

# The Impact of Early Algebra on Later Algebra Learning

NSF-REESE #REC-0633915

## Year 3 Activities Report - 2009

### **Part One: Data collection**

This year we have concentrated on increasing the number of participants in the study. Families of students in the experimental group (those who had participated in our Early Algebra activities in grades 3 through 5) were contacted so that we could administer the assessment and collect their MCAS scores at the end of 7<sup>th</sup> and 8<sup>th</sup> grade. As was the case in 2008, we also intensively recruited students in the experimental and the control groups to participate in an Algebra Summer Camp (see description later in this report). Summer camp activities allowed us to assess the achievements of the experimental and control groups, before and after participating in more advanced algebra activities offered by members of the research team.

The assessment used in 2009 has been modified from the assessment given to the students in fifth grade. Some items from the original assessment were dropped and others were added to focus on more advanced concepts and tools that are part of the middle and high school curriculum. However, in the 2009 assessment some of the same items have been used since third grade. As a result, we have been able to track the progress on particular items from third grade to seventh and eighth grade, providing a wonderful opportunity for tracking of students' progress and for comparisons.

During the 2008-2009 school year we obtained data from 18 students in the experimental group (Experimental Cohort 1 and Experimental Cohort 2 groups) and 46 in the control group. In addition, we observed mathematics classes at schools attended by students in the experimental group. Unfortunately, the algebra content in these classes proved to be insufficient to allow meaningful analyses of individual students' achievements, strategies, and classroom participation as had been intended. This is one of the reasons we developed the Algebra Summer Camp, where data collection before, during, and after camp became a core activity in the project. In cases where students had not attended the 2008 Summer Camp, written assessments were collected from students at their home. Finally, we were able to collect MCAS scores from 54 students.

# The Impact of Early Algebra on Later Algebra Learning

NSF-REESE #REC-0633915

## Part Two: Partnerships

### 1. Partnership with the Curriculum Resource Center (CRC) of the Department of Education at Tufts University

The Early Algebra project has partnered with the Curriculum Resource Center (CRC) of the Department of Education at Tufts University. The CRC provides creative and technical support for our Early Algebra Project under many facets. One facet is the production of a documentary video on Early Algebra that has involved carrying out interviews with colleagues in the field from Teachers College, Columbia University in New York (Herb Ginsburg), the University of Massachusetts – Dartmouth (Maria Blanton), and TERC in Cambridge, Massachusetts (David Carraher). The videos will highlight the longitudinal work that we have been doing in our Early Algebra since 2003, when students in the experimental group were first introduced to algebra in third grade. Another facet of our Partnership with the CRC is the intensive development of the *Early Algebra Teacher Resources* website. These projects will be described in greater detail later in this report.

### 2. Partnership with the Center for Engineering Education and Outreach (CEEEO)

The Early Algebra team has partnered with a group of students, faculty, and researchers at the Center for Engineering Education and Outreach (CEEEO) at Tufts University to develop a series of ten activities that integrate algebra and hands-on engineering exercises. These activities provide students with a broader understanding of algebra concepts and involve useful applications of this knowledge with real-life engineering scenarios. These activities were implemented during the 2009 Algebra Summer Camp.

### 3. Partnership with Boston Public School's Mission Hill School

2009 has brought another year of our project's partnership with the Mission Hill School in Boston and the Boston Public School system (BPS). With our Algebra Summer Camp, we work with the principal at the Mission Hill School to coordinate the use of the school for our summer camp and promote the Algebra Summer camp.

# The Impact of Early Algebra on Later Algebra Learning

NSF-REESE #REC-0633915

The camp constitutes an opportunity for Boston area students, including not only students from the experimental group but also any students who attend the same grade levels as our experimental group students in schools throughout the city of Boston, to gain a greater depth of algebraic understanding. In both 2008 and 2009 camps, BPS provided all breakfast and lunch for the students and our team members were certified under the BPS food safety standards.

