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PI/PD Name: Arthur B Powell

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:
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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: Carolyn A Maher

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

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

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

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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	FOR NSF USE ONLY
NSF 06-609 **01/29/07**	NSF PROPOSAL NUMBER
FOR CONSIDERATION BY NSF ORGANIZATION UNIT(S) (Indicate the most specific unit known, i.e. program, division, etc.) **REC - REESE**	**0723605**

DATE RECEIVED	NUMBER OF COPIES	DIVISION ASSIGNED	FUND CODE	DUNS# (Data Universal Numbering System)	FILE LOCATION
01/29/2007	15	11050000 REC	7625		01/29/2007 5:40pm

EMPLOYER IDENTIFICATION NUMBER (EIN) OR TAXPAYER IDENTIFICATION NUMBER (TIN)	SHOW PREVIOUS AWARD NO. IF THIS IS	IS THIS PROPOSAL BEING SUBMITTED TO ANOTHER FEDERAL AGENCY? YES ☐ NO ☒ IF YES, LIST ACRONYM(S)
226001086	☐ A RENEWAL ☐ AN ACCOMPLISHMENT-BASED RENEWAL	

NAME OF ORGANIZATION TO WHICH AWARD SHOULD BE MADE
Rutgers University Newark

ADDRESS OF AWARDEE ORGANIZATION, INCLUDING 9 DIGIT ZIP CODE
Blumenthal Hall, Suite 206
249 University Avenue
Newark, NJ 07102-1896

AWARDEE ORGANIZATION CODE (IF KNOWN)
0026310000

NAME OF PERFORMING ORGANIZATION, IF DIFFERENT FROM ABOVE

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

PERFORMING ORGANIZATION CODE (IF KNOWN)

IS AWARDEE ORGANIZATION (Check All That Apply) (See GPG II.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 **eMath: Diverse High School Students Developing Mathematical Reasoning through Online Collaboration**

REQUESTED AMOUNT	PROPOSED DURATION (1-60 MONTHS)	REQUESTED STARTING DATE	SHOW RELATED PRELIMINARY PROPOSAL NO. IF APPLICABLE
$ 995,145	36 months	07/01/07	

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 03/29/06
☐ 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
Urban Education

PI/PD POSTAL ADDRESS
110 Warren Street
Bradley Hall, Room 156
Newark, NJ 07102
United States

PI/PD FAX NUMBER
973-353-1622

NAMES (TYPED)	High Degree	Yr of Degree	Telephone Number	Electronic Mail Address
PI/PD NAME **Arthur B Powell**	PhD	2003	973-353-3530	abpowell@andromeda.rutgers.edu
CO-PI/PD **Carolyn A Maher**	EdD	1972	732-932-8848	cmaher3@comcast.net
CO-PI/PD **Gerry Stahl**	PhD	1993	215-895-0544	Gerry.Stahl@drexel.edu
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		

TELEPHONE NUMBER	ELECTRONIC MAIL ADDRESS	FAX NUMBER

*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.

Project Summary

This empirical investigation seeks to understand (a) how students can use online technology to collaborate both synchronously and asynchronously to solve open-ended yet well-designed mathematical tasks that are cognitively demanding and that promote the construction of problem-solving schema; and (b) the resulting mathematical ideas and reasoning that students develop. To support their collaboration, students will have available a variety of computer tools to search for information, represent their ideas, and present their reasoning, including a multi-modal, online tool—VMT-Chat, developed by the Virtual Math Teams project, which also provides an automated means for data collection.

Our research design has the following five objectives: (1) create online conditions in an informal learning environment that elicits mathematical reasoning and the building of convincing arguments; (2) trace the development of that reasoning by studying patterns of discourse that emerge as students work online on mathematical tasks; (3) document and study the nature of student-to-student online communication as they make sense of each other's ideas and reasoning; (4) understand and evaluate the affordances and constraints that the ICT tools we provide have on students' use of different representations; and (5) create social, intellectual networks among students in urban and suburban communities, here and abroad. Participants in the study are racially and ethnically diverse high school students from six different urban and suburban communities with a mix of high- and low-SES school districts.

The tasks on which participants are invited to work come from three areas of mathematics: (1) algebra—sequences and patterns, (2) combinatorics and probability, and (3) geometry. Students will work the tasks in teams of four, first within a school site and later where half of their teammates are physically located at a remote school site. The tasks will be challenging in the sense that participants will initially not be aware of procedural or algorithmic tools to solve the problems but will be invited to develop tools in an online, problem-solving context in collaboration with their teammates. Furthermore, the tasks will invite students to negotiate interpretations, analyses, and other aspects of their work, coalescing toward a solution and will engage them in important cognitive and discursive aspects of mathematical problem solving such as employing heuristics, making connections, specializing, generalizing, explaining, reflecting, conjecturing, justifying, and posing new problems.

Intellectual Merit

This study involves an interdisciplinary research partnership between mathematics education researchers of the Robert B. Davis Institute for Learning at Rutgers University and researchers in computer information systems and the learning sciences as well as online mathematics educators from the Virtual Math Teams Project of The Math Forum at Drexel University. This study builds upon and extends previous NSF awards, three to our research team at Rutgers University and two to our research team at Drexel University. It will yield (a) a model of how students of different SES and geographical locations work in collaborative teams, through online communication technology, to solve cognitively demanding, strands of mathematical tasks; and (b) a model of how to evaluate student learning of students developing mathematical reasoning through online collaboration. Results from this study will provide fundamental knowledge on the mathematical ideas and forms of reasoning that learners of high school age can build by collaborating online. It will yield implications for future research, namely findings that are suggestive of how collaborative, online work in mathematics problem solving can be integrated into the formal setting of high schools.

Broader Impact

The investigation will have two broader impacts. First, the project will create social, intellectual networks among culturally diversity students from low- and high-SES communities, here and abroad, as students exchange their mathematical ideas and develop their reasoning skills. Through working together on interesting, challenging mathematics problems with their teammates and discussing and critiquing solutions with members of other teams, we expect that participants will not only enjoy the social, intellectual interactions but also be encouraged to study mathematics further.

Another impact will be an understanding of learning pathways using the Internet to engage low-SES students, who typically do not have opportunities to interact these technologies, to develop their mathematical reasoning skills and to advance their ability to communicate mathematically. To this end, the study connects urban students with state-of-the-art computer tools to develop an inter-city as well as international community of mathematics learners, uniquely providing access to learning tools and environments of advantaged students. The project will serve to broaden low-SES perspective of themselves as members of a global community of (mathematics) learners.

TABLE OF CONTENTS

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

Appendix Items:

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

*e*Math: Diverse High School Students Developing Mathematical Reasoning through Online Collaboration

1. Problem Addressed, Research Proposed, and Research Needed

1.1 Problem Addressed

Two salient features mark 21st-century employment in science, technology, engineering, and mathematics and related fields: (a) ever-increasing predominance of information and communication technology (ICT) and (b) mounting imperative of teamwork or group collaboration (Hepp K., Hinostroza S., Laval M., & Rehbein F., 2004). National, professional bodies have encouraged the use of information technology and small-group learning in mathematics instruction (see, for instance, National Council of Teachers of Mathematics, 2000). However, with notable exceptions in the learning sciences (Chernobilsky, Nagarajan, & Hmelo-Silver, 2005; Hiltz & Goldman, 2005; Stahl, 2006c), there is a lacuna in research and instructional attention on understanding how students can collaborate online to accomplish mathematical tasks and characteristics of their resulting mathematics learning. Students need experience with ICT and collaboration as well as flexible knowledge of mathematics to compete in the global economy. In education generally, a subtle but significant shift is gradually occurring, from viewing ICT primarily as a patient tutor to more as a tool that facilitates inquiry and critical thinking (John & Sutherland, 2004), as a means for peer learning and online collaboration (Hiltz & Goldman, 2005; O'Donnell, Hmelo-Silver, & Erkens, 2006), and as an instrument for the co-construction of cognitive products by small collectives of individuals (Stahl, 2005, 2006b, 2006c). When technology has been incorporated into mathematics instruction, important differences exist between low- and high-poverty school districts in the extent to which computers and the Internet are used for academic purposes (Warschauer, Knobel, & Stone, 2004). Combined with differential in-school access to computers and the Internet and dissimilar instructional use of ICT among different social groups in schools, mathematics education may, albeit unwittingly, contribute to educational and economic processes of social exclusion. To provide insight into addressing this issue of social exclusion, we propose a three-year, empirical investigation to understand (a) how students can use ICT to collaborate in mathematical problem solving and (b) the resulting mathematical ideas and reasoning they develop.

1.2 Research Proposed

This study involves an interdisciplinary research partnership between mathematics education researchers of the Robert B. Davis Institute for Learning at Rutgers University and researchers in computer information systems and the learning sciences as well as online mathematics educators of the Virtual Math Teams Project of The Math Forum at Drexel University. Our aim is to investigate fundamental issues of diverse learners' cognition and development of mathematical reasoning as they collaborate online to solve strands of challenging, open-ended mathematical problems. As students explore each mathematical task and identify, define, and resolve problematic situations, we will investigate the nature of the mathematical ideas and reasoning they build, the heuristics that they employ to solve the tasks, the connections between underlining mathematical structures of certain tasks, as well as the justifications they offer for the mathematical ideas they build and the mathematical connections they articulate. We will identify the ICT resources that students use to communicate mathematically, to represent their mathematical ideas and reasoning, and to present justifications for their solutions. Moreover, we will also acquire insight into how new mathematical ideas emerge from students' online mathematical discourse and into the facilitation approaches that assist students to maintain their small-group, online interactions. Our research design has the following five objectives: (1) create online conditions in an informal learning environment that elicits mathematical reasoning and the building of convincing arguments; (2) trace the development of that reasoning by studying patterns of discourse that emerge as students work online on mathematical tasks; (3) document and study the nature of student-to-student online communication as they make sense of each other's ideas and reasoning; (4) understand and evaluate the affordances and constraints that the ICT tools we provide have on students' use of different representations; and (5) create social, intellectual networks among students in urban and suburban communities, here and abroad.

1.3 Research Needed

Mathematics education researchers have analyzed the influence of technology on mathematics learning. In a state-of-the-art review of ICT in elementary and secondary education, Burns and Ungerleider (2003) have found that the "largest volume of research on the impact of technology in the content areas has been conducted on mathematics instruction" and that mathematics education "has the longest history of using technology for instructional purposes" (p. 42). Since the middle of the last century, mathematics education has incorporated advances in electronic technology such as desktop, laptop, and hand-held computers for calculations, visualizations, and symbolic manipulations as well as innovations in instruction, including cooperative and collaborative learning groups. These instructional improvements have focused on the use of technology in which learners are in classrooms, working face-to-face and often in small groups (see, for example, Masalski & Elliott, 2005). What mathematics education has not examined sufficiently is the use of ICT to support both synchronous and asynchronous collaboration among students geographically dispersed and the types of mathematics learning that can occur within a collaborative virtual environment.

Research is needed that inquires into how learners develop and communicate mathematical ideas and reasoning through collaborating in small groups online with ICT tools. As Stahl (2006b) aptly comments, "[t]he ubiquitous linking of computers in local and global networks makes possible the sharing of thoughts by people who are separated spatially or temporally" (p. 1). Indeed, the infrastructure of globally networked computers and the Internet are positioned to mediate human collaboration for work and can be harnessed for mathematics learning. Online communication tools coupled with both discipline-specific and general software applications can be used to support knowledge proposals for group negotiation in the context of mathematics problem solving. This is a focus of our proposed research

Moreover, studies are needed that examine the development of students' reasoning as they engage is a sequence or strand of mathematical tasks that build on each other toward important problem-solving heuristics or mathematical concepts. In the learning sciences and in mathematics education, the existing research concerning online collaboration in mathematics has thus far examined students working on interesting but unrelated problems. That is, the problems have not been characterized as problems building on each other to enable students to develop conceptual knowledge within particular domains of mathematics.

1.4 Significant Features of Research Proposed

The empirical research project that we propose addresses particular issues of the needed research that we described above. Our project will focus on the use of ICT to engage a diverse student population, from urban and suburban communities, here and abroad, collaborating synchronously and asynchronously to solve open-ended but well-designed mathematics tasks that are cognitively demanding (American Educational Research Association, 2006) and that promote the construction of mathematical problem-solving schema (Weber, Maher, & Powell, in press). The challenging tasks will invite students to negotiate interpretations, analyses, and other aspects of their work, coalescing toward a solution. The strands of mathematical tasks will be structured to promote the construction of problem-solving schemata and have similar underlying mathematical structure so that participants can build sets of ever-increasing and layered ideas about particular mathematical concepts. This is an important and significant focus of our proposed research.

Another important feature of our research is collaborative, small-group teams. Students will work in teams of four, first within a school site and later where half of their colleagues are physically located at a remote school site. They will collaborate online and have available a variety of ICT tools to search for information, represent their ideas, and present their reasoning. Of particular importance, besides incorporating results from three other previous research projects (see section 2.1), our project will leverage and build on the research and ICT development work of the Virtual Math Teams Project (VMT) of The Math Forum at Drexel University. To communicate and collaborate, participating students in our study will use a multi-modal, online tool—VMT-Chat (described in 3.2.1.1), which also provides an automated means for data collection.

The composition of our research team is also significant. The team is multi-disciplinary and, besides the senior researchers, will include graduate and undergraduate students and high school mathematics teachers. This research will occur in schools in the context of an after-school, informal learning environment. At each school, two mathematics teachers will work with the research team as co-investigators. They will participate in planning, implementing, debriefing the research sessions. In the debriefing sessions, among other issues, the research team will reflect on the use of ICT for collaborative mathematics problem solving and how it can be integrated into the formal setting of high schools. Our teacher partners will be enormously helpful in this.

