forage ahead as a group towards solutions to very challenging problems. From this analysis, a hypothesis emerges that interventions that inject humor in a collaborative learning setting may act as a "social lubricant", and thus may increase success in collaborative problem solving. The Carnegie Mellon team has tested this hypothesis experimentally in a classroom study in which students worked in pairs in a collaborative problem solving environment that shares some common simple functionality with the Virtual Math Teams environment. We refer to this study as the Social Prompts study.

In the experimental condition of the Social Prompts study, before a problem is displayed in the shared problem solving space, a tutor agent first asks each student what we are referring to as a social question. For example, the agent may first ask student 1 "Student 1, if you had to choose between a long flight or a long car ride, which seems more uncomfortable?" The student indicates that a car ride would be preferable. Then the tutor agent may then ask, "Student 2, which are more entertaining – books or movies?", and the student may respond that books are more amusing. These two pieces of information are then used to fill in slots in a template that is then used to generate the math problem. In particular, the resulting story problem says, "Jan packed several books to amuse herself on a long car ride to visit her grandma. After 6/8 of the trip, she had already finished 1/5 of the books she brought. How many times more books should she have brought than what she packed?" The lighthearted nature of the questions was meant to inject a note of humor into the conversation. In order to control for content and presentation of the math content across conditions, we used exactly the same problem templates in the control condition, but rather than presenting the social questions to the students, we randomly selected answers to the social questions "behind the scenes". Thus, students in both conditions worked through the same distribution of problems.

The results of the Social Prompts study provided some evidence in support of the hypothesis that emerged from observations in the Virtual Math Teams environment. We began our analysis by investigating the socially oriented variables measured by means of the questionnaire, specifically perceived problem solving competence of self and partner, perceived benefit, perceived help received, and perceived help provided. For perceived benefit and perceived confidence, scores were high on average (about 4 out of 5) in both conditions, with no significant difference between conditions. However, with perceived help offered as well as perceived help received, there were significant differences between conditions. Students in the experimental condition rated themselves and their partner significantly higher on offering help than in the control condition. Interestingly, there is more evidence of requesting help in the control condition chat logs. However, these requests were frequently ignored. The

learning gains analysis is consistent with the pattern observed on the questionnaire and offers some weak evidence in favor of the experimental condition on learning. The trend was consistently in favor of the experimental condition across tests and across units of material on the test. The strongest effect we see is on lab day 2 where students in the experimental condition gained marginally more on interpretation problems (p=.06, effect size .55 standard deviations). The student chat logs contain rich data on how the collaborative problem solving process transpired. We conducted a qualitative analysis of the conversational data recorded in the chat logs in order to illuminate the findings from the tests and questionnaire data discussed above. Overall, we observed that students were more competitive in the control condition. Insults like "looser", "you stink", "stupid" occurred frequently in the control condition, and never in the experimental condition. Instead, in the experimental condition we observe light hearted teasing. Furthermore, students referred to themselves as a group more frequently in the experimental condition.

The full-circle methodology that we propose begins with ethnographic observations from interactions in the Virtual Math Teams environment. These observations lead to hypotheses that can be tested in high internal validity environments such as lab and classroom studies. These studies help us to confirm causal connections between stimuli and subsequent effects, between which we observe a correlational relationship in our earlier ethnographic analyses. Discovered causal connections can then form the basis for the design of full-scale interventions that can then be prototyped and tested in the Virtual Math Teams environment. These investigations can eventually serve both as a test of the generality and robustness of findings from the lab and classroom studies as well as providing new insights that form the basis for new hypotheses that can then be tested in further cycles, although only a large-scale controlled study, as we propose for in the final year of the project, can provide definitive evidence in favor of an intervention. In our three year project, we propose three complete cycles, ending with a carefully designed, large scale experimental study in the Virtual Math Teams environment to verify the effectiveness of the interventions we will develop in that environment. More information about the sequencing of activities in the proposed project is offered in Section 5.

4.2 Investigation of Contextual Variables in the VMT Environment

From lab and classroom studies where we are able to use pre and post tests, we are able to determine which types of interactions are more conducive to learning than others. We already have such findings, and we already know we can manipulate these behaviors in the lab and in the classroom. One major question we address in the proposed naturalistic observations in the on-line VMT environment as well as the large-scale summative evaluation in that environment in year three is whether or to what extent we can use the same interventions in "the wild" to achieve the same effect on behavior that we observe in the lab or in the classroom. This behavior is directly observable from the logs we collect. Thus, we can investigate these important questions about the effect of alternative interventions on collaborative behavior in the VMT setting even without pre and post tests. Specifically, what we seek to learn from our investigations in the on-line VMT environment is how the contextual variables that distinguish that environment from the lab and the classroom environments may interfere with or change the effects of interventions on student behavior. Such variables include the time of the interaction (e.g., during school hours, in the evening, on the weekend, during the summer), location (co-located or distributed teams), reward structure (e.g., in class assignment, homework assignment, extra credit, or voluntary), group composition (e.g., same grade cohort, mixed grade/age), collaborative pre-disposition (e.g., students coming from schools where collaborative learning is encouraged and frequent versus schools where collaboration is not part of regular instruction), and experience in the environment (e.g., new to the on-line VMT environment versus having participated for a long time). We will carefully keep track of this information about students and take them into consideration as we interpret findings from naturalistic observations used for hypothesis formation. In order to test these hypotheses some of these variables will be manipulated in a quasi-experimental manner in the large-scale summative evaluation in year three.

4.3 Experimental Paradigm

All lab and classroom studies will use the following experimental paradigm.

Participants. Participants will be middle school children recruited through local newspapers or through their teacher and will be randomly assigned to pairs, which will then randomly be assigned to conditions. We recognize that many characteristics of students may interact with our experimental manipulations such as ability level of individual students, differences in ability level of students in pairs, gender of individual students as well as gender mix of pairs, level of interest and motivation of individual students. In order to accommodate this, we will recruit at minimum 20 pairs per condition in each study in an attempt to achieve a balance of all of these factors, and we will include these variables in our analyses.

Materials. All instructional materials including tests, questionnaires, and problem solving activities will be based on existing Math Forum materials, and will be adapted for studies by researchers both at CMU and the Math Forum working in close collaboration. We will also seek guidance from the math coach who is our partner at Propel Charter School (See Section 6). All collaborative work sessions except for controlled studies in year one will take place in the VMT environment described in Section 3.1.

Experimental Procedure. We will strictly control for time in all experimental studies. Each pair will participate in a single two hour session, which includes time for pre and post tests, in some studies a supplementary tutoring session, and group work. In all cases, the experimental manipulation will take place during the group work segment. In studies with a supplementary tutoring segment prior to group work, students will also take a middle test prior to group work in order to separate learning from tutoring from learning during group work. Pre, post, and middle tests will be isomorphic, and we will counter-balance the order of the tests in order to control for any potential differences in difficulty between tests, as in our prior work (Gweon et al., 2006; Gweon et al., 2007). As in our previous studies, students will also take a questionnaire at the end of their participation to assess their perceptions of the collaboration, their attitudes toward their mathematical learning and the on-line learning environment overall .

*Experimental Manipulatio*n. Based on our previous experience, with 20 pairs per condition, we expect each lab study to require 6 weeks times the number of conditions. Thus, a 4 condition study would require about 6 months to run. Allowing time for analysis of results and reflection in between experiments, we expect to run between 4 and 6 studies of this magnitude, or fewer larger studies, within the 3 years of the proposed work. Each study will include a control condition with fully unsupported collaboration in order to obtain an accurate measure of the value of each intervention. Some experimental manipulations, such as ones involving choices about which resources to provide students with, do not require sensitivity to the ensuing collaborative process, whereas others require detecting patterns of collaborative behavior that are indicative of trouble in the collaboration. In early lab studies, as we are continuing to extend the capabilities of our automatic process analysis technology to the specific demands of our proposed work, interventions will be triggered using a Wizard-of-Oz setup as in (Gweon et al., 2006; Benzmueller et al., 2003), where an experimenter is watching the collaboration remotely and selecting interventions at key points in the process. As the technology becomes reliable enough, we will replace the human intervention with automatic triggering of interventions.

Process Analyses. As in our prior studies of collaborative learning, in addition to analyses of test and questionnaire data, we will explore the collaborative process through analysis of the chat logs collected during group work (Meier et al., submitted; Weinberger & Fischer, 2006; Strijbos, 2004; Lally & De Laat, 2002). Variables related to group process such as amount of deep explanation behavior, help seeking and help provision behavior will be analyzed both as ends in themselves, i.e., examining the effect of our experimental manipulations on patterns of communication, but also as mediating variables in our comparisons of pre to post test gains and questionnaire findings.

Prior to each formal study, we will run several pilot testing sessions for each new condition in order to fine tune our execution of our experimental manipulation.

4.4 Example study: Eliciting Helping Behavior with Dynamic Prompts

In our previous investigations with middle school students, we have observed that one area of needed support in collaborative problem solving is supporting the generation of explanations. We can offer some non-interactive support for this by means of fully worked out examples that include explanations, glossaries that define technical terms required for understanding the problems, and examples of clear explanations contrasted with unclear explanations. We can provide all of these things as resources to students in the spirit of the type of non-adaptive support for collaboration offered to students in state-of-the-art collaboration learning environments. These forms of support have already proven useful in prior studies of collaborative learning. What we propose to investigate that builds upon this prior work is the interaction between these non-adaptive forms of support and an adaptive form of support similar to the prompts used in our prior exploration of adaptive prompting with college aged students (Gweon et al., 2006). In that study, the adaptive support we offered students instructed them when to offer help but not how to offer help. But with middle school students (Gweon et al., 2007), we observed that students sometimes realized they should offer help but were not able to.