## **Part Three: Second Year of Algebra Summer Camp**

2009 brought our second year of algebra summer camp. [LINK: Algebra and LEGO Robotics summer camp](#) provided an in-depth look at the learning of not only a portion of our experimental cohort students but a rich group of control students at the same grade levels. Our teaching-research team was comprised of Tufts faculty, undergraduate students, graduate students, and PhD candidates. Students were from the Department of Education, the Department of Mathematics, and the Center for Engineering Education and Outreach (CEEEO). Each algebra activity was videotaped and are being analyzed to investigate the successes and challenges the students were facing with the material and how our experimental cohort compared and interacted with the control group.

- We had an increase in enrollment by 21 students, from 32 students in 2008 to 53 students in 2009.
- We had three returning experimental cohort students from the 2008 camp, and four experimental cohort students that had previously been out of touch came to camp.
- The camp was offered for graduating sixth, seventh, and eighth grade students.
- A total of 31 algebra activities and 10 engineering activities related to algebra were developed and implemented during the two weeks of the summer camp.
- Algebra activities were taught from 9am to 12pm. In the afternoon, from 1pm to 3pm, students worked on engineering tasks with the team from the CEEEO.
- Spring 2009 was spent on the design of algebra activities and the engineering activities for camp, carefully matching the algebra the students would be learning in the morning to the hands-on engineering activities they would be engaged in during the afternoon.

# **The Impact of Early Algebra on Later Algebra Learning**

**NSF-REESE #REC-0633915**

Our summer camp allows for data collection that addresses the core goal of evaluating the impact of Early Algebra on later algebra learning. It is also an opportunity to build upon the research group's expertise that is relevant to the practice of teaching and to the needs of students in the Boston area.

Participants in the summer camp were given an algebra assessment before and after participating in the camp activities. The pre-assessment data for experimental group students are merged with the data collected with individual experimental group at participants at the same grade level who did not enroll in the summer camp. Other participants in camp constitute the control group.

Results on the pre-camp and post camp assessment allows for comparisons between the experimental and control groups, which are relevant to the evaluation of the impact of Early Algebra on later algebra learning. Results in the pre-assessment for the experimental group are compared to those of the control group for an overall evaluation of their achievements and potential differences before they participate in summer camp activities. Scores in the post-camp assessment by the experimental group are then compared to those of the control group to evaluate how the experimental group gains in the post-camp assessment compared to the gains by the control group.

Below are pictures of three of the students that we have been working with and following since 2003, when they were third grade students (pictures on the left). The pictures on the right show the same students during camp 2009, after having finished eighth grade.

# The Impact of Early Algebra on Later Algebra Learning

NSF-REESE #REC-0633915



## Part Four – Website development of Early Algebra Resources for Teachers

The *Early Algebra Resources for Teachers* website is tailored for teachers who want to be informed about Early Algebra and to implement algebra activities in their classrooms. While still a work in progress and with some sections under construction, the website is already available at: <http://go.tufts.edu/earlyaglebra>

- On the website teachers can:
  - o Read about Early Algebra implementation by other teachers around the world.
  - o Request access to watch videos of our Early Algebra activities being taught in the classroom to see first hand how the activities were implemented.
  - o On the website the algebra activities our team has developed over the years are organized by searchable keyword tags. These tags are categorized by

# The Impact of Early Algebra on Later Algebra Learning

NSF-REESE #REC-0633915

Activity Type, Process, and Mathematics Concept. Examples of these keywords can be seen in the image below taken from the website.

- The activities are also categorized by suggested grade level(s) to provide another way teachers can easily find activities to fit their classroom.