Our study will have two significant outcomes. First, we intend to develop a model of how students of different SES and geographical location work in collaborative teams, through online communication technology, to solve cognitively demanding strands of mathematical tasks. Second, through our study, we will build a model of how to evaluate students' development of mathematical reasoning through online collaboration. These outcomes will enable us to propose future research to investigate how to introduce into formal schooling collaborative, online mathematical problem solving among students in distant locations.

1.4 Pilot studies and their results

During the 2005-2006 school year, we conducted pilot studies to explore a number of fundamental questions and the feasibility of our approach (Marcelo A. Bairral, Powell, & dos Santos, in press) (also, see supporting letters). The participants were high school students in two distant, urban locations: Newark, New Jersey and Vitória (Brazil). They met twice a week, after school, for two cycles of three weeks, using videoconferencing and online communications. The organization and process of the small-group teams are described in section 3.2.2. In all, they worked in teams on four open-ended mathematics problems such as the classical Handshake Problem. In these pilot studies, we investigated whether high school students would be willing to work together and with others in this format, give their time, demonstrate interest in the problems and commit their time to work on solving them. Also, we were interested in whether the schools support such an effort. Finally, we wanted evidence that the captured videoconferencing data and electronic communications data would be robust enough to be amenable to discursive analysis and reveal students' construction of schemata.

In our pilot studies, we found that (1) students enjoyed working together and particularly enjoyed the social interaction with their counterparts through videoconferencing and online, (2) the students were acquainted with various online communication tools and were curious to see how they could discuss and explore mathematics with those tools, (3) the students were cognitively engaged with the mathematics problems, (4) the school administration and teachers were supportive, (5) attendance was high and students were willing to work after school during their free time, (6) initial technical problems with videoconferencing and online conferencing were solved, and (7) the students' teachers remarked on the "surprisingly" sophisticated conversations in which the students engaged. Importantly, we observed that students began to reflect on their problem-solving strategies that with further appropriate experiences and time, we believe, would likely become stable problem-solving schemata.

1.5 Guiding research questions

Based on the encouraging results of our pilot studies, we now propose a long-term study to learn in detail about the cognitive, social, and epistemological factors involved in students' online, collaborative problem solving. Our empirical research project will involve diverse participants from high schools in urban and suburban communities in three cities in each the United States and Brazil. The following questions will guide our study of fundamental issues of cognition and the development of mathematical reasoning as geographically distant learners collaborate synchronously and asynchronously online in small teams to solve cognitively demanding, open-ended mathematical problems:

1. *What mathematical ideas and reasoning do students build online?*
2. *How do they use online communicative resources to represent and exchange their mathematical ideas and reasoning and to develop justifications for their solutions of mathematical tasks?*
3. *What facilitation approaches encourage students to coalesce into on-going, small-group teams?*
4. *How do new mathematical ideas emerge from students' online interaction and collaboration?*

As an outcome of responding to these questions, our proposed investigation intends to yield evidence-based insights into the mathematical ideas and reasoning that small-group teams of students build when collaborating online, theory concerning how these ideas and reasoning emerge from their online interactions, and pedagogical practices that facilitate students' ongoing engagement online. Specifically, in the first guiding question, we are interested in examining specific ideas and reasoning that students develop from working on a sequence of tasks that are within particular areas of algebra, geometry, or combinatorics. The second question relates to our interest in understanding what resources students use to express, explain, and justify their ideas, including, for instance, the representations that they develop. For the third question, we intend to inquire into the role of the task, the VMT-Chat environment, and the facilitators—how they contribute differently to sustain the functioning of the small-group teams. We are interested in how to integrate pedagogical scaffolding, technological affordances, and motivational sociability. Here we are also interested in changes that may occur in students' views about mathematics and about themselves as mathematical thinkers. Finally, through addressing our fourth research question, we intend to contribute to theory about how new ideas emerge for individuals and groups from the discursive online collaboration of students working on open-ended but well-defined mathematics problems. The study will pioneer methods for investigating the development and communication about mathematical ideas and reasoning among students collaborating online.

1.6 Significance of proposed research for participants

Our proposed research has three significant, beneficial features for participants. The first concerns the development of students' mathematical abilities. Through working on the three strands of mathematical tasks, participants will build their mathematical ideas related to concepts in algebra, combinatorics and probability, and geometry and further their develop their ability to reason mathematically. Specifically, the tasks will engage participants in important cognitive and discursive aspects of mathematical problem solving such as employing heuristics, making connections, specializing, generalizing, explaining, reflecting, conjecturing, justifying, and posing new problems. Furthermore, participants will construct problem-solving schemata.

The second relates to the fifth objective of our research design: to create social, intellectual networks among students in urban and suburban communities, here and abroad. Participants in the study will engage in intercultural and international mathematical exchanges to develop their reasoning in mathematics. Through these collaborative encounters, urban and suburban participants, here and abroad, will construct social, intellectual networks. As we observed in our pilot studies, participants will particularly enjoy the social interaction of working together on interesting, challenging mathematics problems with their teammates and discussing and critiquing solutions with members of other teams.

Our third beneficial feature refers to our pedagogical goal to construct a model for learning pathways using ICT to involve low-SES students, who typically do not have opportunities to engage these technologies to develop their mathematical reasoning skills and to advance their ability to communicate mathematically. To this end, the study engages urban students with a state-of-the-art ICT tool to develop an inter-city as well as international community of mathematics learners, uniquely providing access to learning tools and environments of advantaged students. Furthering this goal, the model will demonstrate how urban students develop intellectual and social relations with students from different domestic and national communities, and how this contact serves to broaden their perspective on themselves as members of a global community of (mathematics) learners.

2. Results from Prior NSF Support

2.1 What we have studied in previous research

The proposed *e*Math study builds upon and extends previous NSF awards, three to our research team at Rutgers University and two to our research team at Drexel University. In two grants to Rutgers (MDR-9053597 and REC-9814846), we traced the development of mathematical ideas in children from first grade through secondary, college, and beyond as well as our current NSF-supported investigation (REC-0309062) that examines in Plainfield, New Jersey the mathematics learning of urban, low-SES, middle-school students in the informal environment of an after-school enrichment program. Our earlier longitudinal and cross-sectional studies involved students from three New Jersey districts: (a) Kenilworth, a diverse working-class, immigrant community (19 years); (b) New Brunswick, an urban, low-SES district

(4-6 years); and (c) the suburban district of Colts Neck (6 years). Extensive videotaping in classrooms and clinical settings of students working in small groups throughout our projects has made it possible to study individual students' cognitive growth within a variety of contexts and to pursue the subtleties of student thinking. We have traced the continued building of ideas, anchored in connected, long-term content explorations in several domains: (a) counting and combinatorics, (b) algebra, (c) probability, (d) pre-calculus and (e) calculus. We have accumulated a rich collection of open-ended tasks that elicited from students a variety of forms of reasoning. Others have replicated some of these tasks in forty-four states and the District of Columbia. Moreover, 20 dissertations and over 60 publications have results from this work.

At present, our Drexel research team is in the midst of two NSF-supported investigations (IERI 0325447 and SBE-0518477). The first project has completed several iterations of design, development, testing and analysis of the Virtual Math Teams (VMT) service at the Math Forum. Over 1,000 student-sessions have taken place, averaging an hour each. Six doctoral students are working on dissertations based on data from this project. Over 50 publications associated with this project have appeared already (see http://www.mathforum.org/vmt/researchers/publications.html). Software for the VMT-Chat environment is being released as Open Source and is being used by other researchers in collaboration with this project. A methodology for the analysis of online collaborative learning has been developed, called "chat analysis". A re-player tool has been developed to provide adequate access by researchers to the sequentially unfolding interactions in the VMT environment's chat and whiteboard spaces. Several key features of online collaborative learning have been analyzed. Analysis of the interactions included use of a graphical representation of interaction threading.

The second project brings together interdisciplinary researchers interested in how to promote online communities for collaborative learning. The original intention was to build the foundation for an NSF Sciences of Learning Center focused on online collaborative learning. The project now aims to generate smaller scale collaborations among research labs, both nationally and internationally, such as the *e*Math project.

2.2 What We Have Learned from Previous Research

Each of our five projects has been concerned with understanding engaged learning, particularly in the domain of mathematics. From our work examining engaged learning in online communities and through a series of PI meetings and public workshops, we have identified the following signature challenges:

- How to deepen the learning that takes place, given that most current examples of successful engaged learning in online communities remains shallow.
- How to integrate pedagogical scaffolding, technological affordances, and motivational sociability.
- How to introduce inquiry learning in student-centered informal online communities into social contexts dominated by formal schooling.

Our proposed study is informed by these results. The first and second items are explicit features of our study. To address the need to deepen the online learning—as described in below in section 3.2.1.3, Tasks and Task Design—a significant element of our tasks design of tasks is what we call "strands of mathematical problems," a sequence of mathematically connected tasks that enable students to develop schemata of mathematical concepts and problem-solving strategies. From the question of how to integrate pedagogical scaffolding, technological affordances, and motivational sociability emerged our third guiding research question concerning issues of facilitation. An explicit byproduct of this study is to understand for future research activity how to integrate into formal school settings variants of the environment we create in an informal, after-school atmosphere. The teachers who will partner with us will assist us in this endeavor.

From our previous research on the development of mathematical thinking, we have gained a detailed understanding of how learners work with data; of how reasoning and thinking function in communities of learners; and of how the building of fundamental mathematical ideas over time plays an important role in the development of mathematical understanding. From results of interviews (see Maher, 2005), students emphasize the importance of having been able to build mathematically rich ideas from limited information, developing original mathematical techniques rather than being given procedures to master, and explaining their ideas to each other, and understanding others' mathematical reasoning and justification. They report that the process enabled them to build confidence, to take risks in new situations, and to work through difficulties that arose, and in so doing to deepen their understanding of the involved mathematics while constructing mathematical arguments to explain their ideas. Moreover, students value having had flexible and extended time to work on and think deeply about a problem, even if it means leaving the problem alone for a while and doing something else. What has been underscored for us is the importance of minimizing facilitator interventions and maximizing student discourse (Francisco, 2005). All these conditions—tasks, tools, time, and limited intervention—contribute to the generation of a community of learners willing and open to exchanging ideas. In the proposed study, these conditions are expressly incorporated in our research design. As the objective of our research design indicates (see section 1.1), we intend to examine how to express these conditions in our online environment so as to create online environments that elicit and support mathematical reasoning and the building of convincing arguments.

Findings from our current study of mathematical thinking—Informal Mathematics Learning Project (Maher, Powell, Weber, & Lee, 2006; Powell, Maher, & Alston, 2004) are also instructive for our proposed study. We discovered that we could establish many of the conditions from the previous longitudinal study with a new group of students in a relatively short period of time. As a result, sharing and evaluating mathematical ideas and justifications have become part of the sociomathematical norms of this environment. In posing modifications and extensions of given tasks, students displayed evidence of mathematical understanding and awareness of generalizations of mathematical ideas. Students invented or adopted colloquial terms to express their thinking about mathematical objects, ideas, and events. Students also reasoned from evidence, and used symbolic and graphical representations of mathematical ideas and relationships to settle disagreements. Informed by these findings, as we work toward the second and third objectives of our research design (see section 1.1), we will examine how these findings derived from face-to-face problem solving are expressed in online collaboration.

3. Theoretical Framework, Design, Tasks, and Data Collection and Analysis

3.1 Theoretical Framework

A particular theoretical framework, reinforced by the results of our previous studies, informs our proposal to study how diverse high school students develop mathematical reasoning through online collaboration in informal, after-school environments in which information and communication technologies facilitate small-group interactions among students.

Central to our understanding of doing and communicating mathematics is the construction of representations. These include graphs, diagrams, written symbols, gestures, or specific language use produced for personal or public consumption to develop, investigate, and convey ideas, results, and lines of reasoning. Building and discussing inscriptions (written representations) are essential to building and communicating mathematical and scientific concepts (Dörfler, 2000; Lesh & Lehrer, 2000; Powell & Bairral, 2006; Speiser, Walter, & Maher, 2003; Speiser, Walter, & Shull, 2002). As learners invent or appropriate inscriptions—or, more generally, representations—learners change their relationship to what the representation signifies and, as such, turn abstract ideas into concrete ones. Representations built by learners are carried forth, revisited, used, and extended over time. As learners engage in mathematical investigations, they frequently retrieve and critically re-examine their earlier ideas for particular features as they build new knowledge (Davis, 1984; Davis & Maher, 1990; Maher, 2005). They monitor earlier ideas in the process of attempting to make sense of new experiences. As they explain, justify, and convince others of their ideas, a re-examination of the relationships between representations is often triggered (Maher & Speiser, 1997). In this way, learners begin to recognize certain features of their representations. When they receive challenges from peers or the facilitator to explain their ideas, learners frequently modify, reject, or extend their original knowledge representation and fashion convincing arguments to support their generalizations. As learners cycle among representations and justifications, they construct new knowledge. The theories they pose are subsequently modified and refined in contexts that encourage both personal exploration and social interaction. Moreover, mathematical communication supports the construction of representations (Powell, 2003) and can constitute a heuristic in mathematical problem solving (Mason, Burton, & Stacey, 1985; Powell & Maher, 2003).

Our theoretical framework is also informed by work on the interaction between the inscriptions and discourse of learners as windows into learners' development of mathematical ideas, heuristics, and reasoning (Larson, 1995; Powell, 2003; Powell & Maher, 2002; Speiser et al., 2002; Walter & Maher, 2002). Discourse here refers to language (natural or symbolic, oral or gestic) used to carry out tasks—for example, social or intellectual—within a community. In agreement with Pirie and Schwarzenberger (1988), student-to-student or peer conversations are mathematical discussions when they possess the following four features: are purposeful, focus on a mathematical topic, involve genuine student contributions, and are interactive. A tenet of our theoretical perspective, like other sociocultural perspectives (e.g., Cole, 1996; Schleppegrell & Colombi, 2002), is that to do mathematics students must be able to talk or otherwise communicate mathematically, not just be able to solve routine mathematics problems. As Sfard (2001) proposes, "communication should be viewed not as a mere aid to thinking, but as almost tantamount to the thinking itself" (p. 13). We believe that mathematical language and mathematical thinking develop simultaneously in social interaction. As with other scientific languages, the pathway into using academic language in mathematics is through social experience (Palincsar, 1998; Vygotsky, 1978). Because meanings are construed through language, the language that construes particular social meanings comprises the register of that social context (Schleppegrell, 2004, pp. 45-46).