Thus, our first lab study we will contrast Non-adaptive support versus No support versus Non-Adaptive support versus Adaptive support (in the form of simple adaptive prompting as in (Gweon et al., 2006)). The purpose of the tutorial dialogue agents will be to scaffold the process of constructing an explanation by drawing the explanation out of a student step by step. We hypothesize that students will be better equipped to offer help in the Non-adaptive support condition than in the No Non-adaptive support condition, but may not be significantly more likely to attempt to offer help unless they have the additional support of the Dynamic support agents. We further hypothesize that low ability students will benefit more from the more elaborate form of Adaptive support than high ability students.

4.3 Subsequent Lab Studies

The series of studies that we run under this grant will build one on top of the other in terms of results. Thus, it is not possible to fully plan out the exact series of studies that we will run as we fine tune the design of our collaboration support approach and accumulate findings from study to study. However, we have specific ideas about alternative follow-up studies planned after the initial one just mentioned. For example, one question is whether our adaptive support should emphasize encouraging help providing behavior or help seeking behavior. Students may be more motivated to respond to a help request coming directly from their partner student rather than a request to offer help to that student when the request comes from a computer agent. Furthermore, students may be more aware of the specifics of the need for help when the help request comes directly from the student who needs the help, and thus the manipulation of prompting help seeking behavior versus prompting help providing behavior may have an effect on the quality and specificity of the help that is offered. A similar manipulation would be contrasting prompts that simply request that help be offered to the partner student versus prompts that refer to specific types of help or help on a specific topic when that request comes from a computer agent. At a high level, the collaboration support we offer students is meant to increase the level of *transactivity* in the collaborative discourse (Teasley, 1997; Berkowitz & Gibbs, 1983). The manipulations we have discussed thus far all focus on overcoming problem solving difficulties.

4.4 Evaluations in the VMT Environment

The computer-based tools developed under the proposed grant will be tested in naturalistic observations in the on-line VMT environment on a small scale throughout the 3 year project, and will be evaluated in a large-scale summative evaluation in the 3rd year of the project. Throughout the three years, regular uses of

the VMT-Chat environment by middle-school students will take place while the environment is instrumented with these tools.

The tools will be used in four ways:

1. In early naturalistic trial cases in the VMT environment, rather than directly intervening in student collaboration, instead the assessment of the collaborative learning interactions provided by the automatic process analysis technology discussed in Sections 2.3 and 3.3 will be provided asynchronously to human mentors who provide feedback to students between student sessions.
2. In a few trial cases, mentors will be in the chat room while the students are interacting. The mentors will use real-time data from the tools to provide synchronous mentoring to the students.
3. As the tools become more reliable, the support agents will interact with students within the environment, but in a mode where human moderators can intercept the messages when necessary.
4. When the agents have reached an acceptable level of performance, real-time support from the tools in the style found most successful in our lab studies will be provided synchronously to the students themselves during collaboration.
5. In all cases, explorations in the VMT environment will be more naturalistic than in the lab and classroom settings. Analysis of the naturalistic trial cases will mainly take the form of case studies. In the small scale evaluations in the VMT environment in the initial segment of the research project, brief interactions will be analyzed in detail to assess the impact of the data from the tools. Investigations in on-line settings cannot as easily be controlled and replicated to meet the requirements of traditional quantitative analysis. Therefore, qualitative interaction analysis is generally used in design-based research where conditions are changing as technology is redesigned and as the understanding of human participants also evolves (Design-Based Research Collective, 2003; Hutchins, 1996; Koschmann, Stahl, & Zemel, 2006; Maxwell, 2004). We expect these observations to complement the more quantitative findings from our controlled investigations. Their value comes from the highly externally valid insights we will gain from them in terms of moving towards our goal of providing a high quality on-line learning environment at a low cost.

As a final acid test of the technology, in the final year we will run a large scale evaluation in the VMT environment. We will endeavor to conduct this evaluation under as realistic of circumstances, true to how the VMT environment typically operates, as possible while maintaining enough experimental rigor to obtain generalizable and robust results. We will recruit students in the same way that students are typically recruited to participate in the VMT environment. Students who agree to participate will be given a pretest to assess their level of competence with the subject material going in to the study. We will ensure that this VMT "sub-community" does not mix with the larger VMT community during the time of the study, but beyond that we will not dictate the frequency or timing of their interactions in the environment any differently than typical VMT students. More specifically, there will be two such "sub-communities" for this study. In the control condition "sub-community", students will only receive the support that is currently offered in the VMT environment, specifically where limited support is offered by human moderators asynchronously. In the experimental condition, students will receive this support in addition to support by fully automatic support agents that will participate in all of their on-line interactions in the VMT environment for the duration of the study. We will keep careful track of when and how long each participant is logged into the VMT environment so that we can take this into account in our analysis. At the end of the study, students will take a post test. We compare conditions in terms of (1) pre to post test learning gains, (2) time on task, and (3) amount of observed helping behavior.

5. Research Plan Overview Integrating Research and Education

Rosé will oversee all work conducted at CMU, which includes basic research on automatic collaborative process analysis and interactive collaboration support delivery as well as lab and classroom studies. Stahl and Weimar will oversee all work conducted at Drexel University, which includes

integrating adaptive collaboration support technology with the VMT environment and conducting naturalistic observations on-line in the VMT environment. The CMU and Drexel teams will work together to conduct the large summative evaluation in the VMT environment in the final year of the project. The CMU and Drexel team will conduct phone conferences twice a month to coordinate their efforts. They will collaborate closely on the development of the materials for the studies as well as the analysis of data from all lab, classroom, and on-line studies and observations. The timeline of the proposed work will be organized around three cycles of the methodology proposed in Section 4:

Year 1. During the first year we will begin integrating the VMT environment with the dynamic support intervention tools developed at CMU. During the first 6 months of the project as this initial integration is in progress, we will pilot prototype interventions in the VMT environment. To enable getting started on this as early as possible, we will begin by using a hybrid methodology where the behavior of an automated agent is enhanced by the involvement of a human behind the agent as in (Rosé & Torrey, 2005). At the same time, we will conduct the lab study proposed above in Section 4.4 using the existing collaborative problem solving environment at CMU that was used in prior CMU team studies. While this environment does not offer all of the functionality and advantages that the VMT environment offers, it is already integrated with the CMU team tools, and so we continue to use it during year 1 of the project in order to obtain results as quickly as possible. The study described in Section 4.4 already builds on our prior results and observations, and thus is consistent with our proposed mixed methods methodology. In the second half of year 1, we will continue the integration process, analyze the data from the lab study, and use this analysis along with observations from the VMT environment to plan the next cycle.

Year 2. Beginning in Year 2, all lab and classroom studies as well as the naturalistic VMT environment observations will be conducted using the integrated version of the VMT software. During Year 2, in addition to running the next cycle of lab/classroom studies and observations in the VMT on-line environment, we will continue to extend the capabilities of our automatic collaborative learning process analysis technology in directions as motivated by findings from earlier cycles of research.

Year 3. The final year of the project will proceed as Year 2 except that in the final 6 months of the project we will conduct a large-scale summative evaluation study in the VMT on-line environment, as proposed in Section 4.4.

PIs Rosé and Stahl both teach courses in Computer Supported Collaborative Learning, which under this grant will be integrated into a single distributed course. Both courses involve a significant project component, in which distributed teams of students from both universities will join forces to participate in the research. One such opportunity they will have will be to prototype dynamic collaborative learning support interventions using the tools provided by the Carnegie Mellon team, which will then be pilot tested in Drexel's Virtual Math Teams environment. Analysis of chat logs from Virtual Math Teams interactions, especially involving dynamic support agents, will also be a course activity. Thus, students in the courses will not only benefit by learning about the findings from the research, but they will also actively participate in the research. Whereas the course at Drexel emphasizes a socio-cultural approach to computer supported collaborative learning, the course at Carnegie Mellon has more of a cognitive emphasis. Thus, the distributed teams will provide an ideal environment for wrestling with issues on the frontier between these two communities and gaining greater insight into the deep connections between the social and cognitive foundations of collaborative learning.

Results from the proposed research will be presented in conferences and journals in the fields of computer supported collaborative learning, human-computer interaction, and computational linguistics.

6. Partnerships

We have an ongoing partnership with Propel Charter School in Homestead, Pennsylvania where we have run a Math Camp in summer of 2006 and have been running an after school math club during the 2006-2007 academic school year in order to collect data on math explanations and collaborative behavior from urban middle school kids in connection with the specific Math Forum materials we have used and plan to continue use in our studies. This partnership provides one context where the CMU team will conduct classroom studies as part of this project. See letter of support from Propel Charter School's math coach, Ariane Watson, written in support of an earlier proposal related to collaborative math problem solving that was not funded but nevertheless served as a stimulus for beginning to build this partnership in anticipation of an eventual funded research project.

The Math Forum at Drexel University, run by Co-PI Steve Weimer, manages a website (http://mathforum.org) with over a million pages of resources related to mathematics for middle school and high school students, primarily algebra and geometry. This site is well established. A leading online resource for improving math learning, teaching and communication since 1992, it is now visited by over a million different visitors a month. A community has grown up around this site, including teachers, mathematicians, researchers, students and parents using the power of the Web to learn math and improve math education. The site offers a wealth of problems and puzzles; online mentoring; research; team problem solving; collaborations; and professional development. Studies of site usage show that students have fun and learn a lot; that educators share ideas and acquire new skills; and that participants become more engaged over time.