The screenshot shows the 'Early Algebra Teacher Resources' website. The header is orange with the title 'Early Algebra Teacher Resources' and a geometric logo. A dark red navigation bar contains links: Home, Implementations by Teachers, Classroom Activities, Project Videos, Contact Us, View, and Edit. Below the navigation bar, the breadcrumb 'Home > Classroom Activities' is visible. The main content area is titled 'Classroom Activities' and is divided into two sections: 'Activity Type' and 'Process'. The 'Activity Type' section lists: Everyday Context, Hands-On Activity, Math Game, Full Class Discussion, Science Context, and Small Group Work. The 'Process' section lists: Data Collection, Production of Equations, Production of Graphs, Production of Stories, Production of Tables, Compare and Contrast Functions, Interpretation of Equations, Interpretation of Graphs, Interpretation of Stories, and Interpretation of Tables.


- Once the teacher clicks on an activity they are able to review that activity directly on the website and then chose to download the file, complete with the lesson plan and handouts.

# The Impact of Early Algebra on Later Algebra Learning

NSF-REESE #REC-0633915

## Early Algebra Teacher Resources



Home Implementations by Teachers Classroom Activities Project Videos Contact Us  View Edit

[Home](#) > [Classroom Activities](#) > [Compare and Contrast](#)

### Compare and Contrast

Click [here](#) to download lesson.

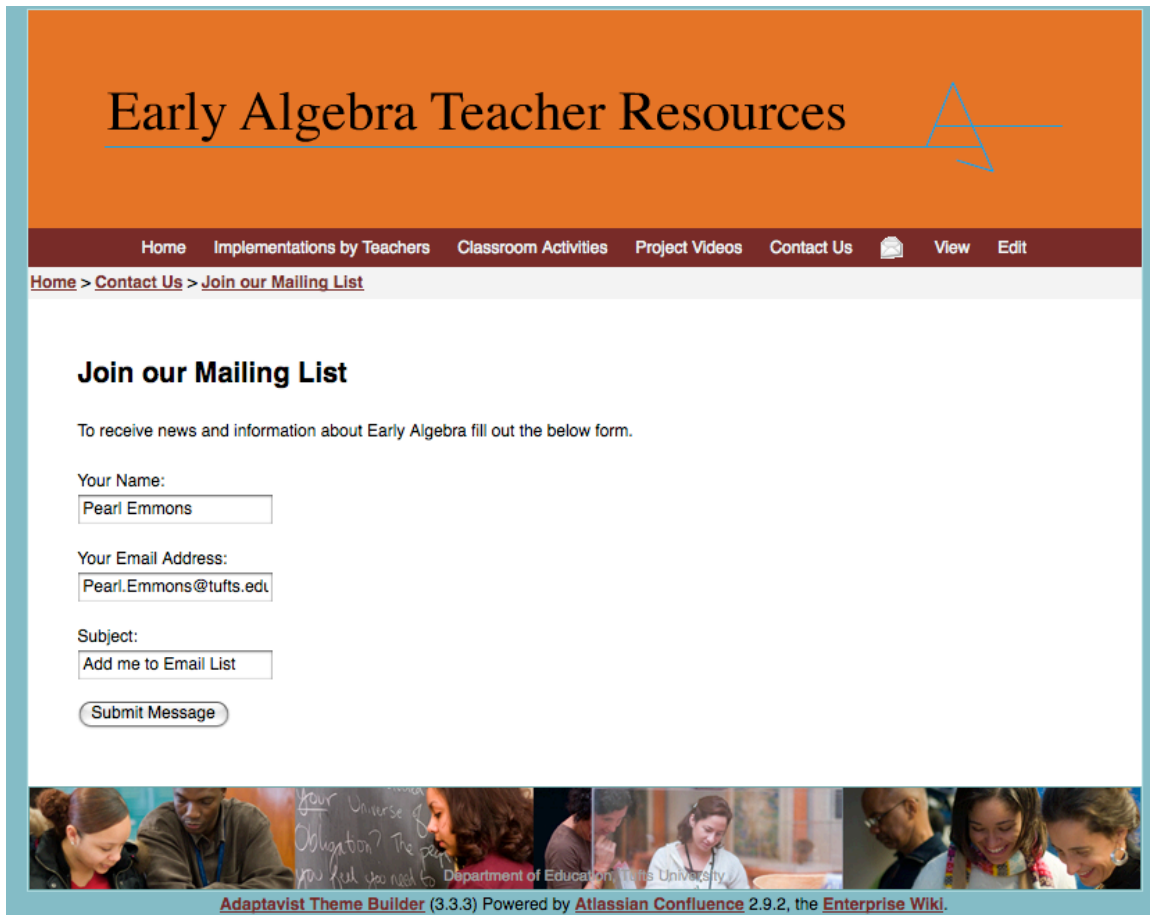
Summary	Students will identify the $y$ -intercept and slope using equations and then use that data to create corresponding tables and graphs.
Goals	1. Students will discover how different $y$ -intercepts affect a function
Materials	Notebooks, overheads, whiteboard markers
Duration	45 minutes
Keywords	Compare/Contrast Functions Linear Functions Production of Graphs Production of Tables Slope Small Group Work