Discourse and representations are means for engaging mathematical ideas and for displaying mathematical reasoning and typically occur through face-to-face or textual means. Computer communication technologies are also vehicles for learners to communicate representations and discuss mathematical ideas (Kramarski, 2002; Mishra & Koehler, 2006). From the perspective of computer-supported collaborative learning (CSCL), Stahl (2005) presents a theory of group cognition as knowledge building at the level of small groups of students functioning within a computer environment. He calls for further empirical research "to clarify the nature of shared knowledge and group cognition" (p. 87). From earlier studies, we have found that given particular pedagogical conditions and student development of sociomathematical norms that socially emergent cognition can indeed be the byproduct of collaborative problem solving (Powell, 2006).

Research using the VMT-Chat environment has identified typical social practices or interactional methods that students use when engaging in online collaborative discourse (Stahl, 2007b). For instance, they may exchange greetings, explore the software interface, orient to the given problem, negotiate about distribution of skills or roles, constitute the problem and an approach to the problem, make proposals on solving the problem, or engage in uptake of proposals by the group, clarify, work on solutions (constructing math objects, drawing, labeling, bringing in information, bridging to past discussions, etc.), check tentative solutions, wrap up, and close discussion.

Stahl (2007a) suggests that the meaning-making process that students engage in to propose, share, understand and make use of mathematical objects, (drawings, special terminology, representations) can be conceived as consisting of layered networks of references and relationships within the discourse. There is a *threading* of the conversational flow, with a particular posting following up on a preceding one (that may not be immediately adjacent in the chat log) and opening the possibility of certain kinds of postings to follow. There is *up-take* of one phrase or action by another, carrying the work of the group ahead. There are often important *continuities* from one posting of a particular individual to the same person's subsequent postings. Various sorts of communication problems can arise—from typos to confusion—and *repairs* can be initiated to overcome the problems. Lines of chat can *reference* items outside the chat, such as whiteboard drawings, formulae learned in the past, or notions raised earlier. Terms and phrases in a posting can serve as *citations* of previous statements, making the former meanings once more present and relevant. This structure of intersubjective meaning making is constitutive of the collaborative knowledge building that takes place in settings like the VMT-Chat environment (Stahl, 2006b).

3.2 Research Design

3.2.1 Research Setting

The *e*Math research sessions will occur during after-school periods in six different high schools, three in each of two countries: the United States and Brazil. In the United States, the three high schools are located in different locales—Newark, New Jersey; Holmdel, New Jersey; and Boston, Massachusetts. In Brazil, the high schools are from each of three different cites—Vitória, Espírito Santo; São Paulo, São Paulo; and Seropédica, Rio de Janeiro. In each country, two of the schools are from urban areas and one is from a suburban district. Letters of intent to participate from all schools are included in the supporting documentation.

Both the urban-suburban and the US-Brazil mix are purposeful features of our research design. The use of ICT in urban high schools for mathematics instruction tends to be for drill in facts and procedures rather than for interpretation and analysis (Ainley, Banks, & Fleming, 2002; Warschauer et al., 2004). The argument offered for this practice is that urban students desperately need to increase their mathematical performance on standardized tests and that without proficiency in facts and procedures they cannot participate in higher-level, cognitively demanding mathematical problems. We believe that—under proper conditions—urban students can participate in high-order, cognitively demanding mathematical tasks and can do so using ICT tools. Moreover, from both social and mathematical perspectives, we believe that urban students can collaborate effectively and productively among themselves and with suburban students here and in another country. We will evaluate these claims and explore the necessary conditions.

The multi-country feature is another intentional aspect of our research design. Inviting American high school students to engage in mathematical problem solving and to collaborate with teenage counterparts in another country will provide them with important cultural and intellectual experiences. From our pilot studies (see section 1.2), we observed that American high school students are indeed interested and motivated to know teens in other cultures and—given challenging, open-ended problems to discuss—enjoy online intellectual exchanges about mathematical ideas. The time zone between the Northeastern part of the United States, where the three US cites are located and Brazil, which has just one time zone, are similar. From a curricular perspective, Brazilian mathematics instruction is closely aligned with American standards advocated by reformers (National Council of Teachers of Mathematics, 2000; Secretaria de Educação Básica, 2006). Furthermore, in both countries by age 15, the mathematical content that students have studied is roughly equivalent and contains little, if any, work in combinatorics or experience with geometry in a dynamic environment provided by software applications such as The Geometer's Sketchpad or Cabri. Geometry and combinatorics are two of the mathematical strands of our project and students will use The Geometer's Sketchpad to explore geometric properties such as those of the bisectors, medians, and altitudes of triangles.

Table 1. *Distribution of Students among Schools and School Dyads*

School Dyads	Number of Participants per School						Total
	Newark	Boston	Holmdel	Vitória	São Paulo	Seropédica	
Dyad A AY 2007-2009	12	12					24
Dyad B AY 2007-2009			12			12	24
Dyad C CY 2008-2010	12				12		24
Dyad D CY 2008-2010				12		12	24
Dyad E CY 2008-2010	12				12		24
Total	24	24	24	24	24	24	120

In all, from six different high schools, 120 students will participate in *e*Math. In our research design, we refer to a pair of school sites as a *school dyad*. Of the 15 possible school pairings, our study will involve five school dyads, each distinguished by a letter, A to E, and each school is identified by the name of city in which it is located. We will gather data from each dyad during one and a half years, either during an academic years (AY) or calendar years (CY). School Dyads A and B will participate in *e*Math during the academic years of 2007 to 2009, while School Dyads C, D, and E will function during the calendar years of 2008 to 2010. We have composed the school dyads so that we can meet the five objects of our research design and to facilitate investigation of our guiding research questions. We will analyze our data from the perspectives of both within and between school dyads. Table 1 (above) displays the distribution of students among schools and school dyads.

3.2.1.1 Virtual Environment

In partnership with the Math Forum and the Virtual Math Teams (VMT) project at Drexel University, the virtual environment for participant interaction will be VMT-Chat. Through NSF support (IERI 0325447 and SBE-0518477), the VMT Project has developed an Internet-based environment that currently consists of an introductory web portal within the Math Forum website (http://mathforum.org/vmt) and a robust and flexible interactive environment called VMT-Chat. The environment includes the VMT Lobby, where users can select chat rooms to enter (see Figure 1). The chat rooms are the locations where teams of users engage in mathematical discussions (see Figure 2). Each chat room contains a text-chat window on the right, a shared drawing area (a whiteboard) on the left, as well as drawing, text, editing, and referencing tools that are accessible from an area above the whiteboard. All interactions that transpire in the VMT chat rooms are recorded and retrievable.

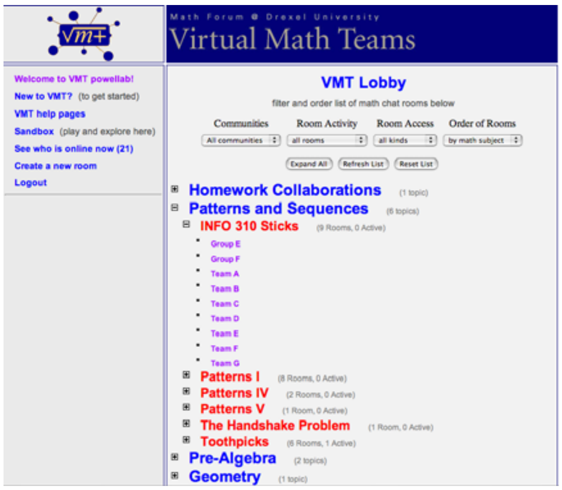

Figure 1. The VMT Lobby.

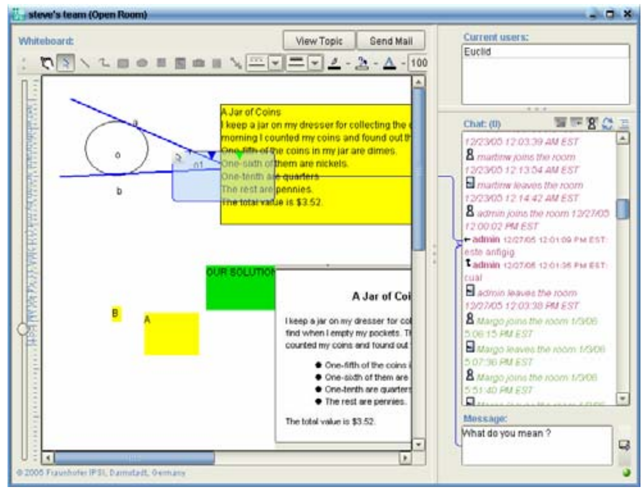

Figure 2. A VMT chat room.

3.2.1.2 Participants

From each of the six participating high schools, we will recruit 12 students in the tenth grade, each approximately 15 to 16-years old, to be involved in our study. Each of the three Brazilian high schools with which we are partnering has students who are learning English as a foreign language and have an interest in improving their oral and written facility in the language. The participants will be recruited from among these students. In school dyad D (see Table 1, section 3.2.1), the participants will be from two different Brazilian schools and will communicate in Portuguese. We will contrast the mathematical communication in this school dyad with the other dyads. In all school dyads, participants will work in small-group teams each consisting of four individuals, randomly assigned.

At each of the six different high schools, 12 students in the tenth grade, approximately 15 to 16-year-olds, will be recruited to participate in the study and randomly assigned to teams, each consisting of four participants. They will use the VMT-Chat environment to create a virtual community of mathematics discourse among local and distant partners.

In the first phase of the project, participants in a given team will all come from the same school. They will use the VMT environment to work together in a familiar social setting on a series of problems in our algebra strand, allowing them to become familiar with the VMT-Chat system and to build collaboration skills. In the second phase of the project, each team will consist of two participants from one school and two participants from another school. These teams will explore other open-ended mathematical situations in our combinatorics and geometry strands. In both phases, teams will have their own chat room.

In addition to VMT-Chat, participants will have access to software applications and other Internet resources. Participants may use word processors, spreadsheets, graphing applications, dynamic geometry applications such as The Geometer's Sketchpad, or applets. They can paste text and screenshots from other applications onto the whiteboard of VMT-Chat. From VMT-Chat, teams will have a link to an electronic discussion board where they may publish their solutions and justifications. Teams will be invited to comment on the other teams' solutions and justifications and, in response, to reconsider and possibly revise their posted solutions and justifications.

3.2.1.3 Tasks and Task Design

To address our guiding research questions, specific tasks will be used to engage learners in building through discourse certain mathematical ideas and exercising and developing further their powers of reasoning. We will draw from an extensive body of experience and tasks derived from the longitudinal and cross-sectional research of the Robert B. Davis Institute for Learning and elsewhere on how mathematical meaning and reasoning are built by learners as well as the corpus of problems that the Math Forum has developed and piloted. Informed by our ongoing formative evaluation during each phase of our study, we will modify tasks and design new ones in response to participants' work.

The mathematical tasks will come from three areas of mathematics: (1) algebra—sequences and patterns, (2) combinatorics and probability, and (3) geometry. The tasks will be challenging in the sense that participants will initially not be aware of procedural or algorithmic tools to solve the problems but will be invited to develop tools in the online, problem-solving context in collaboration with their teammates. The specific tasks that we will choose or design will be accessible, not requiring a particular mathematical expertise, and amenable to a mix of representational systems. Moreover, the tasks will engage participants in important cognitive and discursive aspects of mathematical problem solving such as employing heuristics, making connections, specializing, generalizing, explaining, reflecting, conjecturing, justifying, and posing new problems.

The design of tasks in each mathematical area will enable participants to develop schemata of mathematical concepts and problem-solving strategies. A significant design feature of this study is that students work on *strands* of challenging tasks—or sequences of tasks that may differ superficially but pertain to the same mathematical ideas (Weber et al., in press). The use of strands of related, challenging tasks will allow the research team to accomplish the first three objectives of our research design: create an online environment that allows us to document and trace the development of participants' patterns of discourse and reasoning about particular mathematical concepts over time.

Here we present an example of a strand of tasks that involves concepts central to combinatorics and probability. In the following strand, learners have opportunities to build robust mathematical schemata that lead to binomial coefficients and to develop forms of justification such as combinatorial reasoning and ways to articulate an isomorphism between the underlying mathematical structure of seemingly unrelated problems (Francisco & Maher, 2005; Powell, 2003, 2006; Weber et al., in press):

> Sample Task 1: Towers n-Tall. Your group has two colors of Unifix Cubes. Work together and make as many different towers four cubes tall as is possible when selecting from two colors. See whether your team can plan a good way to find all the towers three, four, five, and n cubes tall.
>
> Sample Task 2: The n-Topping Pizza Problem. A local pizza shop has asked us to help design a form to keep track of certain pizza choices. They offer a cheese pizza with tomato sauce. A customer can then select from toppings such as the following: peppers, sausage, mushroom, and pepperoni. How many different choices for pizza does a customer have? List all the possible choices. Find a way to convince each other that you have accounted for all possible choices.
>
> Sample Task 3: The Four-Topping Pizza with Halves. At customer request, the pizza shop has agreed to offer choices for each half of a pizza. Remember, they offer a cheese pizza with tomato sauce. A customer can then select from the following four toppings: peppers, sausage, mushroom and pepperoni. There is also a choice of crusts: regular (thin) and Sicilian (thick). How many different choices for pizza does a customer have? List all the possible choices. Find a way to convince each other that you have accounted for all possible choices.
>
> Sample Task 4: The World Series Problem. In a World Series, two teams play each other in at least four and at most seven games. The first team to win four games is the winner of the World Series. Assuming that both teams are equally matched, what is the probability that a World Series will be won: (a) In four games? (b) In five games? (c) In six games? and (d) In seven games? Justify your answers.
>
> Sample Task 5: The Taxicab Problem. A taxi driver is given a specific territory of a town, represented by the grid of streets in the diagram below (not shown in this proposal). All trips originate at the taxi

stand, the point in the top left corner of the grid. One very slow night, the driver is dispatched only three times; each time, she picks up passengers at one of the intersections indicated by the other points on the grid. To pass the time, she considers all the possible routes she could have taken to each pick-up point and wonders if she could have chosen a shorter route. What is the shortest route from the taxi stand to each point? How do you know it is the shortest? Is there more than one shortest route to each point? If not, why not? If so, how many? Justify your answers.