7. Results from Prior NSF Funding

Rosé has supervised NSF EHR/SGER-0411483 (REC: Calculategy: Exploring the Impact of Tutorial Dialogue Strategy in Shaping Student Behavior in Effective Tutorial Dialogue for Calculus). This SGER project provided the foundational research on adaptive collaboration support that this proposal is built upon. This project began by exploring the idea of the instructional benefit of errors, which has its roots in Piaget's notion of *cognitive conflict* (Piaget, 1985). This cognitive conflict plays an important role in stimulating cognitive restructuring by making children aware of a deficiency in their current understanding for explaining the world around them. In a recent study (Gweon et al., 2005) we reexamined the effects of group composition on the functioning of collaborative learning dyads in the light of recent work on learning from incorrectly worked examples (Grosse and Renkl, submitted). In a follow-up study we explored the use of prompts to encourage more teaching oriented behavior from the student participants in light of results indicating that students benefit more from working with less capable peers when they engage in deep explanation activities (Gweon et al., 2006). This study demonstrated that adaptive support for collaboration increases teaching behavior and has a significant positive effect on student learning. Other publications from this work include foundational work for the subsequent TagHelper tools project (Gweon et al., 2005b), with subsequent work and downloadable toolkit at http://www.cs.cmu.edu/~cprose/TagHelper.html, and work on eliciting learning oriented behavior with dialogue agents (Rosé & Torrey, 2005).

CoPIs Weimar and Stahl have jointly supervised the Virtual Math Teams (VMT) project at Drexel University. NSF DUE 0333493 Collaboration Services, $450,000, August 2003 to July 2005, NSF REC 0325447 Catalyzing & Nurturing Online Workgroups, $2,299,978, September 2003 to August 2008. Virtual Math Teams (VMT), led by Gerry Stahl, Drexel University, College of Information Science and Technology, Steve Weimar, Director of The Math Forum @ Drexel, and Wes Shumar, Associate Professor, Culture and Communication, Drexel University: The VMT Project investigates issues of online collaborative mathematics problem solving by extending the Math Forum's popular "problem of the week" service for use by small groups of students. These issues include the pedagogy of online collaborative learning of school mathematics, the design of appropriate software and the methodology of empirical research in such settings. See http://www.mathforum.org/vmt/researchers/orientation.html for more information as well as an extensive set of publications originating from this work.

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Project coordinator in Natural Language Tutoring Group

Publications Most Closely Related to the Proposal

[]Kumar, R., Rosé, C. P., Wang, Y. C., Joshi, M., Robinson, A. (to appear). Tutorial Dialogue as Adaptive Collaborative Learning Support, Submitted to AIED 2007

[]Gweon, G., Rosé,C. P., Albright, E., Cui, Y. (to appear). Evaluating the Effect of Feedback from a CSCL Problem Solving Environment on Learning, Interaction, and Perceived Interdependence, *Proceedings of CSCL 2007*.

[]Wang, H. C., Rosé, C.P., Cui, Y., Chang, C. Y, Huang, C. C., Li, T. Y. (to appear). Thinking Hard Together: The Long and Short of Collaborative Idea Generation for Scientific Inquiry, *Proceedings of CSCL 2007*.

[]McLaren, B., Scheuer, O., De Laat, M., Hever, R., de Groot, R. & Rosé, C. P. (to appear). Using Machine Learning Techniques to Analyze and Support Mediation of Student E-Discussions, *Proceedings of AIED 2007*.

[] Donmez, P., Rosé, C. P., Stegmann, K., Weinberger, A., and Fischer, F. (2005). Supporting CSCL with Automatic Corpus Analysis Technology, to appear in *the Proceedings of Computer Supported Collaborative Learning*. nominated for best paper award

Other Publications

[] Rosé, C. P., Aleven, V., Robinson, A., Wu, C. (in press). CycleTalk: Toward a Dialogue Agent that Guides Design with an Articulate Simulator, invited submission to the *International Journal of AI in Education Special Issue on "The Best of ITS '04"*

[] Litman, D., Rosé, C. P., Forbes-Riley, K., Silliman, S. & VanLehn, K. (in press). Spoken Versus Typed Human and Computer Dialogue Tutoring, invited submission to *the International Journal of AI in Education Special Issue on "The Best of ITS '04"*

[] Arguello, J. & Rosé, C. P. (2006). Museli: A Multi-source Evidence Integration Approach to Topic Segmentation of Spontaneous Dialogue, Proceedings of *the North American Chapter of the Association for Computational Linguistics*
[] Gweon, G., Rosé, C. P., Zaiss, Z., & Carey, R. (2006). Providing Support for Adaptive Scripting in an On-Line Collaborative Learning Environment, Proceedings of *CHI 06: ACM conference on human factors in computer systems*. New York: ACM Press.
[] Kumar, R., Rosé, C. P., Aleven, V., Iglesias, A., Robinson, A. (2006). Evaluating the Effectiveness of Tutorial Dialogue Instruction in an Exploratory Learning Context, *Proceedings of the Intelligent Tutoring Systems Conference.*

Awards and Honors
Elected to the Faculty Senate, 2007
Winner of Best Poster Award at ITS, 2006
Nominated for Best Paper Award at ITS, 2006
Nominated for Best Paper Award at ACM SIGCHI, 2006, 2007.
Nominated for Best Paper Award at Computer Supported Collaborative Learning, 2005.
Nominated for Best Paper Award at AI in Education Conference, 2001.
Carnegie Scholar Award, Carnegie Mellon University, 1994-1997.
Phi Beta Kappa, University of California at Irvine, 1991.
Golden Key National Honor Society, University of California at Irvine, 1991.
Simms Memorial Scholarship, University of California at Irvine, 1991-1992.

Recent External Professional Activities
Member of the Association for Computational Linguistics
Member of the International Artificial Intelligence in Education Society
Member of the International Society of the Learning Sciences
Member of ACM SIGCHI

Founding Editorial Board Member for the Journal of Dialogue Systems 2006-

Faculty Affiliate of the University of Pittsburgh's Sara Fine Institute (an institute devoted to the study of inter-personal behavior and technology)

Tutorial Co-Chair, AIED 2007
Co-Organizer for ICLS 2006 Workshop on Dynamic Support for CSCL: Conceptual Approaches and Technologies for Flexible Support of Collaborative Knowledge Construction
Program Committee for FLAIRS 2006
Program Committee for ITS 2006
Program Committee for AAAI 2006
Scientific Committee for LREC 2006
Invited Expert External Reviewer for internal Call for Learning Center Project Proposals at Swiss Federal Institute of Technology in Lausanne (EPFL), Summer 2005
Program Committee for AIED 2005

Gerry Stahl

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Drexel University
Philadelphia, PA 19104

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www.cis.drexel.edu/faculty/gerry

Gerry Stahl teaches, publishes and conducts research in human-computer interaction (HCI) and computer-supported collaborative learning (CSCL). His new book, *Group Cognition: Computer Support for Building Collaborative Knowledge* is published by MIT Press. He is founding Executive Editor of the *International Journal of Computer-Supported Collaborative Learning* (ijCSCL). He is the Principal Investigator of the *Virtual Math Teams Project*, a large 5-year research effort in collaboration with the Math Forum@Drexel. He served as Program Chair for the international CSCL '02 conference, Workshops Chair for CSCL '03, CSCL '05, ICCE '06 and CSCL'07. He teaches undergraduate, masters and PhD courses in HCI, CSCW and CSCL at the i-School of Drexel.

Professional Preparation

Massachusetts Institute of Technology (MIT)	Humanities & Science (Math & Philosophy)	BS 1967
University of Heidelberg	Continental Philosophy	1967-68
University of Frankfurt	Social Theory	1971-73
Northwestern University	Philosophy	MA 1971
Northwestern University	Philosophy	PhD 1975
University of Colorado	Computer Science	MS 1990
University of Colorado	Computer Science	PhD 1993
University of Colorado	Computer Science & Cognitive Science	Postdoc 1996-99

Appointments & Professional Experience

2002-present **Associate Professor**
College of Information Science & Technology
Drexel University, Philadelphia, PA

2001-2002 **Visiting Research Scientist**
BSCW Development Team, CSCW Department, FIT
GMD and Fraunhofer Institutes, Bonn, Germany

1999-2001 **Assistant Research Professor**
Department of Computer Science & Institute of Cognitive Science
University of Colorado, Boulder, CO

1996-1999 **Post Doctoral Research Fellow**
Center for LifeLong Learning and Design
University of Colorado, Boulder, CO

1993-1996 **Director of Software R&D**
Owen Research Inc., Boulder, CO

Relevant Publications

Stahl, G. (2006). *Group cognition: Computer support for building collaborative knowledge*. Cambridge, MA: MIT Press. Available online at http://www.cis.drexel.edu/faculty/gerry/mit/.

Stahl, G. & Hesse, F. (2006). Inaugural issue. *International Journal of Computer-Supported Collaborative Learning (ijCSCL), 1* (1). Available online at http://ijCSCL.org.

Stahl, G. (Ed.). (2002). *Computer support for collaborative learning: Foundations for a CSCL community*. Proceedings of CSCL 2002. January 7-11. Boulder, Colorado, USA. Hillsdale, NJ: Lawrence Erlbaum Associates Available online at http://isls.org/cscl/cscl2002proceedings.pdf.

Stahl, G. (2005). *Groups, group cognition & groupware [keynote]*. Paper presented at the International Workshop on Groupware (CRIWG 2005), Racife, Brazil. Available online at http://www.cis.drexel.edu/faculty/gerry/pub/criwg2005.pdf.