- Another feature of the *Early Algebra Teacher Resources* website is the mailing list. Teachers can choose to join an Early Algebra mailing list that will add them to a list serve managed by the Department of Education at Tufts University. The mailing list will provide teachers with a way to receive news about new Early Algebra publications, curriculum materials, news, and opportunities.



# The Impact of Early Algebra on Later Algebra Learning

NSF-REESE #REC-0633915



The screenshot shows the 'Early Algebra Teacher Resources' website. The header is orange with the title 'Early Algebra Teacher Resources' and a blue geometric logo. A dark red navigation bar contains links: Home, Implementations by Teachers, Classroom Activities, Project Videos, Contact Us, View, and Edit. Below the navigation bar is a breadcrumb trail: Home > Contact Us > Join our Mailing List. The main content area is white and features a 'Join our Mailing List' section. It includes a brief instruction: 'To receive news and information about Early Algebra fill out the below form.' The form has three input fields: 'Your Name:' with 'Pearl Emmons', 'Your Email Address:' with 'Pearl.Emmons@tufts.edu', and 'Subject:' with 'Add me to Email List'. A 'Submit Message' button is at the bottom of the form. Below the form is a horizontal strip of four small images showing people in a classroom setting. At the very bottom of the page, there is a footer: 'Adaptivist Theme Builder (3.3.3) Powered by Atlassian Confluence 2.9.2, the Enterprise Wiki.'

## Part Five: Implementation of Early Algebra by Teachers in Argentina

In the Spring of 2009 one of our team members (Bárbara Brizuela) taught an Early Algebra course in Bariloche, Patagonia, Argentina for pre-service and in-service mathematics teachers as well as professors from the department of mathematics at Universidad Nacional del Comahue, Centro Regional Universitario Bariloche. As part of this course, students in the class had to implement at least three Early Algebra activities in their own classrooms, with small groups of students, or in their colleagues' classrooms. These implementations were video recorded. This allowed for later analyses of the interventions. Video documentation, final papers, and powerpoints made by the course participants will be made available through our *Early Algebra Teacher Resources* website as a way to share with other teachers what colleagues have done in their own classrooms. This may prove to be more helpful to them than researchers' accounts and reports.



# The Impact of Early Algebra on Later Algebra Learning

NSF-REESE #REC-0633915

## Part Six: Presentations by Researchers on the Project's Achievements

Aside from sharing news and information with others at Tufts University and with our partners, data from the 2008 algebra summer camp also served as the basis for the courses and presentations to the international research and educational community, as described below.

During the Spring of 2009, Bárbara Brizuela, as a Visiting Professor (Fulbright Scholar) at the Universidad Nacional del Comahue, Centro Regional Universitario Bariloche. Bariloche, Patagonia, Argentina, taught a course (“Enseñanza y aprendizaje de álgebra temprana”: Teaching and learning of early algebra) for in-service and pre-service Mathematics teachers in the Mathematics Department.