Collaborating to solve these tasks, participants can develop important mathematical ideas and ways of reasoning. Through solving the Towers n-Tall problem and the n-Topping Pizza problem, students learn about combinations of n objects chosen k at a time. Specifically, one way students can grapple with this problem would be to consider the number of towers n-cubes high that can be built with no blue cubes, one blue cube, two blue cubes, three blue cubes, and so on. As students explore the problem, they can also conceptualize the idea of binomial coefficients. In the Four-Topping Pizza with Halves problem, students learn about sums of consecutive integers, and expand upon their knowledge of n objects chosen k at a time, since solving this problem is equivalent to taking all possible pizzas from the n-Topping Pizza and selecting two at a time to form possible pizzas with halves. In these three problems, students tend to reason using proof by cases and proof by contradiction. In the Towers n-tall problem, students find all possible towers through the use of different cases, and by using of proof by contradiction, conclude that no more towers can be found. Students reason in similar ways in the n-Topping Pizza and Four-Topping Pizza with Halves problems.

From the World Series Problem, students can learn about the concept of sample space, equal probable events, as well as encounter binomial coefficients again. In the Taxicab Problem, students can develop notions about Pascal's triangle, combinatorial counting, and controlling variables, as well as conceptualize binomial coefficients differently.

For each of the five tasks, students can create and solve a simpler version of the task first, analyze its relationship to the given task, and use their analysis to solve the given task, as well as offer extensions or generalizations. Over time, students' reasoning will broaden and deepen and became increasingly symbolic and generalized. In the Towers n-Tall problem, students' notation tends to be mostly pictorial. However, in the Taxicab Problem, students are inclined to use variables and other symbolic notation more prevalently. Furthermore, through the course of collaborating on these tasks, students engage in inductive, deductive, and recursive reasoning.

3.2.2 Plan for Research Sessions

The functioning of each school dyad will be divided into two parts: Phase I and Phase II. Phase I concerns the intra-school teamwork of the participants, Phase II the inter-school teamwork. Each phase will consist of a cycle of research sessions, where participants interact in teams to solve mathematical problems, using VMT-Chat. Phase I consist of one cycle of sessions, while Phase II consists of two cycles of sessions. In both phases, members of the research team will not provide explicit guidance on how problems should be solved. Our investigation involves understanding how the participants collaborate and develop mathematical ideas and reasoning while engaging with the strand of mathematical tasks.

During Phase I, in each school, the 12 participants will use the VMT-Chat environment to work together in their familiar social setting on a series of problems in our algebra strand. This will allow participants to become acquainted with the VMT-Chat system and to build collaboration skills. Moreover, the strand of tasks—sequences and patterns—will be of a genre somewhat familiar to the participants. Nevertheless, the particular problems are likely to be challenging, especially as students will have to develop justifications for their solutions. The participants will work in teams composed of four individuals from their school, randomly assigned, and each team will collaborate in one VMT-Chat room. In this phase, we will conduct a cycle of research sessions of one hour and a half, twice a week for a total of four weeks.

Before starting Phase II—following a "design experiment" approach— we will conduct a formative evaluation of the first cycle of research sessions and perform a preliminary analysis of the data collected. Informed by the evaluation and analysis, Phase II will engage participate in two cycles of sessions of online mathematics problem solving. Each team will consist of two participants from each school of the dyad. These teams will explore other open-ended mathematical situations in our strands of combinatorics and probability problems and of geometry problems, one strand per cycle. Research sessions in each cycle will consist of a problem-solving session of one and a half hours, twice a week for a total of three weeks.

3.2.3 Data Collection

Our data will come from two main sources: students' work and researchers' observations. The sources of student work includes the transcripts from their interaction in the VMT-Chat environment and electronic discussion board postings as well as from videotaped pre-session individual interviews and follow-up interviews of individual and small-group teams. Data from researchers' observations include planning session scripts; session notes, and reflective journals; planning and debriefing meetings; and written observations of the pedagogical activity of the research team as members interact with students. Table 2 below indicates which data sources address each of our four guiding research questions:

Table 2. *Data Sources that Address Particular Research Questions*

Guiding Research Questions	Data Sources
Within a particular mathematical strand, what mathematical ideas and reasoning do students build from their interactions online?	• Strands of mathematical tasks. • Text, whiteboard inscriptions, and e-mail exchanges, and discussion board postings from VMT-Chat. • Researchers' observation notes.
How do students use online communicative resources to represent and exchange their mathematical ideas and reasoning and to develop justifications for their solutions of mathematical tasks?	• Strands of mathematical tasks • Text, whiteboard inscriptions, and e-mail exchanges, and discussion board postings from VMT-Chat. • Researchers' observation notes.
What facilitation approaches encourage students to coalesce into on-going, small-group teams?	• Researchers' observation notes. • Videotape of debriefing sessions. • Videotape of interviews of participants.
How do new mathematical ideas emerge from students' online interaction and collaboration?	• Strands of mathematical tasks • Text, whiteboard inscriptions, and e-mail exchanges, and discussion board postings from VMT-Chat. • Researchers' observation notes. • Videotape of interviews of participants. • Videotape of debriefing sessions.

3.2.4 Analysis of Data

Similar to design experiment or design-based research (Brown, 1992; Cobb, Confrey, diSessa, Lehrer, & Schauble, 2003), our analytic process involves spiraling stages of development in which reflections of ongoing classroom-based research are used to inform subsequent research tasks and other instructional design decisions. We will examine the data from the persistent VMT-Chat logs of the online interactions of the teams within a school to monitor what is being captured and will modify data collection techniques as needed. This process will also include a formative evaluation of the social and collaborative functioning of the teams and the progress that they make toward solving the mathematical tasks and presenting their solutions as well as commenting and critiquing the solutions of other teams.

Analytically, we are interested in both individual and group cognition. As such, we will analyze our data with the analytic unit being at times individual participants and at other times the small-group team. Informed by the mathematical tasks, analyses of the persistent VMT-Chat logs of inscriptions and text data will allow us to address guiding research questions 1, 2, and 4. For inquiring into the asynchronous data, our methodology will be based on the work of Bairral (2003; 2004). In addition, we will conduct descriptive micro-analysis using methods of "chat analysis" developed in the VMT project (Stahl, 2007b). This approach adapts the rigorous methods of Conversation Analysis (Sacks, Schegloff, & Jefferson, 1974; ten Have, 1999) to the unique forms of interaction that take place in environments like VMT-Chat. It looks at how participants construct shared meaning as described in Section 3.1 above. It identifies the social practices that small online groups of students create in order to do mathematics together, such as joint deictic referencing (Stahl, 2006c) synergistic problem solving (Stahl, 2006a) or negotiating math proposals (Stahl, 2006d).

Investigating the development of mathematical ideas and reasoning—guiding research questions 1, 2, and 4—we will code for instances in the data of participants' online communications of their discursive attention to any of four markers of mathematical elements—objects, relations among objects, dynamics linking different relations, and heuristics (Gattegno, 1988; Powell, 2003). In their text and whiteboard inscriptions, participants either communicate affirmations or interrogatives about these mathematical elements, and as such, we will code for eight different types of critical events that provide insight into participants' mathematical ideas. The matrix in Table 3 contains the critical event codes.

Table 3. *Matrix of Event Types Designated as Critical*

Subject and type of utterance or inscription	**O**bjects	**R**elations among objects	**D**ynamics linking different relations	**H**euristics
Affirmations	**AO**	**AR**	**AD**	**AH**
Interrogatives	**IO**	**IR**	**ID**	**IH**

It is possible that an interaction will receive multiple codes. The research team will analyze the mathematical ideas and forms of reasoning that participants produce individually and as a team, tracing the development of their ideas and reasoning patterns over time.

Our third research question will be responded to on the basis of analyses of researchers' planning and observation notes, the mathematical tasks, and videotapes of the debriefing sessions. To analyze our video recording, we will apply methods for studying videodata ideas theorized and developed by Powell, Francisco, and Maher (2003). Using the persistent VMT-Chat logs, to inquire into facilitation approaches that encourage students to coalesce into on-going, small-group teams, we will develop emergent themes as well as apply *a priori* codes. The codes developed will pertain to categories of facilitator intervention. For instance, a critical event may be defined as a facilitator-team interaction that occasions evidence of a team's mathematical thinking. Codes applied to the data may include the following:

- F(r): Facilitator invites a team to reconsider a student's idea
- F(rs) Facilitator invites a team to comment on another team's idea
- F(d): Facilitator invites a student to contribute to the team's ongoing interaction
- F(c): Facilitator invites a team to clarify their statement or idea
- F(j): Facilitator invites a team to justify its idea, statement, or solution
- F(con): Facilitator confirms that a team and the facilitator agree on what has been done or said

3.3 Research activity schedule

Table 4 below details the schedule interactions within and between the school dyads, when preliminary and final data analyses occur, and when formative and summative evolutions will happen. During the three years of our proposed *e*Math study, school dyads will function during three time periods: fall, spring, and fall. In the intervening times, we will analyze the data collected.

Before the start of the school dyads, we will recruit teachers from all participating schools. From our pilot studies, we already have a working relationship with teachers at four of our six schools. We will also engage teachers in professional development activities relevant to the *e*Math project, including learning VMT-Chat by collaborating in teams to resolve strands of mathematical tasks. The three project years will be divided into three overlapping research periods, each lasting one and a half years. The first research period corresponds to Phase I, while Phase II consists of the second and third periods. Each period will consist of (1) a first cycle of research sessions, (2) a formative evaluation and preliminary data analysis, (3) a second cycle of research sessions, (4) a second formative evaluation and data analysis, and (5) a third cycle of research sessions. See Table 4 below.

Table 4. *Timeline of Research Sessions, Evaluation, and Data Analysis*

Date		Activity	Dyad
2007	Sept. - Nov.	Research sessions	School Dyads A & B
	Nov. - Dec.	Formative evaluation and preliminary data analysis	
2008	Jan - Feb		
	March - May	Research sessions	School Dyads C & D
	June - Aug.	Formative evaluation and preliminary data analysis	
	Sept. - Nov.	Research sessions	School Dyad E
	Nov. - Dec.	Formative evaluation and preliminary data analysis	
2009	Jan - Feb		
	March - May	Research sessions	
	June - Aug.	Formative evaluation and preliminary data analysis	
	Sept. - Nov.	Research sessions	
	Nov. - Dec.	Summative evaluation, final data analysis, writing research reports	
2010	Jan - June		

At each school, one month before each initial cycle of research sessions, the research team will recruit students by posting and sending home flyers and holding an informational meeting with potential student participants. We will attempt to recruit an equal number of female and male students. During each initial cycle of research sessions, we will engage participants in intra-school, online mathematics problem solving. Informed by our first and second formative evaluations and data analyses, we will engage participants in inter-school online problem solving during the second and third cycle of research sessions.

For School Dyads A and B, we will hold initial cycles of research sessions from September to November of 2007, and have a formative evaluation and conduct preliminary data analysis from November to December and January to February of 2008. Afterward, we will carry out a second cycle of research sessions from March to May, and from June to August, we will perform a formative evaluation and conduct preliminary data analysis. Finally, we will conduct a third cycle of research sessions from September to November 2008.

For School Dyads C and D, we will hold initial cycles of research sessions from March to May of 2008, and have a formative evaluation and conduct preliminary data analysis from June to August. We will also carry out a second cycle of research sessions from September to November, and from November to December 2008 and January to February of 2009, we will perform a formative evaluation and conduct preliminary data analysis. We will conduct a third cycle of research sessions from March to May 2009.

For School Dyad E, we will hold initial cycles of research sessions in September to November of 2008, and have a formative evaluation and conduct preliminary data analysis from November to December and January to February of 2009. We will also carry out a second cycle of research sessions from March to May, and from June to August, we will perform a formative evaluation and conduct preliminary data analysis. We will conduct a third cycle of research sessions from September to November 2009.

Finally, from November to December of 2009, and January to June of 2010, we will have a summative evaluation, final data analysis sessions, and write research reports.

4. Evaluation Plan

We will hire an external evaluator who will participate in the formative evaluations in Year II and III and will supervise the summative evaluation. Moreover, we intend to evaluate the development of participants' mathematical reasoning and problem solving schemata. After the first cycle of research sessions in Phase I, as part of our formative evaluation of those sessions, based on the actual work of the participants, we will develop an evaluation rubric to assess the development over time of participants' mathematical reasoning and problem solving schemata. As evidenced in the data of the participants' online interactions, among the dimensions that we may be interested in evaluation are conceptual understanding, strategies and reasoning, communication, and mathematical insight—as well as instantiations of employing heuristics, making connections, specializing, generalizing, explaining, reflecting, conjecturing, justifying, and posing new problems.