Stahl, G. (2003). *The future of computer support for learning: An American/German DeLFIc vision [keynote]*. Paper presented at the First Conference on e-Learning of the German Computer Science Society (DeLFI 2003), Munich, Germany. Proceedings pp. 13-16. Available online at http://www.cis.drexel.edu/faculty/gerry/publications/presentations/delfi.

Stahl, G. (2006). Analyzing and designing the group cognitive experience. *International Journal of Cooperative Information Systems (IJCIS)*. Available online at http://www.cis.drexel.edu/faculty/gerry/pub/ijcis.pdf.

Stahl, G. (2006). Group cognition in an online chat community: Analyzing collaborative use of a cognitive tool. *Journal of Educational Computing Research (JECR) special issue on Cognitive tools for collaborative communities*. Available online at http://www.cis.drexel.edu/faculty/gerry/pub/jecr.pdf.

Stahl, G. (2006). Sustaining group cognition in a Math chat environment. *Research and Practice in Technology Enhanced Learning (RPTEL), 1* (2). Available online at http://www.cis.drexel.edu/faculty/gerry/pub/rptel.pdf.

Stahl, G., Rohde, M., & Wulf, V. (2006). Introduction: Computer support for learning communities. *Behavior and Information Technology (BIT)*. Available online at http://www.cis.drexel.edu/faculty/gerry/pub/bit_intro.pdf.

Stahl, G. (2005). Group cognition in computer assisted learning. *Journal of Computer Assisted Learning*. Available online at http://www.cis.drexel.edu/faculty/gerry/publications/journals/JCAL.pdf.

Synergistic Activities

- 2005-2007: "*SoL Catalyst: Engaged Learning in Online Communities*." (PI with co_PIs Sharon Derry, Mary Marlino, K. Ann Renninger, Daniel Suthers, Stephen Weimar) $180,762; sponsor: NSF SOL.
- 2003-2008: "*IERI: Catalyzing & Nurturing Online Workgroups to Power Virtual Learning Communities.*" (PI with co-PIs Stephen Weimar and Wesley Shumar) $2,300,000; sponsor: NSF IERI.
- 2003-2005: "*Collaboration Services for the Math Forum Digital Library*" (PI with co-PIs Stephen Weimar and Wesley Shumar) $450,000; sponsor: NSF NSDL.
- 1997-2000: "*Allowing Learners to be Articulate: Incorporating Automated Text Evaluation into Collaborative Software Environments*" (primary author and primary software developer; PIs: Gerhard Fischer, Walter Kintsch and Thomas Landauer) $678,239; sponsor: James S. McDonnell Foundation.
- 1997-2000: "*Conceptual Frameworks and Computational Support for Organizational Memories and Organizational Learning*" (co-PI with Gerhard Fischer and Jonathan Ostwald), $725,000; sponsor: NSF.
- 1998-1999: "*Collaborative Web-Based Tools for Learning to Integrate Scientific Results into Social Policy*" (co-PI with Ray Habermann) $89,338;sponsor: NSF.

Collaborators & Other Affiliations

Scientific Advisory Boards: Knowledge Media Research Center (KMRC, Germany), Learning Sciences Laboratory (LSL, NIE, Singapore), Knowledge Practices Laboratory (K-P Lab, Finland).

Collaborators and Co-Editors: Clarence (Skip) Ellis, Gerhard Fischer, Raymond Habermann, Walter Kintsch, Thomas Landauer, Curtis LeBaron, Raymond McCall, Jonathan Ostwald, Alexander Repenning, Tamara Sumner (U. Colorado, Boulder); Robert Allen, K. Ann Renninger, Wesley Shumar, Stephen Weimar, Alan Zemel (Drexel U., Philadelphia); Timothy Koschman (Southern Illinois U.); Angela Carell, Thomas Herrmann, Andrea Kienle, Ralf Klamma, Kai-Uwe Loser, Wolfgang Prinz, Markus Rohde, Volker Wulf (Germany); Sten Ludvigsen, Anders Morch, Barbara Wasson (Norway), Cesar Alberto Collazos (Chile); Jan-Willem Strijbos (Netherlands). Carolyn Rose (CMU), Daniel Suthers (Hawaii), Sharon Derry (Wisconsin), Mary Marlino (UCAR)

Dissertation Advisors: Gerhard Fischer, Clayton Lewis, Raymond McCall, Mark Gross (U. Colorado, Boulder). Samuel Todes, Theodor Kiesel (Northwestern).

Graduate Students, Post-Docs, visiting Researchers: Rogerio dePaula, Elizabeth Lenell, Alena Sanusi, David Steinhart (U. Colorado, Boulder); Murat Cakir, Ilene Litz Goldman, Trish Grieb-Neff, Yolanda Jones, Wanda Kunkle. Deb LeBelle, Debra McGrath, Pete Miller, Johann Sarmiento, Ramon Toledo, Jim Waters, Alan Zemel, Nan Zhou (Drexel U., Philadelphia); Andrea Kienle (U. Dortmund, Germany); Cesar Alberto Collazos (U. Chile, Chile); Jan-Willem Strijbos (Open U., Netherlands); Fatos Xhafa (Open U. Catalonia, Spain); Stefan Trausan-Matu (Politechnica University of Bucharest, Romania); Angela Carell (Bochum U., Germany); Martin Wesner, Martin Műhlpfordt (FhG-IPSI, Germany); Elizabeth Charles (Canada), Weiquin Chen (Norway).

A more complete resume with live links is available at: http://www.cis.drexel.edu/faculty/gerry/resume.html

Stephen Andrew Weimar
Director of the Math Forum @ Drexel

Address: The Math Forum @ Drexel
3210 Cherry Street
Philadelphia, PA 19104
215-895-0236

PROFESSIONAL PREPARATION

Haverford College	Philosophy	B.A., 1980

APPOINTMENTS

Director, The Math Forum @ Drexel, Drexel University (2001-present): Responsible for research and business development, operations, and program design of the leading application of the Internet to improve mathematics education.

Vice President, Learning Partnerships, WebCT (2000-2001): Led the development of the online academic communities and consulting services to form an effective business unit driving the successful implementation of WebCT for higher education, K-12, and corporate clients.

Co-Principal Investigator and Project Director, Geometry Forum, Math Forum, Swarthmore College (1994–2000)**:** Coordinate project development for this Internet-based electronic community and NSF-sponsored research project in math education and telecommunications.

Education Consultant (1988–1994): Freelance consultant to schools, colleges, and educational organizations for teacher professional development.

Executive Director, Philadelphia Chapter of Educators for Social Responsibility (ESR) (1983–1988): Established and administered this professional organization for public, private, and parochial school teachers in the Philadelphia area.

Math Teacher, Germantown Friends School, Philadelphia (1980–1983): Middle and high school mathematics.

PUBLICATIONS

Weimar, S, A., et. al. (1993-2007). *The Math Forum* http://mathforum.org/

Giersch, S., Klotz, E. A., McMartin, F., Muramatsu, B., Renninger, K. A., Shumar, W., et al. (2004, July/August). If you build it, will they come? Participant involvement in digital libraries. *D-Lib Magazine, 10*(7/8). Retrieve from http://www.dlib.org/dlib/july04/giersch/07giersch.html

Renninger, K. A., Weimar, S. A., & Klotz, E. A. (1998) Teachers And Students Investigating And Communicating About Geometry: The Math Forum. In R. Lehrer and D. Chazan (Eds.), *New Directions in Teaching and Learning Geometry*. Hillsdale, NJ: Lawrence Erlbaum Associates.

SYNERGISTIC ACTIVITIES

Co-Principal Investigator, *Leadership Development for Technology Integration,* creating online workshops and site-based leadership development that drive the use and integration of math software tools from the National Science Digital Library (NSDL).

Co-Principal Investigator, *Customized Resources for NSDL*, a collaboration with Beverly Woolf at the University of Massachusetts to provide instructional middleware that will solicit teacher/student input about learning needs and characteristics, personalize instruction for individual an student, based on cognitive, affective and social characteristics, and grade the effectiveness of the resource.

Co-Principal Investigator, Virtual Math Teams, a collaboration with Gerry Stahl in the Drexel College of Information Science and Technology investigating effective environments for online mathematics problem-solving in groups. A key goal is to develop scalable systems to support student participation in and learning from the Problem of the Week.

Co-Principal Investigator, Web Math Communication, a collaboration with Krandick and others in the Drexel Department of Computer Science investigating strategies for improving students' and mentors' reuse of prior questions and answers, along with tools to enhance mathematical communication and exploration.

COLLABORATORS & OTHER AFFILIATIONS

Agogino, Alice, U. Cal. Berkeley
Albers, Donald, Math. Assoc. of America
Awerbuch, Jonathan, Drexel University
Char, Bruce, Drexel University
Chung, Mark, SRI
Croft, Bruce, UMass
Cuoco, Al, EDC
Derry, Sharon, University of Wisconsin
DiGiano, Christopher J., SRI
Duffin, Joel, Utah State
Falk, John, Institute for Learning Innovation
Goldenberg, Paul, EDC
Heal, Robert, Utah State
Hewett, Thomas, Drexel University
Hoadley, Chris, Penn State
Johnson, Jeremy, Drexel University
King, Jim, Washington
Krandick, Werner, Drexel University
Loken, Eric, Penn State
Marlino, Mary, DLESE
Merlino, Joe, LaSalle College
Moore, Lang, Duke University
Panoff, Robert, Shodor
Reese, George, University of Illinois, Urbana-Champaign
Renninger, K. Ann, Swarthmore College
Repenning, Alex, University of Colorado, Boulder
Roschelle, Jeremy, SRI
Shechtman, Nikki, SRI
Shumar, Wesley, Drexel University
Simutis, Len (Eisenhower National Clearinghouse)
Stahl, Gerry, Drexel University
Suthers, Daniel, University of Hawaii
Underwood, Jody, ETS
Webb, Norman L., U. of Wisconsin
Wood, Bill, U. of Maryland
Woolf, Beverly, University of Massachusetts

SUMMARY PROPOSAL BUDGET YEAR 1

FOR NSF USE ONLY		
PROPOSAL NO.	DURATION (months) Proposed	Granted
AWARD NO.		