Bárbara Brizuela also gave the following presentations in Argentina, México, Spain, and Brazil:

Brizuela, B. M. (2009, April). El uso de notaciones como herramientas en la resolución de problemas [The use of notations in the context of solving problems]. Invited presentation at Universidad Nacional del Comahue, Centro Regional Universitario Bariloche. Bariloche, Patagonia, Argentina.

Brizuela, B. M. (2009, May). Enseñanza y aprendizaje de algebra temprana [Teaching and learning of early algebra]. Invited two-day Workshop for in-service teachers. Secretaría de Promoción Científica, Ministerio de Ciencia y Tecnología, Gobierno de la Provincia de Córdoba, Argentina.

Brizuela, B. M. (2009, August). La enseñanza y aprendizaje del álgebra temprana en niños de 7 a 9 años de edad [The teaching and learning of early algebra in children 7 to 9 years old]. Invited presentation at Universidad Pedagógica Nacional, Ajusco. México DF, México.

Brizuela, B. M. (2009, September). El uso de las notaciones en la solución de problemas matemáticos en niños de primaria [The use of notations while solving mathematical problems among elementary school children]. Invited presentation at Universidad Autónoma de Madrid, Facultad de Psicología. Madrid, Spain.

Brizuela, B. M. (2009, October). As notações no contexto da resolução de problemas matemáticos [Notations in the context of solving mathematical problems]. Invited presentation as part of “Education Week” organized by the Victor Civita Foundation with the purpose of celebrating teachers’ day in Brazil. São Paulo, Brazil.

# The Impact of Early Algebra on Later Algebra Learning

NSF-REESE #REC-0633915

Finally, the paper *Slope as a procedure: The impact of axis scale*, by Mary Caddle and Darrell Earnest, was accepted to and presented at the 33rd Conference of the International Group for the Psychology of Mathematics Education (PME). This paper focused on the work that one of the groups at camp did while working on a problem involving a linear function, and the consequences of representing the same function on different coordinate planes with varying scales on the axes. The paper showed the richness of the mathematical debate between students, as well as the importance of instructional decisions related to representations of functions.

The paper showcased the depth of the algebra summer camps. In addition, while no comparisons between experimental cohort and control students can be made on the basis of the classroom episode, the episode and the paper do show the strong algebraic reasoning and argumentation skills exhibited by two experimental cohort students who had instruction in Early Algebra during their elementary school education. The paper also validates the worth of video of classroom interactions, as without video the details of the discussion could never have been examined so closely. The video was also used as part of the presentation at PME, allowing conference attendees to see the students' actions along with their words as they interacted with the representations of function, and also allowing attendees to see the intensity of student discussion.

## **Part Seven: Documentary Video on Early Algebra**

The Early Algebra video project being produced by the CRC at the Department of Education at Tufts University is a four-part video on the work that this team has done on Early Algebra as well as Early Algebra research in mathematics education as a whole. The video illustrates how Early Algebra is implemented in the classroom, the knowledge we gain about student thinking through this kind of research, and what Early Algebra colleagues are doing to help make Early Algebra a reality in elementary school classrooms.

In Part I the video gives an overview of what Early Algebra is and how it works. Part II demonstrates three of our Early Algebra activities in a third grade classroom, with detailed descriptions of how the teacher is able to guide the children towards understanding the underlying algebra in the problem they are discussing. In Part III the

# **The Impact of Early Algebra on Later Algebra Learning**

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**NSF-REESE #REC-0633915**

video goes in depth into how our Early Algebra research shows the depth and complexity of the mathematics that children are capable of understanding at an age that was previously considered too young for these kinds of tasks and problems. Finally, Part IV takes a look at the work we have been doing on documenting the impact of Early Algebra on later algebra learning.