5. Implications of Research

5.1 Outcomes

This research addresses the pressing need for inquiry into how teams of learners develop mathematical reasoning through online collaboration to solve cognitively demanding, open-ended problems. Two important outcomes of this study include the following: (a) a model of how students of different SES and geographical locations work in collaborative teams, through online communication technology, to solve cognitively demanding, strands of mathematical tasks; and (b) a model of how to evaluate student learning of students developing mathematical reasoning through online collaboration. In addition to these models, this study will provide fundamental knowledge on the mathematical ideas and forms of reasoning that learners of high school age can build by collaborating online; and for future research, findings suggestive of how collaborative, online work in mathematics problem solving can be integrated into the formal setting of high schools.

5.2 Dissemination

We will communicate the results of our study through peer-reviewed publications and conference presentations within both the communities of researchers in mathematics educators and the learning sciences, addressing issues of importance for research, practice, and policy. What we learn will be disseminated nationally through connecting with the MetroMath: Center for American Cities at Rutgers. Locally and regionally, what we learn will inform activities within the teaching and learning community both within the university and through our partnerships with school districts through the network of the New Jersey State Systemic Initiative (SSI). The Davis Institute for Learning houses a Regional Center within the SSI, and networks with teacher educators and researchers internationally. Through presentations, publications, as well as existing and potential collaborations, we will also disseminate our work. We intend to produce several products from our study. As we have done with the "Surprises in Mind" (2000) documentary, we will collaborate with the Science Media Group of the Harvard-Smithsonian Astrophysics Observatory to obtain additional funding to create a documentary, which can be televised nationally, reaching hundreds of thousands of people, over the CBP Annenberg Educational Channel. Along with a documentary, we have the potential to develop materials for teacher professional development.

Finally, results of our study will also be disseminated through the Math Forum, which now receives about three million unique visitors a month and is subscribed to by many school teachers and districts. Our findings will inform the refinement of the VMT project into a regular service of the Math Forum. Through this service, teachers nationally and internationally, in urban and in suburban settings, in low-SES and high-SES districts will be encouraged to involve their students in collaborative online problem solving of sequences of open-ended math problems. The problems promoted in this scaled-up Math Forum service will be based on the findings of the *e*Math project.

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a. Professional Preparation

Undergraduate

Hampshire College	Mathematics and Statistics	B.S. 1976

Graduate

University of Michigan	Mathematics	M.S. 1977
Rutgers University	Mathematics Education	Ph.D. 2003

b. Appointments

Rutgers University	Robert B. Davis Institute for Learning Graduate School of Education Associate Director	2003-Present
Rutgers University	Department of Urban Education Newark College of Arts and Sciences Associate Professor	1987-Present
Rutgers University	Department of Academic Foundations Newark College of Arts and Sciences Assistant Professor	1981-1987

c. Publications

1. **Powell, A. B**., & Bairral, M. A. (2006). *A escrita e o pensamento matemático: Interações e potencialidades* [*Writing and mathematical thinking: Interactions and potentialities*]. Campinas, São Paulo: Papirus.
2. **Powell, A. B.** (2006). Socially emergent cognition: Particular outcome of student-to-student discursive interaction during mathematical problem solving. *Horizontes*, 24(1), 33-42.
3. Weber, K, Maher, C. A., **Powell, A. B.** (2006). Strands of challenging mathematical problems and the construction of mathematical problem-solving schema. ICMI Study 16. Norwegian University of Science and Technology.
4. **Powell, A. B**., & Hanna, E. (2006). Understanding teachers' mathematical knowledge for teaching: a theoretical and methodological approach. In Proceedings of the Thirtieth annual meeting of the International Group for the Psychology of Mathematics Education. Prague, Czech Republic.
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6. **Powell, A. B.,** & Maher, C. A. (2003). Heuristics of twelfth graders building isomorphisms. In N. A. Pateman, B. J. Dougherty & J. T. Zilliox (Eds.), *Proceedings of the 2003 Joint Meeting of PME and PMENA* (Vol. 4, pp. 23-30). Honolulu: CRDG, College of Education, University of Hawai'i

d. Synergistic Activities

i. Co-PI on NSF grant (MDR-9053597), "Research on Informal Mathematics Learning," investigating characteristics of mathematics learning and its facilitation in an informal, after-school, and urban environment. The project consists of two interconnected studies. The first focuses in-depth on (1) the mathematical ideas and forms of mathematical reasoning that middle-school students develop and use as they investigate well-defined, open-ended tasks; (2) the patterns of discourse among the students as they build solutions to each task; and (3) over the course of the study, changes that occur in students' views

about mathematics and about themselves as mathematical thinkers. The second study documents and analyzes facilitator interventions and their consequent influence on student-to-student discursive interactions and individual student learning. The two studies employ curricular materials, a pedagogical approach, as well as methodological and analytic tools developed at the Robert B. Davis Institute for Learning. The setting for both studies is an informal after-school program for students of Hubbard Middle School in Plainfield, which is an economically depressed, urban school district with a population of 98% African American and Latino students.
ii. Have designed and lead numerous professional development activities for practicing teachers in New Jersey (including Newark, Plainfield, Englewood, and New Brunswick), in The Bronx, New York City, and in other urban districts in other regions of the United States as well as in other parts of the world (Canada, China, Mozambique, South Africa, and Brazil).
iii. Have develop and implemented courses for prospective teachers in the areas of mathematics pedagogy, mathematics teaching with technology, and problem solving in teaching secondary-school mathematics.

e. Collaborators & Other Affiliations
i. Collaborators (last 48 months)
Barrail, Marcelo Almeida, Universidade Federal Rural do Rio de Janeiro (Brazil)
Borba, Marcelo Carvalho, Universidade Estadual Paulista, Rio Claro (Brazil)
Cao Feiyu, People's Education Press, (China)
Chazan, Dan, University of Maryland, College Park
D'Ambrosio, Ubiratan, Universidade Estadual De Campinas (Brazil)
Dörfler, Willi, Universität Klagenfurt, (Austria)
Driscoll, Mark, Education Development Center
Frankenstein, Marilyn, University of Massachusetts-Boston,
Gerdes, Paulus, Universidade Pedagógica, Maputo, (Mozambique)
Greer, Brian, Portland State University
Heyl, Roseann, Newark Public Schools
Julie, Cyril, University of the Western Cape (South Africa)
Nemirovsky, Ricardo, San Diego State University
Maher, Carolyn A., Rutgers University
Morgan, Pamela, Newark Public Schools
Stahl, Gerry, Drexel University
Weber, Keith, Rutgers University
ii. Graduate and Postdoctoral Advisors
Maher, Carolyn A., Rutgers University
Brown, Morton, University of Michigan
iii. Thesis Advisor and Postgraduate-Scholar Sponsor
Hanna, Evelyn
iv. Graduate Students worked with:
Antônio Olímpio Junior (2006)
Sumaia Aparecida Curry Vazquez (2004)
Larry D. Kannemeyer (2003)

f. Courses taught past 3 years
Developmental Mathematics (undergraduate), Mathematics and Instructional Technology (undergraduate), Information and Communication Technology in Secondary Schools (undergraduate), Mathematical Problem Solving, (Honors), Research into the Development of Mathematical Ideas (graduate), Qualitative Research Methods (graduate), and Video Data Methodology (graduate).

Carolyn A Maher
Graduate School of Education
Rutgers - The State University
10 Seminary Place
New Brunswick, NJ 08901-1108

Professional Preparation:

- Ed.D., Ed.M., Mathematics Education, Rutgers University
- B.A, Mathematics, Rutgers University

Appointments:

- Professor of Mathematics Education, Rutgers University, 1992-
- Chairperson, Department of Learning and Teaching, Graduate School of Education, Rutgers University, 1992-1995, 1999-2000
- Director, Robert B, Davis Institute for Learning, Graduate School of Education, Rutgers University, 1998-
- Doctoral Faculty, Graduate School of Education, Rutgers University, 1989-1999
- Doctoral Faculty, Graduate School, Rutgers University, 2000-
- Editor, Journal of Mathematical Behavior, 1998-
- Director, Rutgers Regional Center, Statewide Systemic Initiative, 1991-

Publications Related to Project:

Davis, R. B. & Maher, C. A. (1997). How students think: The role of representations. In L. English (Ed.), Mathematical reasoning: Analogies, metaphors, and images (pp.93-115). Hillsdale, NJ: Lawrence E. Erlbaum Associates.

Francisco, J. M. & Maher, C. A. (2005). Conditions for promoting reasoning in problem solving: Insights from a longitudinal study. Special Issue: Mathematical problem solving: What we know and where we are going (Guest Editors: Cai, J, Mamona-Downs, J. & Weber, K.) The Journal of Mathematical Behavior, 24(3-4), 361-372.

Maher, C.A. (in press). The development of mathematical reasoning: A 16-year study. Invited Senior Lecture for the 10th International Congress on Mathematics Education. In Senior Lectures, ICME10: Copehagen, Denmark.

Maher, C.A. (in press). Children's reasoning: Discovering the idea of mathematical proof. In M. Blanton, M and D Stylianou (Eds.), Teaching and learning proof across the grades, New Jersey: Lawrence Erlbaum Associates.

Maher, C. A., Muter, E. M. & Kiczek, R. D. (2006). The development of proof making by students. In P. Boero (Ed.), Theorems and proof in schools: from history, epistemology and cognition to classroom practice (pp. 197-208). Sense Publishers (PB ISBN 90-77874-21-6; HB ISBN 90-77874-22-4).

Maher, C. A., (2005). How students structure their investigations and learn mathematics: insights from a long-term study. The Journal of Mathematical Behavior, 24(1), pp. 1-14.

Maher, C. A., Martino, A. M. (2000). From patterns to theories: Conditions for conceptual change. Journal of Mathematical Behavior, 19(2), 247-271.

Maher, C. A. & Martino, A. M. (1996). The development of the idea of mathematical proof: A 5-year case study. Journal for Research in Mathematics Education,27 (2), 194-214.

Powell, A., Francisco, J. & Maher, C.A. (2003), An analytical model for studying the development of learners' mathematical ideas and reasoning using videotape data. The Journal of Mathematical Behavior, 22(4), pp. 405-435.

Powell, A. B., Maher, C. A., & Alston, A. S. (2004). Ideas, sense making, and the early development of reasoning in an informal mathematics settings. In D. E. McDougall & J. A. Ross (Eds.), Proceedings of the twenty-sixth annual meeting of the North American Chapter of the International Group for the Psychology of Mathematics Education (Toronto, Ontario) (pp. 585-591). Toronto: OISE/UT.

Speiser, R., Walter, C., & Maher, C. A. (2003). Representing motion: An experiment in learning. The Journal of Mathematical Behavior, *22* (1), p.1-35.

Weber, K., Maher, C.A. & Powell, A. B. (in press). Strands of challenging mathematical problems and the construction of mathematical problem-solving schema. ICMI 16 Study Group, Trondheim, Norway. Springer-Velag, publishers.

Other Significant Publications:

Maher, C. A. & Speiser, R. (1997). How far can you go with block towers? Stephanie's Intellectual Development. Journal of *Mathematical Behavior, 16*(2), 125-132.

Steencken, E. P. & Maher C. A. (2002). Young children's growing understanding of fraction ideas. In B. H. Littwiller & G. Bright (Eds.), 2002 NCTM Yearbook: Making Sense of Fractions, Ratios, and Proportions, pp. 49-60. Reston, VA: National Council of Teachers of Mathematics.

Synergistic Activities:

Served as a consultant to the "Private Universe Project in Mathematics" for the Harvard-Smithsonian Center for Astrophysics. The Project resulted in the production of six one-hour videotapes based on the longitudinal study and outreach activities resulting from it and a documentary about the potential for students' learning.

Invited Plenary talks include:

What can research on pre-college math learning contribute to undergraduate mathematics teaching and learning? Invited Plenary for the Special Interest Group of the Mathematical Association of America, Ninth Conference on Research in Undergraduate Education, Rutgers University, New Jersey, (2006, February).

The development of mathematical reasoning: 16-Year study. Invited lecture at the 10th International Congress of Mathematics Education, Copenhagen, Denmark, (2004, July).

Studying the development of reasoning using videotape data: A pivotal strand. Invited plenary speaker at the University of Helsinki, Finland, (2004, June).

How students structure their own investigations and educate us: What we have learned from a fourteen year study. Invited plenary session for the XXVI Annual Meeting of the International Conference for the Psychology of Mathematics Education (PME26). Norwich, England: School of Education and Professional Development, University of East Anglia, (2002, July).

Gave presentations and led workshops for groups of researchers, teachers, mathematics educators and administrators throughout North America as well as in Australia, Brazil, China, Finland, Israel, Japan, Mozambique, South Africa, Sweden, and Taiwan.

Collaborator with Rutgers University Center for Mathematics, Science and Computer Education, DIMACS, Metro Math Center for Learning and Teaching, School of Engineering on their IGERT grant project, New Jersey Math-Science Partnership, the SUC_2ES_2 project with UMDNJ and EOSHI, and the New Jersey Statewide Systemic Initiative.

Collaborators and Other Affiliations:

Collaborators: Gunnar Gjone (University of Oslo, Norway), Arthur Powell, (Rutgers University), Robert Speiser (BYU), Keith Weber, Rutgers University.
Other Affiliations: Editor, *Journal of Mathematical Behavior*; Series Editor, Ablex Publishing, Stamford, CT Editorial Board, *Journal of Research in Mathematics Education*.