ORGANIZATION: **Carnegie-Mellon University**

PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR: **Carolyn P Rose**

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-months CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)
1. **Carolyn P Rose - PI**	2.00	0.00	0.00	$ 13,404	$
2. **Gerry Stahl - Co-PI**	0.00	0.00	0.00	0	
3. **Stephen A Weimar - Co-PI**	0.00	0.00	0.00	0	
4.					
5.					
6. (**0**) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	0	
7. (**3**) TOTAL SENIOR PERSONNEL (1 - 6)	2.00	0.00	0.00	13,404	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. (**0**) POST DOCTORAL ASSOCIATES	0.00	0.00	0.00	0	
2. (**0**) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	0.00	0.00	0.00	0	
3. (**1**) GRADUATE STUDENTS				26,584	
4. (**6**) UNDERGRADUATE STUDENTS				2,769	
5. (**0**) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				0	
6. (**0**) OTHER				0	
TOTAL SALARIES AND WAGES (A + B)				42,757	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				3,096	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				45,853	
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.) **High End PC** $ 3,000					
TOTAL EQUIPMENT				3,000	
E. TRAVEL 1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS)				3,658	
2. FOREIGN				3,035	
F. PARTICIPANT SUPPORT COSTS					
1. STIPENDS $ **0**					
2. TRAVEL **0**					
3. SUBSISTENCE **0**					
4. OTHER **0**					
TOTAL NUMBER OF PARTICIPANTS (**0**) TOTAL PARTICIPANT COSTS				0	
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				0	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				48	
3. CONSULTANT SERVICES				0	
4. COMPUTER SERVICES				2,108	
5. SUBAWARDS				59,213	
6. OTHER				39,687	
TOTAL OTHER DIRECT COSTS				101,056	
H. TOTAL DIRECT COSTS (A THROUGH G)				156,602	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE) **Overhead on Subcontract (Rate: 48.5000, Base: 25000) (Cont. on Comments Page)**					
TOTAL INDIRECT COSTS (F&A)				42,611	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				199,213	
K. RESIDUAL FUNDS (IF FOR FURTHER SUPPORT OF CURRENT PROJECTS SEE GPG II.C.6.j.)				0	
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				$ 199,213	$

M. COST SHARING PROPOSED LEVEL $ **0** AGREED LEVEL IF DIFFERENT $

PI/PD NAME: **Carolyn P Rose**

ORG. REP. NAME*

FOR NSF USE ONLY		
INDIRECT COST RATE VERIFICATION		
Date Checked	Date Of Rate Sheet	Initials - ORG

 ***ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET**

SUMMARY PROPOSAL BUDGET COMMENTS - Year 1

**** I- Indirect Costs**
Overhead Rate (Rate: 48.5000, Base 62857)

SUMMARY PROPOSAL BUDGET YEAR 2

FOR NSF USE ONLY		
PROPOSAL NO.	DURATION (months) Proposed	Granted
AWARD NO.		

ORGANIZATION
Carnegie-Mellon University

PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR
Carolyn P Rose

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-months CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)
1. **Carolyn P Rose - PI**	2.00	0.00	0.00	$ 13,872	$
2. **Gerry Stahl - Co-PI**	0.00	0.00	0.00	0	
3. **Stephen A Weimar - Co-PI**	0.00	0.00	0.00	0	
4.					
5.					
6. (**0**) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	0	
7. (**3**) TOTAL SENIOR PERSONNEL (1 - 6)	2.00	0.00	0.00	13,872	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. (**0**) POST DOCTORAL ASSOCIATES	0.00	0.00	0.00	0	
2. (**0**) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	0.00	0.00	0.00	0	
3. (**1**) GRADUATE STUDENTS				27,912	
4. (**6**) UNDERGRADUATE STUDENTS				7,114	
5. (**0**) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				0	
6. (**0**) OTHER				0	
TOTAL SALARIES AND WAGES (A + B)				48,898	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				3,204	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				52,102	
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)					
High End PC $ 3,088					
TOTAL EQUIPMENT				3,088	
E. TRAVEL 1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS)				3,782	
2. FOREIGN				3,126	
F. PARTICIPANT SUPPORT COSTS					
1. STIPENDS $ **0**					
2. TRAVEL **0**					
3. SUBSISTENCE **0**					
4. OTHER **0**					
TOTAL NUMBER OF PARTICIPANTS (**0**) TOTAL PARTICIPANT COSTS				0	
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				0	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				51	
3. CONSULTANT SERVICES				0	
4. COMPUTER SERVICES				2,395	
5. SUBAWARDS				62,174	
6. OTHER				41,579	
TOTAL OTHER DIRECT COSTS				106,199	
H. TOTAL DIRECT COSTS (A THROUGH G)				168,297	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE)					
Overhead Rate (Rate: 48.5000, Base: 69849)					
TOTAL INDIRECT COSTS (F&A)				33,877	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				202,174	
K. RESIDUAL FUNDS (IF FOR FURTHER SUPPORT OF CURRENT PROJECTS SEE GPG II.C.6.j.)				0	
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				$ 202,174	$

M. COST SHARING PROPOSED LEVEL $ **0** AGREED LEVEL IF DIFFERENT $

PI/PD NAME
Carolyn P Rose

ORG. REP. NAME*

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INDIRECT COST RATE VERIFICATION		
Date Checked	Date Of Rate Sheet	Initials - ORG

 ***ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET**

SUMMARY PROPOSAL BUDGET YEAR 3

FOR NSF USE ONLY		
PROPOSAL NO.	DURATION (months) Proposed	Granted
AWARD NO.		

ORGANIZATION: **Carnegie-Mellon University**

PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR: **Carolyn P Rose**

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-months CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)
1. **Carolyn P Rose - PI**	2.00	0.00	0.00	$ 14,358	$
2. **Gerry Stahl - Co-PI**	0.00	0.00	0.00	0	
3. **Stephen A Weimar - Co-PI**	0.00	0.00	0.00	0	
4.					
5.					
6. (**0**) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	0	
7. (**3**) TOTAL SENIOR PERSONNEL (1 - 6)	2.00	0.00	0.00	14,358	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. (**0**) POST DOCTORAL ASSOCIATES	0.00	0.00	0.00	0	
2. (**0**) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	0.00	0.00	0.00	0	
3. (**1**) GRADUATE STUDENTS				29,304	
4. (**6**) UNDERGRADUATE STUDENTS				3,524	
5. (**0**) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				0	
6. (**0**) OTHER				0	
TOTAL SALARIES AND WAGES (A + B)				47,186	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				3,318	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				50,504	
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)					
High End PC $ 3,183					
TOTAL EQUIPMENT				3,183	
E. TRAVEL 1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS)				3,895	
2. FOREIGN				3,220	
F. PARTICIPANT SUPPORT COSTS					
1. STIPENDS $ **0**					
2. TRAVEL **0**					
3. SUBSISTENCE **0**					
4. OTHER **0**					
TOTAL NUMBER OF PARTICIPANTS (**0**) TOTAL PARTICIPANT COSTS				0	
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				0	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				48	
3. CONSULTANT SERVICES				0	
4. COMPUTER SERVICES				2,324	
5. SUBAWARDS				65,282	
6. OTHER				43,545	
TOTAL OTHER DIRECT COSTS				111,199	
H. TOTAL DIRECT COSTS (A THROUGH G)				172,001	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE)					
Overhead Rate (Rate: 48.5000, Base: 68621)					
TOTAL INDIRECT COSTS (F&A)				33,281	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				205,282	
K. RESIDUAL FUNDS (IF FOR FURTHER SUPPORT OF CURRENT PROJECTS SEE GPG II.C.6.j.)				0	
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				$ 205,282	$

M. COST SHARING PROPOSED LEVEL $ **0** AGREED LEVEL IF DIFFERENT $

PI/PD NAME: **Carolyn P Rose**

ORG. REP. NAME*

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INDIRECT COST RATE VERIFICATION		
Date Checked	Date Of Rate Sheet	Initials - ORG

 ***ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET**

SUMMARY PROPOSAL BUDGET

Cumulative

FOR NSF USE ONLY		
PROPOSAL NO.	DURATION (months) Proposed	Granted
AWARD NO.		

ORGANIZATION: **Carnegie-Mellon University**

PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR: **Carolyn P Rose**

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-months CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)
1. **Carolyn P Rose - PI**	6.00	0.00	0.00	$ 41,634	$
2. **Gerry Stahl - Co-PI**	0.00	0.00	0.00	0	
3. **Stephen A Weimar - Co-PI**	0.00	0.00	0.00	0	
4.					
5.					
6. ( ) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	0	
7. (**3**) TOTAL SENIOR PERSONNEL (1 - 6)	6.00	0.00	0.00	41,634	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. (**0**) POST DOCTORAL ASSOCIATES	0.00	0.00	0.00	0	
2. (**0**) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	0.00	0.00	0.00	0	
3. (**3**) GRADUATE STUDENTS				83,800	
4. (**18**) UNDERGRADUATE STUDENTS				13,407	
5. (**0**) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				0	
6. (**0**) OTHER				0	
TOTAL SALARIES AND WAGES (A + B)				138,841	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				9,618	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				148,459	
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.) $ 9,271					
TOTAL EQUIPMENT				9,271	
E. TRAVEL 1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS)				11,335	
2. FOREIGN				9,381	
F. PARTICIPANT SUPPORT COSTS					
1. STIPENDS $ 0					
2. TRAVEL 0					
3. SUBSISTENCE 0					
4. OTHER 0					
TOTAL NUMBER OF PARTICIPANTS (**0**) TOTAL PARTICIPANT COSTS				0	
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				0	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				147	
3. CONSULTANT SERVICES				0	
4. COMPUTER SERVICES				6,827	
5. SUBAWARDS				186,669	
6. OTHER				124,811	
TOTAL OTHER DIRECT COSTS				318,454	
H. TOTAL DIRECT COSTS (A THROUGH G)				496,900	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE)					
TOTAL INDIRECT COSTS (F&A)				109,769	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				606,669	
K. RESIDUAL FUNDS (IF FOR FURTHER SUPPORT OF CURRENT PROJECTS SEE GPG II.C.6.j.)				0	
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				$ 606,669	$

M. COST SHARING PROPOSED LEVEL $ **0** AGREED LEVEL IF DIFFERENT $

PI/PD NAME: **Carolyn P Rose**

ORG. REP. NAME*

FOR NSF USE ONLY		
INDIRECT COST RATE VERIFICATION		
Date Checked	Date Of Rate Sheet	Initials - ORG

C ***ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET**

PERSONNEL COSTS

Salaries: All salaries are based on 2006-2007 salaries. Faculty and staff salaries reflect an anticipated annual increase effective July 1. This incorporates merit increases as well as cost of living and market condition considerations. Graduate support is increased effective September 1. The colleges each set their graduate support rates in consultation with their faculty, department heads, deans and the Provost, taking into account an evaluation of our historical market position in comparison to our peer institutions. Salaries for research faculty and staff are based on a twelve-month calendar year; salaries for teaching faculty and graduate students are based on a nine-month academic year and three summer months.

Faculty and Staff Increase Rate:	3.50%
Average Graduate Support Increase Rate:	5.00%

Fringe Benefits: The University's fiscal year is July 1 - June 30. Fringe benefits for faculty and staff are calculated as follows. No fringe benefits are calculated on graduate student stipends or undergraduate student wages.

CMU fiscal year 2006 and thereafter	23.10%

OPERATING EXPENSES

General operating expenses are increased annually based on an estimate of inflation.

Operating Expense Increase Rate:	3.00%

Expenditures budgeted under operating expenses for this proposal are costs that can be identified specifically with this particular sponsored project and are required in the direct performance of the research. Some of these expenses can be estimated with a high degree of accuracy for this project and are listed individually. Other expenses are estimated using a formula. These expenses include applicable computer supplies and software, copying, telephone and fax toll charges, postage and express mail, technical supplies and printing expenditures. These proposed expenses are based on the following percentages of research salaries and fringe benefits.

Copying/Publications	0.10%
Telephone	0.10%
Postage & Shipping	0.20%

These percentages were derived from a comparison of 2004-2005 expenditures to 2004-2005 research salaries and fringe benefits. Since we round to the nearest dollar monthly, on a project basis, these expenses may not be exactly equal to the percent times the salary dollars. Category G1 represents telecommunications services (long distance calls). Copying/Publications and Postage charges are combined under category G2.

TRAVEL

This project requires that project personnel travel on two (5 days/4 nights) trips per year. These trips will be designated for travel to the sponsor's site, to attend relevant scientific conferences at which ideas and information are exchanged with colleagues, to work directly with research collaborators, and to conduct educational business relating to this research effort. It also requires that key project personnel attend major conferences in their field each year, many of which are frequently held outside of the United States. For this reason, the foreign travel budget includes one trip for (6 days/5 nights).

Travel has been estimated based on sample flight costs and daily expense rates for general east or west coast destinations. These travel amounts are calculated based on a sampling of typical trips taken by members of the department this past fiscal year and are increased at the same rate as operating expenses based on an estimate of inflation. Travel costs using personal vehicles are calculated at $0.485/mile. Airfare costs are based on average present costs, unless a destination is specified. Daily domestic expenses are calculated at a rate of $102 per day for food expenses, ground travel including car rental and miscellaneous expenses. Nightly expenses are calculated at $94 per night for hotel accommodations. Daily foreign expenses are based on $135 per day, while nightly expenses are $155 per night.

COMPUTING SERVICES

Included are technical and facilities maintenance costs. The School of Computer Science maintains its own computing facility and is not dependent on the university maintained facility. Included in the maintenance costs of our facilities are the costs associated with networking, systems software support, time-shared machines, printing, maintenance contracts and salaries of the facility staff, including computer operators, systems programmers, systems engineers, line technicians and repair technicians. Facilities maintenance costs in the School were found to be 4.6% of research personnel and fringe benefits costs in fiscal year 2004-2005.

GRADUATE STUDENT TUITION REMISSION

This includes full tuition and fees for one graduate student.

EQUIPMENT (Capital & Non-capital)

Computer purchases are done through CMU’s purchasing division which requires quotes from three comparable vendors before purchase.

{Please provide details}
Year 1: In order to provide computing equipment for the graduate students and staff on this project we will need to purchase One High-end PC. (Non-capital equipment)

Year 2: One High-end PC (Non-capital equipment)

Year 3: One High-end PC (Non-capital equipment)

OVERHEAD

Overhead on this proposal has been calculated at our current proposed or negotiated rate for all fiscal years in accordance with OMB Circular A-21, Section G.7.The modified total direct cost base (MTDC) amount used in calculating the indirect costs is the total direct costs, excluding capital equipment, 100% of graduate student tuition remission and individual subcontract costs in excess of $25,000.

Overhead Rate: 48.50%

SUMMARY PROPOSAL BUDGET YEAR 1

FOR NSF USE ONLY		
PROPOSAL NO.	DURATION (months) Proposed	Granted
AWARD NO.		

ORGANIZATION: **Drexel University**

PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR: **Gerry Stahl**

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-months CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)
1. **Gerry Stahl - Associate Prof**	0.00	0.00	1.00	$ 11,472	$
2. **Stephen A Weimar - Director**	1.00	0.00	0.00	9,167	
3.					
4.					
5.					
6. (0) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	0	
7. (2) TOTAL SENIOR PERSONNEL (1 - 6)	1.00	0.00	1.00	20,639	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. (0) POST DOCTORAL ASSOCIATES	0.00	0.00	0.00	0	
2. (1) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	1.50	0.00	0.00	8,127	
3. (0) GRADUATE STUDENTS				0	
4. (0) UNDERGRADUATE STUDENTS				0	
5. (0) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				0	
6. (0) OTHER				0	
TOTAL SALARIES AND WAGES (A + B)				28,766	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				7,709	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				36,475	
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)					
TOTAL EQUIPMENT				0	
E. TRAVEL 1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS)				3,000	
2. FOREIGN				0	
F. PARTICIPANT SUPPORT COSTS					
1. STIPENDS $ 0					
2. TRAVEL 0					
3. SUBSISTENCE 0					
4. OTHER 0					
TOTAL NUMBER OF PARTICIPANTS (0) TOTAL PARTICIPANT COSTS				0	
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				0	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				0	
3. CONSULTANT SERVICES				0	
4. COMPUTER SERVICES				0	
5. SUBAWARDS				0	
6. OTHER				0	
TOTAL OTHER DIRECT COSTS				0	
H. TOTAL DIRECT COSTS (A THROUGH G)				39,475	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE) **Indirect (Rate: 50.0000, Base: 39475)**					
TOTAL INDIRECT COSTS (F&A)				19,738	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				59,213	
K. RESIDUAL FUNDS (IF FOR FURTHER SUPPORT OF CURRENT PROJECTS SEE GPG II.C.6.j.)				0	
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				$ 59,213	$

M. COST SHARING PROPOSED LEVEL $ 0 AGREED LEVEL IF DIFFERENT $

PI/PD NAME: **Gerry Stahl**

ORG. REP. NAME*

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INDIRECT COST RATE VERIFICATION		
Date Checked	Date Of Rate Sheet	Initials - ORG

 *ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET

SUMMARY PROPOSAL BUDGET YEAR 2

FOR NSF USE ONLY		
PROPOSAL NO.	DURATION (months) Proposed	Granted
AWARD NO.		