Gerry Stahl

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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 and 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: "*SLC 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 SLC.
- 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

Sara C. Michael-Luna
Department of Urban Education
Rutgers University
110 Warren Street
Newark, NJ

Education

2005	PhD	Curriculum and Instruction	University Of Wisconsin	Madison, WI
1994	M.S.	Urban Education	University Of Wisconsin	Milwaukee, WI
1992	B.A.	English	Lakeland College	Sheboygan, WI

Employment History:

2005 -present	Assistant professor of Literacy	Rutgers University
1994-1999	Director of the English Language Institute	Lakeland College

Publications

Publications related to project (* denotes publication in peer-reviewed journal)

- Michael-Luna, S. & Canagarajah, S. (Accepted). Foundational Experiences in Academic Literacy Apprenticeship: Pedagogical Implications for negotiating multilingualism in higher education. *Journal of Applied Linguistics*.*

- Michael-Luna, S. (Accepted). Todos Somos Blancos/We Are All White: Constructing racial identities through texts. *Journal of Language, Identity and Education*.*

- Michael-Luna, S. (Under review). Reconceptualizing Early Childhood English Language Learners as Native Multilingual Speakers: Language Hybridity in TESOL Praxis. Submitted to *TESOL Quarterly*.*

- Michael-Luna, S. (Under review). Narratives in the Wild: Unpacking Critical Race Theory Methodology for Early Childhood Bilingual Education. In Kabuto, R. & Lin, A. (eds.). *Race, Culture and Identities in Second Language Education.*

- Michael-Luna, S. (In preparation). (Re)Constructing multilingual learners within the monolingual Discourse of Schooling: Counter story as the story. To be submitted to *Teachers College Record*.*

- Michael-Luna, S. (ed.) (In preparation). Understanding Resistance in Language Learning and Teaching. To be submitted to *Cambridge University Press.*

- Michael-Luna, S. (2005). The Power of Local Literacies: negotiating communities of practice through reading and writing. Book Review Article. *Journal of Language, Identity and Education*.*

Synergistic activities

- AERA-Division G, Social Context of Educational Research Fellow (2005-2009), American Educational Research Association.
- *TESOL Quarterly* (Teaching English to Speakers of Other Languages Quarterly), Editorial Board (2006-2009).
- AERA-IES Dissertation Grant (2004-2005). American Educational Research Association.
- Tashia F. Morgridge Wisconsin Distinguished Graduate Fellowship (2004-2005). University of Wisconsin-Madison.
- Spencer Doctoral Research Program, Fellow (2002-2005). University of Wisconsin-Madison.

Collaborators
Jennifer Austin (Rutgers University), Suresh Canagarajah (Baruch College, CUNY), Catherine Compton-Lily (University of Wisconsin), Lucille Heimer (University of Wisconsin), Anand Marri (Teachers College), Bonny Norton (University of British Columbia), Kelleen Toohey (Simon Frasier University), Jane Zuengler (University of Wisconsin).

SUMMARY PROPOSAL BUDGET

YEAR 1

ORGANIZATION: Rutgers University Newark				FOR NSF USE ONLY — PROPOSAL NO.	DURATION (months): Proposed / Granted
PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR: Arthur B Powell				AWARD NO.	

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. Arthur B Powell - PI	0.00	2.25	1.00	$ 32,500	$
2. Carolyn A Maher - Co-PI	0.00	0.00	0.50	7,222	
3. Sara Michael-Luna - Researcher	0.00	0.00	1.00	6,889	
4. Gerry Stahl - Co-PI (Drexel Univ.)	0.00	0.00	0.00	0	
5.					
6. (0) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	0	
7. (4) TOTAL SENIOR PERSONNEL (1 - 6)	0.00	2.25	2.50	46,611	
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.)	6.00	0.00	0.00	25,000	
3. (2) GRADUATE STUDENTS				24,000	
4. (2) UNDERGRADUATE STUDENTS				8,000	
5. (0) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				0	
6. (0) OTHER				0	
TOTAL SALARIES AND WAGES (A + B)				103,611	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				19,505	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				123,116	
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)				2,500	
2. FOREIGN				3,500	
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				21,000	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				0	
3. CONSULTANT SERVICES				24,500	
4. COMPUTER SERVICES				0	
5. SUBAWARDS				56,790	
6. OTHER				1,000	
TOTAL OTHER DIRECT COSTS				103,290	
H. TOTAL DIRECT COSTS (A THROUGH G)				232,406	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE) Facilities & Administrative (F&A) costs (Rate: 54.5000, Base: 200616)					
TOTAL INDIRECT COSTS (F&A)				109,336	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				341,742	
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)				$ 341,742	$
M. COST SHARING PROPOSED LEVEL $ 0	AGREED LEVEL IF DIFFERENT $				

PI/PD NAME: Arthur B Powell	FOR NSF USE ONLY — INDIRECT COST RATE VERIFICATION		
ORG. REP. NAME*	Date Checked	Date Of Rate Sheet	Initials - ORG

 *ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET

SUMMARY PROPOSAL BUDGET

YEAR 2

ORGANIZATION: Rutgers University Newark			FOR NSF USE ONLY		
			PROPOSAL NO.	DURATION (months) Proposed	Granted
PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR: Arthur B Powell			AWARD NO.		

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. Arthur B Powell - PI	0.00	2.25	2.00	$ 44,625	$
2. Carolyn A Maher - Co-PI	0.00	0.00	0.50	7,583	
3. Sara Michael-Luna - Researcher	0.00	0.00	1.00	7,233	
4. Gerry Stahl - Co-PI (Drexel Univ.)	0.00	0.00	0.00	0	
5.					
6. (0) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	0	
7. (4) TOTAL SENIOR PERSONNEL (1 - 6)	0.00	2.25	3.50	59,441	
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.)	6.00	0.00	0.00	26,250	
3. (2) GRADUATE STUDENTS				25,500	
4. (2) UNDERGRADUATE STUDENTS				8,500	
5. (0) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				0	
6. (0) OTHER				0	
TOTAL SALARIES AND WAGES (A + B)				119,691	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				21,015	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				140,706	
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)				2,500	
2. FOREIGN				3,500	
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				2,000	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				0	
3. CONSULTANT SERVICES				24,500	
4. COMPUTER SERVICES				0	
5. SUBAWARDS				58,880	
6. OTHER				1,000	
TOTAL OTHER DIRECT COSTS				86,380	
H. TOTAL DIRECT COSTS (A THROUGH G)				233,086	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE) Facilities & Administrative (F&A) costs (Rate: 54.5000, Base: 174207)					
TOTAL INDIRECT COSTS (F&A)				94,943	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				328,029	
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)				$ 328,029	$
M. COST SHARING PROPOSED LEVEL $ 0	AGREED LEVEL IF DIFFERENT $				

PI/PD NAME: Arthur B Powell	FOR NSF USE ONLY		
	INDIRECT COST RATE VERIFICATION		
ORG. REP. NAME*	Date Checked	Date Of Rate Sheet	Initials - ORG

 *ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET

SUMMARY PROPOSAL BUDGET

YEAR 3

	FOR NSF USE ONLY		
ORGANIZATION: Rutgers University Newark	PROPOSAL NO.	DURATION (months)	
		Proposed	Granted
PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR: Arthur B Powell	AWARD NO.		

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. Arthur B Powell - PI	0.00	2.25	1.00	$ 35,831	$
2. Carolyn A Maher - Co-PI	0.00	0.00	0.50	7,963	
3. Sara Michael-Luna - Researcher	0.00	0.00	1.00	7,595	
4. Gerry Stahl - Co-PI (Drexel Univ.)	0.00	0.00	0.00	0	
5.					
6. (0) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	0	
7. (4) TOTAL SENIOR PERSONNEL (1 - 6)	0.00	2.25	2.50	51,389	
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.)	6.00	0.00	0.00	27,563	
3. (2) GRADUATE STUDENTS				27,000	
4. (2) UNDERGRADUATE STUDENTS				9,000	
5. (0) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				0	
6. (0) OTHER				0	
TOTAL SALARIES AND WAGES (A + B)				114,952	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				22,616	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				137,568	
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				3,000	
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				2,000	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				0	
3. CONSULTANT SERVICES				24,500	
4. COMPUTER SERVICES				0	
5. SUBAWARDS				61,074	
6. OTHER				1,000	
TOTAL OTHER DIRECT COSTS				88,574	
H. TOTAL DIRECT COSTS (A THROUGH G)				232,142	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE) Facilities & Administrative (F&A) costs (Rate: 54.5000, Base: 171068)					
TOTAL INDIRECT COSTS (F&A)				93,232	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				325,374	
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)				$ 325,374	$
M. COST SHARING PROPOSED LEVEL $ 0	AGREED LEVEL IF DIFFERENT $				

PI/PD NAME: Arthur B Powell	FOR NSF USE ONLY		
	INDIRECT COST RATE VERIFICATION		
ORG. REP. NAME*	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
Rutgers University Newark

PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR
Arthur B Powell

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. Arthur B Powell - PI	0.00	6.75	4.00	$ 112,956	$
2. Carolyn A Maher - Co-PI	0.00	0.00	1.50	22,768	
3. Sara Michael-Luna - Researcher	0.00	0.00	3.00	21,717	
4. Gerry Stahl - Co-PI (Drexel Univ.)	0.00	0.00	0.00	0	
5.					
6. ( ) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	0	
7. (4) TOTAL SENIOR PERSONNEL (1 - 6)	0.00	6.75	8.50	157,441	
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.)	18.00	0.00	0.00	78,813	
3. (6) GRADUATE STUDENTS				76,500	
4. (6) UNDERGRADUATE STUDENTS				25,500	
5. (0) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				0	
6. (0) OTHER				0	
TOTAL SALARIES AND WAGES (A + B)				338,254	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				63,136	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				401,390	
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)				8,000	
2. FOREIGN				10,000	
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				25,000	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				0	
3. CONSULTANT SERVICES				73,500	
4. COMPUTER SERVICES				0	
5. SUBAWARDS				176,744	
6. OTHER				3,000	
TOTAL OTHER DIRECT COSTS				278,244	
H. TOTAL DIRECT COSTS (A THROUGH G)				697,634	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE)					
TOTAL INDIRECT COSTS (F&A)				297,511	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				995,145	
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)				$ 995,145	$

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

PI/PD NAME
Arthur B Powell

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

BUDGET JUSTIFICATION

A. SENIOR PERSONNEL

Funding for faculty release time during the academic year and summer salary is requested for Arthur Powell, PI, his efforts with overall project direction, contact with school administrators, supervision of research apprentices, and collaborative research activities, including task design for the *e*Math after-school sessions, data analysis and dissemination of findings, with the Co-PIs (Bairral, Maher and Stahl). Funding for summer salary for Carolyn Maher is requested for her efforts as the Co-PI at Rutgers for the project. She will participate in research team meetings and debriefing sessions that follow the research sessions with students. She will also select readings for the research team, engage in data analysis, and produce papers for publication and presentation. Funding for summer salary is requested for Sara Michael-Luna for her contributions to data analysis and dissemination of findings with regard to discourse and communication patterns among the student subjects, guided by her experience studying English Language Learners. Funding for Co-PI Gerry Stahl is requested through the subcontract to Drexel University (see that budget and justification for details). Funding for Co-PI Marcelo Bairral is through consultancy because he is employed at a Brazilian institution of higher education (see Section G. below).

B. OTHER PERSONNEL

Funding is requested for half-time support for the *e*Math Project Director, who will work closely with the PI and other Senior Personnel to support planning and design of activities and then will ensure that the research is conducted accordingly. She will coordinate meetings, schedule *e*Math after-school sessions, facilitate contact with teacher-researchers at each school site, write and send letters about *e*Math after-school activities to student participants and their parents, and collect and maintain project data. She will also manage the project's budget and expenditures, procure supplies, and support Senior Personnel with preparation of project reports and papers with research findings.

Funding is requested for two Graduate Students to work approximately 15 hours per week, calendar year, on data collection and analysis. They will be responsible for videotaping each research session and debriefing discussion that immediately follows it, taking observation notes at each research session, collecting written work from the *e*Math sessions, monitoring the high school students' online interactions, contacting The Math Forum staff concerning maintenance issues with VMT-Chat, and assisting in data analysis. Funding is also requested for two Undergraduate Students to work approximately 10 hours per week, academic year, as apprentices in research by providing support to the Graduate Students with their project responsibilities.

C. FRINGE BENEFITS

Fringe benefit rates are calculated by type of position and the estimated rates provided by Rutgers SRO vary by year. Rates in year 1 are: 35% of academic year salary for faculty and of calendar year salary for full-time staff, 9% on hourly wages, and 0% on faculty summer pay. Rates in year 2 are: 36% of annual salary for full-time faculty and staff, 9% on hourly wages, and 0% on faculty summer pay. Rates in year 3 are: 37% of annual salary for full-time faculty and staff, 9% on hourly wages, and 0% on faculty summer pay.

D. EQUIPMENT (no funds requested)

E. TRAVEL

Funds requested for domestic travel are for (1) the PI or Co-PI to attend the annual PI meeting in Washington, D.C., (2) the PI or a graduate assistant to attend the after-school sessions at the high school in Boston, (3) bringing the teacher-researchers from Boston to Newark to meet with their NJ-based counterparts and Senior Personnel, and (4) dissemination of findings at professional conferences held at locations in North America. Funds requested for foreign travel are for (1) bringing Marcelo Almeida Bairral from Brazil to NJ or sending Arthur Powell to Brazil for collaborative research work that cannot be done remotely, and (2) dissemination of findings at professional conferences held at international locations.

F. PARTICIPANT SUPPORT (no funds requested)

G. OTHER DIRECT COSTS

Materials and Supplies funding is requested to cover the costs of two digital video cameras ($3,000), three MacBook Pro laptops ($7,500), computer supplies and software ($4,500), and videotapes, DVDs, and other project supplies ($6,000) plus funding for scanning students' work and photocopying costs related to maintaining project records and conducting project work ($4,000).

Consulting Services funding in the amount of $12,500 per year is to work with Marcelo Almeida Bairral as Co-PI who will collaborate on design, implementation, and analysis of the research and be responsible for overseeing the activities at the Brazilian sites. He will also participate in the publication and dissemination of project findings (see his two-page biographical sketch in the Supporting Documents to this proposal). Consulting Services funding in the amount of $36,000 is requested to give each of the 12 teachers who will collaborate on this research a payment of $1,000 per year for all three years. Their contributions to the project will include assistance with recruiting high school student participants, helping the researchers with planning and facilitating the after-school sessions, participating in the debriefings that follow the sessions, and helping to resolve project coordination or implementation issues at the school sites.