ORGANIZATION: **Drexel University**

PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR: **Gerry Stahl**

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-months CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)
1. **Gerry Stahl - Associate Prof**	0.00	0.00	1.00	$ 12,046	$
2. **Stephen A Weimar - Director**	1.00	0.00	0.00	9,625	
3.					
4.					
5.					
6. (0) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	0	
7. (2) TOTAL SENIOR PERSONNEL (1 - 6)	1.00	0.00	1.00	21,671	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. (0) POST DOCTORAL ASSOCIATES	0.00	0.00	0.00	0	
2. (1) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	1.50	0.00	0.00	8,533	
3. (0) GRADUATE STUDENTS				0	
4. (0) UNDERGRADUATE STUDENTS				0	
5. (0) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				0	
6. (0) OTHER				0	
TOTAL SALARIES AND WAGES (A + B)				30,204	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				8,095	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				38,299	
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)					
TOTAL EQUIPMENT				0	
E. TRAVEL 1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS)				3,150	
2. FOREIGN				0	
F. PARTICIPANT SUPPORT COSTS					
1. STIPENDS $ 0					
2. TRAVEL 0					
3. SUBSISTENCE 0					
4. OTHER 0					
TOTAL NUMBER OF PARTICIPANTS (0) TOTAL PARTICIPANT COSTS				0	
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				0	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				0	
3. CONSULTANT SERVICES				0	
4. COMPUTER SERVICES				0	
5. SUBAWARDS				0	
6. OTHER				0	
TOTAL OTHER DIRECT COSTS				0	
H. TOTAL DIRECT COSTS (A THROUGH G)				41,449	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE) **Indirect (Rate: 50.0000, Base: 41449)**					
TOTAL INDIRECT COSTS (F&A)				20,725	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				62,174	
K. RESIDUAL FUNDS (IF FOR FURTHER SUPPORT OF CURRENT PROJECTS SEE GPG II.C.6.j.)				0	
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				$ 62,174	$

M. COST SHARING PROPOSED LEVEL $ 0 AGREED LEVEL IF DIFFERENT $

PI/PD NAME: **Gerry Stahl**

ORG. REP. NAME*

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INDIRECT COST RATE VERIFICATION		
Date Checked	Date Of Rate Sheet	Initials - ORG

 *ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET

SUMMARY PROPOSAL BUDGET

YEAR 3

FOR NSF USE ONLY		
PROPOSAL NO.	DURATION (months) Proposed	Granted
AWARD NO.		

ORGANIZATION: **Drexel University**

PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR: **Gerry Stahl**

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-months CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)
1. **Gerry Stahl - Associate Prof**	0.00	0.00	1.00	$ 12,648	$
2. **Stephen A Weimar - Director**	1.00	0.00	0.00	10,106	
3.					
4.					
5.					
6. (0) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	0	
7. (2) TOTAL SENIOR PERSONNEL (1 - 6)	1.00	0.00	1.00	22,754	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. (0) POST DOCTORAL ASSOCIATES	0.00	0.00	0.00	0	
2. (1) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	1.50	0.00	0.00	8,960	
3. (0) GRADUATE STUDENTS				0	
4. (0) UNDERGRADUATE STUDENTS				0	
5. (0) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				0	
6. (0) OTHER				0	
TOTAL SALARIES AND WAGES (A + B)				31,714	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				8,499	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				40,213	
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)					
TOTAL EQUIPMENT				0	
E. TRAVEL 1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS)				3,308	
2. FOREIGN				0	
F. PARTICIPANT SUPPORT COSTS					
1. STIPENDS $ 0					
2. TRAVEL 0					
3. SUBSISTENCE 0					
4. OTHER 0					
TOTAL NUMBER OF PARTICIPANTS (0) TOTAL PARTICIPANT COSTS				0	
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				0	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				0	
3. CONSULTANT SERVICES				0	
4. COMPUTER SERVICES				0	
5. SUBAWARDS				0	
6. OTHER				0	
TOTAL OTHER DIRECT COSTS				0	
H. TOTAL DIRECT COSTS (A THROUGH G)				43,521	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE) **Indirect (Rate: 50.0000, Base: 43521)**					
TOTAL INDIRECT COSTS (F&A)				21,761	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				65,282	
K. RESIDUAL FUNDS (IF FOR FURTHER SUPPORT OF CURRENT PROJECTS SEE GPG II.C.6.j.)				0	
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				$ 65,282	$

M. COST SHARING PROPOSED LEVEL $ 0 AGREED LEVEL IF DIFFERENT $

PI/PD NAME: **Gerry Stahl**

ORG. REP. NAME*

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INDIRECT COST RATE VERIFICATION		
Date Checked	Date Of Rate Sheet	Initials - ORG

 *ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET

SUMMARY PROPOSAL BUDGET

Cumulative

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PROPOSAL NO.	DURATION (months) Proposed	Granted
AWARD NO.		

ORGANIZATION: **Drexel University**

PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR: **Gerry Stahl**

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-months CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)
1. **Gerry Stahl - Associate Prof**	0.00	0.00	3.00	$ 36,166	$
2. **Stephen A Weimar - Director**	3.00	0.00	0.00	28,898	
3.					
4.					
5.					
6. ( ) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	0	
7. (**2**) TOTAL SENIOR PERSONNEL (1 - 6)	3.00	0.00	3.00	65,064	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. (**0**) POST DOCTORAL ASSOCIATES	0.00	0.00	0.00	0	
2. (**3**) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	4.50	0.00	0.00	25,620	
3. (**0**) GRADUATE STUDENTS				0	
4. (**0**) UNDERGRADUATE STUDENTS				0	
5. (**0**) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				0	
6. (**0**) OTHER				0	
TOTAL SALARIES AND WAGES (A + B)				90,684	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				24,303	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				114,987	
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)					
TOTAL EQUIPMENT				0	
E. TRAVEL 1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS)				9,458	
2. FOREIGN				0	
F. PARTICIPANT SUPPORT COSTS					
1. STIPENDS $ **0**					
2. TRAVEL **0**					
3. SUBSISTENCE **0**					
4. OTHER **0**					
TOTAL NUMBER OF PARTICIPANTS (**0**) TOTAL PARTICIPANT COSTS				0	
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				0	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				0	
3. CONSULTANT SERVICES				0	
4. COMPUTER SERVICES				0	
5. SUBAWARDS				0	
6. OTHER				0	
TOTAL OTHER DIRECT COSTS				0	
H. TOTAL DIRECT COSTS (A THROUGH G)				124,445	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE)					
TOTAL INDIRECT COSTS (F&A)				62,224	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				186,669	
K. RESIDUAL FUNDS (IF FOR FURTHER SUPPORT OF CURRENT PROJECTS SEE GPG II.C.6.j.)				0	
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				$ 186,669	$

M. COST SHARING PROPOSED LEVEL $ **0** AGREED LEVEL IF DIFFERENT $

PI/PD NAME: **Gerry Stahl**

ORG. REP. NAME*

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INDIRECT COST RATE VERIFICATION		
Date Checked	Date Of Rate Sheet	Initials - ORG

C ***ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET**

Budget Justification for ALT Proposal — Drexel Subcontract with CMU

"Increasing Helping Behavior in Collaborative Problem Solving in the Virtual Math Teams Environment"

Co-PI Stahl will receive one month salary per year to participate actively in this project. He will be responsible for the conceptual integration of the interventions of this project in the Virtual Math Teams project which he directs. He will also be heavily involved in the design, implementation and analysis of project interventions. He will participate intimately in the integration of CMU software modules with the VMT software infrastructure. He will actively publish results from the study.

Co-PI Weimar will receive one month of annual salary per year in order to actively participate in this project. He will be responsible for the programmatic integration of the interventions of this project in the Math Forum services. He will also be heavily involved in the pedagogy of the interventions and the recruitment and organization of the teacher and student participants.

Technical Support Revelino Gurron will receive 1.5 months annual salary. He will be responsible for maintenance and revision of the VMT software to support integration with modules from CMU and to modify functionality for project interventions and testing.

Drexel fringe benefits are calculated at the rate of 26.8%.

Travel funds are needed for periodic face-to-face meetings between Drexel and CMU project staff. Travel funds are also needed for travel to conferences to promote the project and to disseminate findings.

Drexel indirect costs are calculated at the rate of 50%.

Current and Pending Support

(See GPG Section II.D.8 for guidance on information to include on this form.)

The following information should be provided for each investigator and other senior personnel. Failure to provide this information may delay consideration of this proposal.

Investigator: Carolyn P. Rose	Other agencies (including NSF) to which this proposal has been/will be submitted.

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: A Shared Resource for Robust Semantic Interpretation for Both Linguists and Non-Linguists

Source of Support: Office of Naval Research, Cognitive and Neural Sciences Division

Total Award Amount: $300,000 Total Award Period Covered: 11/15/2004 – 11/15/2007

Location of Project: Carnegie Mellon University

Person-Months Per Year Committed to the Project. Cal: 1.5 Acad: Sumr:

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: TagHelper : A Semi-Automatic Tool That Facilitates Reliable Content Analysis of Corpus Data

Source of Support: NSF-Sciences of Learning Center

Total Award Amount: $221,840 Total Award Period Covered: 10/01/2004 to 9/30/2009

Location of Project: Carnegie Mellon University

Person-Months Per Year Committed to the Project. Cal: 1.0 Acad: Sumr:

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: Facilitating Accountability for Standards-Based Math at All Levels

Source of Support: GE Foundation

Total Award Amount: $365,000 Total Award Period Covered: 01/01/2005 to 12/31/2007

Location of Project: Carnegie Mellon University

Person-Months Per Year Committed to the Project. Cal: 2.0 Acad: Sumr:

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: IERI: Learning-Oriented Dialogs in Cognitive Tutors:Toward a Scalable Solution to Performance Orientation

Source of Support: NSF

Total Award Amount: $1,270,000 Total Award Period Covered: 10/10/2004 to 10/10/2010

Location of Project: Carnegie Mellon University

Person-Months Per Year Committed to the Project. Cal: 2.0 Acad: Sumr:

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: Tutalk: Infrastructure for authoring and experimenting with natural language dialogue in tutoring systems and learning research.

Source of Support: NSF-Sciences of Learning Center

Total Award Amount: $160,373 Total Award Period Covered: 10/01/2004 to 9/30/2009

Location of Project: Carnegie Mellon University

Person-Months Per Year Committed to the Project. Cal: 1.0 Acad: Sumr:

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*If this project has previously been funded by another agency, please list and furnish information for immediately preceding funding period.

Current and Pending Support

(See GPG Section II.D.8 for guidance on information to include on this form.)

The following information should be provided for each investigator and other senior personnel. Failure to provide this information may delay consideration of this proposal.

Investigator: Carolyn P. Rose	Other agencies (including NSF) to which this proposal has been/will be submitted.

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: Tutoring Scientific Explanations via Natural Language

Source of Support: University of Pittsburgh

Total Award Amount: $42,376 Total Award Period Covered: 01-01-2004 to 12-31-2007

Location of Project: Carnegie Mellon University

Person-Months Per Year Committed to the Project. Cal: 0 Acad: Sumr:

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: ADEPT: Assessing Design Engineering Project Classes with Multi-Disciplinary Teams

Source of Support: National Science Foundation

Total Award Amount: $934,556 Total Award Period Covered: 5-01-2007 to 4-30-2010

Location of Project: Carnegie Mellon University

Person-Months Per Year Committed to the Project. Cal: 1.0 Acad: Sumr:

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: CycleTalk: Further Exploring the Pedagogical Value of Tutorial Dialogue in Simulation Based Learning

Source of Support: Office of Naval Research (ONR)

Total Award Amount: $513,307 Total Award Period Covered: 11-1-2006 to 10-31-2009

Location of Project: Carnegie Mellon University

Person-Months Per Year Committed to the Project. Cal: 2.0 Acad: Sumr:

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

Source of Support:

Total Award Amount: $ Total Award Period Covered:

Location of Project:

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

Source of Support:

Total Award Amount: $ Total Award Period Covered:

Location of Project:

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

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*If this project has previously been funded by another agency, please list and furnish information for immediately preceding funding period.

Current and Pending Support

(See GPG Section II.D.8 for guidance on information to include on this form.)

The following information should be provided for each investigator and other senior personnel. Failure to provide this information may delay consideration of this proposal.

Investigator: Gerry Stahl

Other agencies (including NSF) to which this proposal has

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: Catalyzing & Nurturing Online Workgroups to Power Virtual Learning Communities

Source of Support: NSF ITR

Total Award Amount: $2,299,978 Total Award Period Covered: 9/03-8/08

Location of Project: Drexel University, College of Information Science and Technology

Person-Months Per Year Committed to the Project. Acad: Sumr: 1.0

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: Engaged Learning in Online Communities

Source of Support: NSF, Science of Learning Centers catalyst

Total Award Amount: 180,762 Total Award Period Covered: 10/05-9/07

Location of Project: Drexel University

Person-Months Per Year Committed to the Project. Acad: Sumr: 0.5

Current and Pending Support
(See GPG Section II.D.8 for guidance on information to include on this form.)

The following information should be provided for each investigator and other senior personnel. Failure to provide this information may delay consideration of this proposal.

Investigator: Stephen Weimar

Other agencies (including NSF) to which this proposal has been/will be

Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: The Math Forum's Virtual Fieldwork Sequence

Source of Support: NSF DUE 06536

Total Award Amount: $498,100 Total Award Period Covered: 9/1/007-8/31/09

Location of Project: Drexel University

Person-Months Per Year Committed to the Project. Cal: .2.4 Acad: Sumr:

Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: An Online Practice-Based Course Sequence to Develop the Mathematics Teacher Professional Network (MTPN)

Source of Support: U.S. Department of Education

Total Award Amount: $1,991,549 Total Award Period Covered: 6/07-5/11

Location of Project: Pennsylvania and Concord, MA

Person-Months Per Year Committed to the Project. Cal: 1.2 Acad: Sumr:

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: Catalyzing & Nurturing Online Workgroups to Power Virtual Learning Communities of High-Quality Component-based Educational Software

Source of Support: NSF ITR

Total Award Amount: $2,299,978 Total Award Period Covered: 9/03-8/08

Location of Project: Drexel University, College of Information Science and Technology

Person-Months Per Year Committed to the Project. Cal: 2.5 Acad: Sumr:

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: Engaged Learning in Online Communities

Source of Support: NSF, Science of Learning Centers catalyst

Total Award Amount: $180,762 Total Award Period Covered: 10/05-9/07

Location of Project: Drexel University

Person-Months Per Year Committed to the Project. Cal: 1 Acad: Sumr:

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: Leadership Development for Technology Integration

Source of Support: NSF NSDL

Total Award Amount: $724,709 Total Award Period Covered: 10/05-9/08

Location of Project: Drexel University

Person-Months Per Year Committed to the Project. Cal: 1.2 Acad: Sumr:

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: Customized Services for NSDL

Source of Support: NSF NSDL

Total Award Amount: $99,281 Total Award Period Covered: 11/05-10/07

Location of Project: University of Massachusetts

Person-Months Per Year Committed to the Project. Cal: 1 Acad: Sumr:

Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: Collaborative Research: Representations for Analyzing Collaborative Knowledge Construction in Technology-mediated Learning Environments

Source of Support: NSF, REESE

Total Award Amount: $249,062 Total Award Period Covered: 08/01/07 – 07/31/10

Location of Project: Drexel University, IST

Person-Months Per Year Committed to the Project. Cal: 1 Acad: Sumr:

Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: Expanding the Computing Education Pipeline from K12 through Careers

Source of Support: NSF, CPATH

Total Award Amount: $500,000 Total Award Period Covered: 07/01/07 – 06/30/10

Location of Project: Drexel University, Computer Science

Person-Months Per Year Committed to the Project. Cal: .67 Acad: Sumr:

Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: Increasing Helping Behavior in Collaborative Problem Solving in the Virtual Math Teams Environment

Source of Support: NSF-ALT

Total Award Amount: 186,488 subcontract Total Award Period Covered: 1/1/08-12/31/2010

Location of Project: Carnegie Mellon University

Person-Months Per Year Committed to the Project. Cal: 1 month Acad: Sumr:

H. Carnegie Mellon University Facilities/GFE

Research Facilities in the School of Computer Science (SCS)

Heterogeneous Distributed Computing – The SCS research facility provides numerous and diverse computers for faculty and graduate-student use — more than 3000 machines. All have transparent access to the Andrew File System, a 625Gbyte, shared file space, and to one another through the Network File System protocol. SCS maintains several terabytes of secondary storage. Beyond these resources, the University provides various independent facilities for general use. Computationally intensive applications can also use PSC computers, including Cray T3E, C90-16/512, and J90 supercomputers.

Experimental Systems – SCS has a reputation for developing innovative computers, devices, networks, and systems that benefit diverse applications. Current large-scale, experimental efforts include the Darwin "application-aware" networking project and the NASD project on storage interfaces with direct device/client communication.

Networking – Carnegie Mellon operates a fully-interconnected, multimedia, multiprotocol campus network. The system incorporates state-of-the-art commercial technology and spans over 100 segments in a "collapsed backbone" infrastructure that enables mutual access among all campus systems, including the PSC supercomputers. To extend the network, the Information Networking Institute, with NSF funding, is developing a wireless infrastructure. Now supporting mobile computing throughout campus, the system will eventually deliver to users' handheld or laptop computers all the functionality of their desktop machines, on campus or off.
Externally, SCS connects directly to the Internet, through T3 (45Mbit/s) and 10Mbit/s links, the NSF-sponsored vBNS (OC12) network, and the DARPA-sponsored CAIRN and ATM-based AAI (OC3) wide-area experimental networks and the Internet-2 and NGI networking initiatives.

Office Space – Faculty have private offices, while postdoctoral staff and graduate students share office space.

Other – Carnegie Mellon's School of Computer Science (SCS) in the largest academic organization devoted to the study of computers. The school's six degree-granting departments and units – the Computer Science Department, the Robotics Institute, the Language Technologies Institute, the Human Computer Interaction Institute, the Center for Automated Learning and Discovery, and the ISRI – include over 200 faculty, 400 graduate students, and 200-member professional technical staff. SCS also collaborates with other University Research Centers, including the DoD-funded Software Engineering Institute (SEI); the NSF-sponsored Pittsburgh Supercomputing Center (PSC), the Information Networking Institute and the Institute for Complex Engineered Systems (ICES).

Research Facilities for Proposed Work

The faculty, staff and students who will perform the proposed work will make use of the existing computational and networking infrastructure. This includes a variety of single-user Unix workstations and PCs running Windows and Linux. These workstations are networked via a high bandwidth local Ethernet (100Mbps).

Ariane Watson (Math Coach)
Propel Charter School –
Homestead
129 E. Tenth Avenue
Homestead, PA 15120

Carolyn Penstein Rosé
Carnegie Mellon University
Pittsburgh, PA 15217

Dear Carolyn,

I am writing this letter to express our enthusiastic support for your NSF proposal entitled: Optimizing Feedback for Eliciting Pedagogically Valuable Explanation in Collaborative Problem Solving.

We are pleased to partner with you to run a Math Camp at Propel Charter School with 6th and 7th graders this coming July using the Math Forum materials. As you know, our 6th and 7th graders are greatly in need of this support. Furthermore, we realize this partnership will provide valuable data for your research on adaptive support for collaborative problem solving. At the same time, we will be deepening our own understanding of how to best support our kids in their conceptual development of math.

We are excited about establishing a more long term collaboration with you in which we will work together to shape the direction the research at Carnegie Mellon takes so that an infrastructure for supporting productive collaboration can be developed and then deployed experimentally in our school.

Sincerely,

Ariane Watson

Ariane Watson
Math Coach
Propel Charter School of Homestead