Subcontract funding is to work with Co-PI Gerry Stahl and the Math Forum Group at Drexel University. The funds include 1 month summer pay for the Co-PI, 2.4 months calendar year staff support for the Math Forum, fringe benefits on salary, computer-VMT fee, and indirect costs. These costs and their justification are detailed in the Drexel budget.

Other funding is requested in the amount of $1,000 per year in all three years for the costs of conducting video-conferences for Senior Personnel to work with all the teacher-researchers for planning *e*Math activities, discussing task design, and coordinating aspects of implementation among the school dyads formed from the six U.S. and Brazil school sites.

I. INDIRECT COSTS

The Indirect, or Facilities and Administrative (F&A), Cost rate being utilized for this project is the federally approved rate for off-campus research at Rutgers University, which is 54.5% of the Modified Total Direct Cost (MTDC). MTDC equals Total Direct Cost minus Rent for Buildings & Grounds, Participant Support, Permanent Equipment, Tuition, and Subcontract Amounts over the first $25,000 of each Subcontract.

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 - Co-PI	0.00	0.00	1.00	$ 11,472	$
2.					
3.					
4.					
5.					
6. (0) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	0	
7. (1) TOTAL SENIOR PERSONNEL (1 - 6)	0.00	0.00	1.00	11,472	
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.)	2.40	0.00	0.00	10,500	
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)				21,972	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				5,888	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				27,860	
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)				0	
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				10,000	
5. SUBAWARDS				0	
6. OTHER				0	
TOTAL OTHER DIRECT COSTS				10,000	
H. TOTAL DIRECT COSTS (A THROUGH G)				37,860	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE) Indirect Costs (Rate: 50.0000, Base: 37860)					
TOTAL INDIRECT COSTS (F&A)				18,930	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				56,790	
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)				$ 56,790	$

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

PI/PD NAME: **Gerry Stahl**

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

YEAR 2

ORGANIZATION: Drexel University				FOR NSF USE ONLY — PROPOSAL NO.	DURATION (months) Proposed / Granted
PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR: Gerry Stahl				AWARD NO.	

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 - Co-PI	0.00	0.00	1.00	$ 12,045	$
2.					
3.					
4.					
5.					
6. (0) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	0	
7. (1) TOTAL SENIOR PERSONNEL (1 - 6)	0.00	0.00	1.00	12,045	
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.)	2.40	0.00	0.00	11,025	
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)				23,070	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				6,183	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				29,253	
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)				0	
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				10,000	
5. SUBAWARDS				0	
6. OTHER				0	
TOTAL OTHER DIRECT COSTS				10,000	
H. TOTAL DIRECT COSTS (A THROUGH G)				39,253	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE) Indirect Costs (Rate: 50.0000, Base: 39253)					
TOTAL INDIRECT COSTS (F&A)				19,627	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				58,880	
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)				$ 58,880	$
M. COST SHARING PROPOSED LEVEL $ 0	AGREED LEVEL IF DIFFERENT $				

PI/PD NAME: Gerry Stahl	FOR NSF USE ONLY — INDIRECT COST RATE VERIFICATION		
ORG. REP. NAME*	Date Checked	Date Of Rate Sheet	Initials - ORG

 *ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET

SUMMARY PROPOSAL BUDGET

YEAR 3

ORGANIZATION: **Drexel University**				FOR NSF USE ONLY	
				PROPOSAL NO.	DURATION (months): Proposed / Granted
PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR: **Gerry Stahl**				AWARD NO.	

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 - Co-PI	0.00	0.00	1.00	$ 12,648	$
2.					
3.					
4.					
5.					
6. (0) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	0	
7. (1) TOTAL SENIOR PERSONNEL (1 - 6)	0.00	0.00	1.00	12,648	
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.)	2.40	0.00	0.00	11,576	
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)				24,224	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				6,492	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				30,716	
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)				0	
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				10,000	
5. SUBAWARDS				0	
6. OTHER				0	
TOTAL OTHER DIRECT COSTS				10,000	
H. TOTAL DIRECT COSTS (A THROUGH G)				40,716	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE) Indirect Costs (Rate: 50.0000, Base: 40716)					
TOTAL INDIRECT COSTS (F&A)				20,358	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				61,074	
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)				$ 61,074	$
M. COST SHARING PROPOSED LEVEL $ 0	AGREED LEVEL IF DIFFERENT $				

PI/PD NAME: **Gerry Stahl**	FOR NSF USE ONLY		
	INDIRECT COST RATE VERIFICATION		
ORG. REP. NAME*	Date Checked	Date Of Rate Sheet	Initials - ORG

 *ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET

SUMMARY PROPOSAL BUDGET

Cumulative

ORGANIZATION **Drexel University**				FOR NSF USE ONLY PROPOSAL NO.	DURATION (months) Proposed	Granted
PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR **Gerry Stahl**				AWARD NO.		

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 - Co-PI	0.00	0.00	3.00	$ 36,165	$
2.					
3.					
4.					
5.					
6. ( ) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	0	
7. (1) TOTAL SENIOR PERSONNEL (1 - 6)	0.00	0.00	3.00	36,165	
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.)	7.20	0.00	0.00	33,101	
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)				69,266	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				18,563	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				87,829	
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)				0	
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				30,000	
5. SUBAWARDS				0	
6. OTHER				0	
TOTAL OTHER DIRECT COSTS				30,000	
H. TOTAL DIRECT COSTS (A THROUGH G)				117,829	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE)					
TOTAL INDIRECT COSTS (F&A)				58,915	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				176,744	
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)				$ 176,744	$
M. COST SHARING PROPOSED LEVEL $ 0	AGREED LEVEL IF DIFFERENT $				

PI/PD NAME **Gerry Stahl**	FOR NSF USE ONLY INDIRECT COST RATE VERIFICATION		
ORG. REP. NAME*	Date Checked	Date Of Rate Sheet	Initials - ORG

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

eMath: Diverse High School Students Developing Mathematical Reasoning through Online Collaboration

Budget Justification for Drexel University Budget

Personnel

Co-PI

Gerry Stahl will direct Drexel University's share of the collaborative project and will provide the primary point of contact of the Drexel effort for the project. He will lead and coordinate the research at the Drexel site. He is budgeted for one month of summer salary per year.

Staff Support

Revelino Guron, Jr. will provide staff support in the generation, collection and automated manipulation of project data. He will provide software programming support and administration of the usage of the VMT online collaboration environment. He will assist in related data management and software development efforts. He is budgeted for 20% of his annual salary per year.

Fringe Benefits

Full-time academic personnel at Drexel University receive fringe benefits budgeted at 26.8% of salary.

Other Direct Costs

The Math Forum will host all sessions of the VMT environment used extensively in this project. A fee of $10,000 per year will be budgeted for Math Forum staff support of the use of the software and hardware environment in this project. This includes modification and adaptation of the environment as needed for the research project and administrative assistance in registering students and in producing data on student sessions for analysis in the research project.

Indirect Costs

Drexel University charges 50% Indirect Costs.

Current and Pending Support

(See GPG Section II.C.2.h 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: **Arthur Powell**

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: **eMath: Diverse High School Students Developing Mathematical Reasoning through Online Collaboration**

Source of Support: **National Science Foundation**

Total Award Amount: $ **995,145** Total Award Period Covered: **07/01/07 - 06/30/10**

Location of Project: **Rutgers University, Newark, New Jersey**

Person-Months Per Year Committed to the Project. Cal: **0.00** Acad: **2.25** Sumr: **1.00**

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:

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: Summ:

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

 USE ADDITIONAL SHEETS AS NECESSARY

Current and Pending Support

(See GPG Section II.C.2.h 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 Maher**

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: **Synthesizing Video Data on Students' Mathematical Reasoning**

Source of Support: **National Science Foundation**

Total Award Amount: $ **199,997** Total Award Period Covered: **07/01/07 - 12/31/09**

Location of Project: **Rutgers University, New Brunswick, New Jersey**

Person-Months Per Year Committed to the Project. Cal: **0.00** Acad: **0.00** Sumr: **1.00**

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:

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: Summ:

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

 USE ADDITIONAL SHEETS AS NECESSARY

Current and Pending Support

(See GPG Section II.C.2.h 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 been/will be submitted.

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

Project/Proposal Title: **Engaged Learning in Online Communities**

Source of Support: **NSF Sciences of Learning Centers -- Catalyst**

Total Award Amount: $ **180,762** Total Award Period Covered: **09/20/05 - 09/19/07**

Location of Project: **Drexel University, Philadelphia**

Person-Months Per Year Committed to the Project. Cal: **0.00** Acad: **0.00** Sumr: **1.00**

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

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

Source of Support: **NSF IERI**

Total Award Amount: $ **2,300,000** Total Award Period Covered: **09/01/03 - 08/30/08**

Location of Project: **Drexel University, Philadelphia**

Person-Months Per Year Committed to the Project. Cal: **0.00** Acad: **0.00** Sumr: **1.00**

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:

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: Summ:

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

FACILITES, EQUIPMENT, AND OTHER RESOURCES

FACILITIES:

Laboratory:

Clinical:

Animal:

Computer: Senior Personnel that will work on this project have laptop and/or desktop computers and basic software to meet their computing needs. The budget for this project includes funds to purchase 3 new MacBook Pro laptop computers to supplement the computer needs of all project personnel.

Faculty, students, and staff at Drexel University have access to Microsoft Office 2003, Visual Studio 2005, MS Developer Network, Front Page 2003, Outlook, Visio, SPSS 15 for Windows, Adobe Acrobat 8.0, and SQLserver software. For Math Forum information, see Other Resources.

Office: All personnel participating in this project will use the office infrastructure that supports them in proportion to their effort on the project. In addition to faculty offices on campus, the Robert B. Davis Institute for Learning leases a suite in downtown New Brunswick, which includes office space for the PI and Co-PI at Rutgers University. This office suite also has space available that could be used by the Project Director, graduate students and undergraduate students, as well as a conference room for holding project meetings. Office facilities include capability to print, photocopy and scan.

The Co-PI at Drexel University has faculty office space and computer equipment (see computer software information above). Math Forum office space and facilities provided by Drexel University includes a suite of offices, conference room, server room, Internet II access, desktop and laptop computers, copy machine, fax machine, and a printer.

Other: In Newark, University High School has a state-of-the-art video conferencing facility that can be used for connecting with *e*Math research partners in Brazil, where they will use a local video conferencing facility.

MAJOR EQUIPMENT:

The Robert B. Davis Institute for Learning (RBDIL) at Rutgers Graduate School of Education will make its multimedia equipment, including video recording equipment and video editing systems, available to the *e*Math project. This will be used to supplement the two video cameras that will be purchased with funds budgeted in through the grant.

OTHER RESOURCES:

The RBDIL will make available materials that have been generated by years of research on the development of students' mathematical thinking, which include open-ended, problem-solving tasks that span across several mathematical strands.

Drexel University's Information Resources and Technology Department and MathForum.org share the hosting of the Math Forum website. The Math Forum website resides on IBM, Dell, and Penguin hardware. As the MathForum.org hosted Penguin machines are removed from service, new IBM and Dell servers with dual core xeon processors are replacing them.

MathForum.org is transitioning the location of its server suite from the Math Forum offices to the central computing facilities of Drexel University. Drexel University's Information Resources and Technology Department is an enterprise level provider, servicing the information technology needs of more than thirty academic institutions. The physical environment, Internet connectivity, networking, hardware, webservers, and operating systems are monitored 24/7.

The Math Forum website is served using Apache/Tomcat web server software running under the Red Hat Linux operating system. The website applications have been developed using both open-source and commercial tools, with the majority of the site engineered utilizing a java development framework. SQL compliant database engines, including PostgreSQL, MySQL, and Sybase's Adaptive Server Enterprise product, support Math Forum applications. Six of our nineteen servers support a development environment that exactly duplicates our production applications and production database servers, promoting a process for implementing well vetted software by technical staff and user audience.

MARCELO BAIRRAL
Institute of Education, Federal Rural University of Rio de Janeiro (UFRRJ)
Rodovia BR km 7
23890-000, Seropédica-RJ, Brasil
Tel/fax (55-21) 2682-1841
e-mail: mbairral@ufrrj.br

Professional Experience

UFRRJ, Institute of Education

SENIOR SCIENTIST 1997-PRESENT

Formation

Federal Fluminense University-UFF. Licentiate in Mathematics, 1990.
Federal Fluminense University-UFF. Post-graduate studies in Mathematics, 1992.
Santa Úrsula University-USU. Master studies in Mathematics Education, 1996.
Barcelona University, Doctor in Mathematics Education, 2002.

Visiting scholar
2006-2007: Rutgers, Rutgers, The State University of New Jersey, Newark
Department of Urban Education (Brazilian Ministry of Education/Capes grant BEX 1313/06-1)

Funded Research

- Professional Teacher Development in Distance Learning Programs (Ministry of Education/CAPES grant BEX1855/99-9, Ministry of Education/SESu, grant 321/2003 and 277/2004).
- Geometry for 11-14 years old students' thought Internet (FAPERJ: Foundation to Research Support of State of the Rio de Janeiro, grant E-26/170.492/2004).
- Digital Inclusion of Youth and Adults (Ministry of Education/SESu grant 293/2005).
- Students interactions and mathematic learning within virtual environments (National Council of Technological and Scientific Development/CNPq grant 311245/2006-4).
- Discourse and mathematic learning of high-school students in virtual environments (Ministry of Science and Technology/CNPq grant 478985/2006-1).

Selected Publications

Bairral, M. A. (in press). Building a community of practice to promote inquiry about geometric: A study case of pre-service teachers interacting online. *Interactive Educational Multimedia*.

Bairral, M. A., & Freitas, I. (in press). Argumentar é Preciso! O Fórum Virtual como Espaço de Discussão na Formação Inicial de Professores de Matemática. *Movimento, 14*.

Bairral, M. A., Powell, A. B., & dos Santos, G. T. (in press). Análise de Interações de Estudantes do Ensino Médio em Chat [Analysis of high school students' online chat interaction]. *Educação e Cultura Contenporânea [Education and Contemporary Culture]*

Bairral, M. A. (2005a). Alguns contributos teóricos para a análise da aprendizagem matemática em ambientes virtuais. *Paradigma, 26*(2), 197-214.

Bairral, M. A. (2005b). Debate Virtual y Desarrollo Profesional. Una Metodología para el Análisis del Discurso Docente. *Revista de Educación*(336), 439-465.

Bairral, M. A. (2004b). Compartilhando e Construindo Conhecimento Matemático: Análise do Discurso nos Chats [Sharing and constructing mathematical knowledge: Discourse analysis of chats]. *BOLEMA: O Boletim de Educação Matemática [BOLEMA: The Bulletin of Mathematics Education, 17*(22), 37-61.

Bairral, M. A. (2004c). Virtual Interaccions, shared teacher's meanings and geometric hipertextual tasks. In J. Giménez, G. E. FitzSimons & C. Hahn (Eds.), *A challenge for mathematics education: To reconcile commonalities and differences* (pp. 288-293). Barcelona: Graó.

Bairral, M. A. (2003a). Aprender a Aprender Geometría en Entornos Virtuales. Análisis de Significados Docentes sobre la Noción de Medida. *Educação Matemática Pesquisa, 5*(2), 81-103.

Bairral, M. A. (2003b). Dimensões de Interação na Formação a Distância em Matemática. *Perspectiva, 27*(98), 33-42.

Bairral, M. A. (2003c). O valor das Interações Virtuais e da Dinâmica Hipertextual no Desenvolvimento Profissional Docente [The value of virtual interactions and hypertextual dynamic in teacher professional development]. *Quadrante, 12*(2), 53-87.

Bairral, M. A., & Giménez, J. (2003). *On line professional community development and collaborative discourse in geometry.* Paper presented at the Joint Meeting of PME and PMENA Honolulu.

Bairral, M. (2002). *Desarrollo Profesional Docente en Geometría. Análisis de un Proceso de Formación a Distancia*. [Teacher Professional Development in Geometry. Analysis of a Distance Training Process]. Doctoral Thesis. Barcelona University. Electronic version: http://www.tdcat.cesca.es/TDCat-1008102-120710/

Bairral, M. A., & Giménez, J. (2004). *Geometria para 3º e 4º ciclos pela Internet*. Seropédica, RJ: EDUR.

Bairral, M. A., & Zanette, L. (2005). *Geometric learning and interaction in a virtual community of practice.* Paper presented at the The Fifteenth ICMI Study Group ¨The Professional Education and Development of Teacher of Mathematics", Águas Lindóia, SP.

Giménez, J., & Bairral, M. A. (2004). *Frações no Ensino Fundamental: Conceituação, Jogos e Atividades Lúdicas*. Seropédica, RJ: EDUR.

Giménez, J., Rosich, N., & Bairral, M. A. (2001). Debates Teletutorizados y Formación Docente. El caso de ¨Juegos, Matemáticas y Diversidad¨ [Teletutorized Debates and Teacher Training. The case of ¨Games, Mathematics and Diversity”]. *Revista de Educación*(326), 411-426.

Other Activities

- -Designer of virtual environments to enrich the E-learning of mathematics: www.gepeticem.ufrrj.br
- -Editor of the Bulletin *GEPEM (*ISSN-0104-9739)
- -Reviewer of the following Journal: *Zetetiké* and *Research in Science Education (Brazil)*, *Paradigma* (Venezuela), and *Quadrante* (Lisbon).
- -Reviewer of Annual Meeting of the National Association of Research in Education (ANPEd), Brazil.

Collaborators in the past 48 Months
Arthur B. Powell, Rutgers University (USA)
Joaquin Giménez, Barcelona University (Spain)

THE NEWARK PUBLIC SCHOOLS
University High School of the Humanities
55 Clinton Place
Newark, New Jersey 07108
973-374-2944
(Fax) 973-351-2003

Marion A. Bolden
State District Superintendent

Roger Leon
Principal

Lucille E. Davy
Commissioner of Education

Regina Sharpe
Vice Principal

January 24, 2007

Dr. Arthur B. Powell
Department of Urban Education
The Robert B. Davis Institute for Learning
Rutgers University
Bradley Hall, Room 156
110 Warren Street,
Newark, NJ 07102

Dear Dr. Powell:

On behalf of University High School or the Humanities, I am pleased to write this letter that authorizes a unique partnership between my school, University High School of the Humanities in Newark, New Jersey, the Boston International High School in Massachusetts, and three cooperating high schools in Brazil, all under the direction of Rutgers University. While the focus and emphasis will be in the area of mathematics, I believe that an incredible cultural exchange will transcend language for the betterment of all involved.

I wish to offer my enthusiastic support for the research project, which you are proposing for the REESE program of the National Science Foundation, called "*e*Math: Diverse High School Students Developing Mathematical Reasoning through Online Collaboration." This project will be a continuation of our pilot project. For a year, we have conducted pilot mathematics problem-solving sessions between students of UHS and the Faesa school in Vitória, Espírito Santo in Brazil via videoconference. Students from both countries were excited to be engaged in discussions of open-ended mathematics problems with their Brazilian counterparts, and all the students look forward to engaging in further discussions. I believe that these pilots greatly benefited our students mathematically, due to the open-ended nature of the problems, as well as enhancing their technological and global awareness, stemming from their use of various online communication tools to discuss and explore mathematics with their counterparts here and abroad.

I commend Rutgers University for this initiative and for working with our school. Through this, students will be able to learn different ways of thinking mathematically and to clearly convey their mathematical thinking to others. Your project will help satisfy a serious void in the field of mathematics education.

Sincerely,

Roger Leon
Roger Leon
Principal

ALL CHILDREN *WILL* LEARN

THE NEWARK PUBLIC SCHOOLS
University High School
55 Clinton Place
Newark, New Jersey 07108
973-351-2010
(Fax) 973-351-2003

Marion A. Bolden
State District Superintendent

Roger Leon
Principal

Lucille E. Davy.
Commissioner of Education

Regina A. Sharpe
Vice Principal

January 24, 2007

Dr. Arthur B. Powell
Department of Urban Education
The Robert B. Davis Institute for Learning
Rutgers University
Bradley Hall, Room 156
110 Warren Street,
Newark, NJ 07102

Dear Dr. Powell:

On behalf of the Mathematics Department of University High School for the Humanities (UHS), I am excited to be a part of this unique partnership between our school and Rutgers University and welcome the opportunity for our students to communicate mathematically with students from Holmdel High School in Holmdel, New Jersey, Boston International School in Massachusetts, as well as from three cooperating high schools in Brazil.

This will be a continuation of our pilot project. For a year, we have conducted pilot mathematics problem-solving sessions between students of UHS and the Faesa school in Vitória, Espírito Santo in Brazil via videoconference. Our students enjoyed the contact they had with the Brazilian students, and all of the students liked finding out about each other's interests. Furthermore, students from both countries were excited to be engaged in discussions of open-ended mathematics problems with their Brazilian counterparts, and all the students look forward to engaging in further discussions. I believe that these pilots greatly benefited our students mathematically, due to the open-ended nature of the problems, as well as enhanced their technological and global awareness, stemming from their use of various online communication tools to discuss and explore mathematics with their counterparts here and abroad.

The pilot project is consistent with the new mathematics curriculum that we have begun implementing school-wide at UHS as of the fall of 2006. The curriculum promotes active learning and teaching centered around collaborative small-group investigations of problem situations followed by student/teacher-led whole class summarizing activities that lead to analysis, abstraction and further application of underlying mathematical ideas. Students will experience mathematics as a means of making sense of data and of problems that arise in diverse contexts within and across cultures.

Engaging students in collaborating on tasks in small groups develops their ability both to deal with and to find commonality in, a diversity of ideas and simulates the future work environment of our students. More importantly, communicating these ideas to each other is the key to the

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Regina A. Sharpe
Vice Principal

mastery of mathematical concepts. It is through communication that students can gauge their understanding and openly acknowledge questions that exist in their knowledge base. Communication is a vital, continuous process that both stimulates thought and leads to mastery. I look forward to continuing our partnership with Rutgers University.

Very truly yours,

Roseann Heyl

Roseann Heyl
Mathematics Chairperson

BOSTON PUBLIC SCHOOLS

BOSTON INTERNATIONAL HIGH SCHOOL
OSCAR SANTOS
Headmaster

Dr. Arthur B. Powell
Department of Urban Education
The Robert B. Davis Institute for Learning
Rutgers University
Bradley Hall, Room 156
110 Warren Street
Newark, NJ 07102

Dear Dr. Powell:

As the Headmaster of the Boston International High School (BIHS), I am pleased to write this letter that authorizes a unique partnership between my school, University High School for the Humanities in Newark, NJ; Holmdel High School in Holmdel, NJ; and three cooperating high schools in Brazil, all under the direction of Rutgers University. While the focus and emphasis will be in the area of mathematics, I believe that an incredible cultural exchange will transcend language for the betterment of all involved.

I wish to offer my enthusiastic support for the research project, which you are proposing for the REESE program of the National Science Foundation, called "*e*Math: Diverse High School Students Developing Mathematical Reasoning through Online Collaboration." I believe that this project will greatly benefit our students mathematically, due to the open-ended nature of the problems, as well as enhance their technological and global awareness, stemming from their use of various online communication tools to discuss and explore mathematics with their counterparts here and abroad.

This collaboration between BIHS and Rutgers offers our students opportunities to learn different ways of thinking mathematically and to clearly convey their mathematical thinking to other students from different parts of the country and the world. Your project will help satisfy a serious void in the field of mathematics education, and we are excited about the possibility of taking part in this research study.

If you have any questions or concerns, please feel free to contact me at the school at (617) 635-9373 or on my cell phone at (617) 590-4553.

Sincerely,

Oscar Santos
Headmaster
Boston International High School

25 Glen Road, Jamaica Plain, Massachusetts 02130 • 617-635-9373 FAX 617-635-8224

HOLMDEL TOWNSHIP SCHOOL DISTRICT

"A COMMITMENT TO EXCELLENCE"

Office of the Assistant Superintendent
Curriculum and Instruction
4 Crawfords Corner Road
Holmdel, NJ 07733
tel: 732-946-1800
fax: 732-946-1875

January 29, 2007

Dr. Arthur B. Powell
Department of Urban Education
The Robert B. Davis Institute for Learning
Rutgers University
Bradley Hall, Room 156
110 Warren Street,
Newark, NJ 07102

Dear Dr. Powell:

On behalf of the Holmdel School District, I am pleased to write this letter that authorizes a unique partnership between Holmdel High School, University High School of the Humanities in Newark, the Boston International High School in Massachusetts, and three cooperating high schools in Brazil, all under the direction of Rutgers University. While the focus and emphasis will be in the area of mathematics, I believe that an incredible cultural exchange will transcend language for the betterment of all involved.

I wish to offer my enthusiastic support for the research project, which you are proposing for the REESE program of the National Science Foundation, called "*e*Math Diverse High School Students Developing Mathematical Reasoning through Online Collaboration." I believe that this project will greatly benefit our students mathematically, due to the open-ended nature of the problems they will be doing. In addition, participation in the project will enhance our students' technological and global awareness, stemming from their use of various online communication tools to discuss and explore mathematics with their counterparts here and abroad.

I commend Rutgers University for this initiative and for working with Holmdel High School. Through this project, our students will be able to learn different ways of thinking mathematically and they will be able to clearly convey their mathematical thinking to others. Your project will help satisfy a serious void in the field of mathematics education.

Sincerely,

Judith H. Landis

Judith H. Landis, Ed.D.
Interim Assistant Superintendent of Schools

UFRuralRJ - Instituto de Educação
Departamento de Teoria e Planejamento de Ensino
Rodovia BR 465 – km 7
Seropédica – Rio de Janeiro – Brasil
Cep. 23851-970
Telefone/fax: (0055-21) 26821841
mbairral@ufrrj.br

Rio de Janeiro, 2nd January 2007

Dr. Arthur B. Powell
Department of Urban Education
The Robert B. Davis Institute for Learning
Rutgers University
110 Warren Street,
Newark, NJ 07102

Dear Dr. Powell:

It is a pleasure to participate as a Co-Principal Investigator in the research project "*e*Math: Diverse High School Students Developing Mathematical Reasoning through Online Collaboration". This research will be developed in the Department of Urban Education at Rutgers University with Dr. Arthur B. Powell and other investigators.

Given my research experience in analyzing the growth of pedagogical content knowledge of teachers engaged in online chat environments, I am particularly interested in collaborating on building a framework for analyzing the online mathematical discussions of small groups composed of high school students. This research is important for understanding how to improve the mathematical reasoning of learners,

Dr. Marcelo Almeida Bairral

FAESA
EDUCAÇÃO SUPERIOR

Vitória, 11 January 2007

It is a pleasure in participate as with our students in the research project "*e*Math: Diverse High School Students Developing Mathematical Reasoning through Online Collaboration." This research will be developed in the Department of Computer Science at Faculdades Integradas Esp'rito-Santenses – FAESA with the Msc Maria Alice Veiga Ferreira de Souza and other investigators. We have arranged for video conferencing with computers in the same place. Our students enjoyed and learned a lot from last year's pilot project. We look forward to continuing our collaboration.

Prof. Erthelvio Monteiro Nunes Jr.
Director