

Research On
Mega-Math: Discrete Mathematics
And
Computer Science for Children

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Abstract

The objective of the subcontract was to provide further research on the approach to mathematics education embodied in the workbook "This is Mega-Mathematics!" essentially produced under the subcontract and its preceding informal (alas!) cooperative arrangements. The workbook is now widely and freely distributed on the Internet under the copyright of the Los Alamos National Labs. This research was to consist of: (1) the development and dissemination of materials, (2) experimentation with use of the materials in classroom visits and other events, (3) communication of the ideas embodied in the materials to various forums concerned with mathematics education reform, (4) the development of connections to the computer games industry, (5) the development of new workbook-type materials, (6) publications, (7) the development of connections to Science Museums, (8) the development of uses of the Internet to make MegaMath materials and ideas available through that medium, (9) the stimulation of and coordination with other projects in mathematics education reform. All of these objectives have been accomplished in what should be regarded as one of the most interesting and cost-effective projects ever undertaken in mathematics education, a testimony to the vision and creative imagination of the Los Alamos Labs.

1 Background and Overview

The MegaMath Project centers on new approaches to mathematical science education that were pioneered by the principal investigator and described in the paper "Computer SCIENCE in the Elementary Schools" (*CBMS Issues in Mathematics Educ.* 3 (1993), 143-163.) The contract was for research work to develop and promote these materials and perspectives that

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give an important role to computer science topics, and computer technology-based accessibility, in mathematics education generally. Much of the contract work was concerned with the development, elaboration and dissemination of the workbook *This Is Mega-Mathematics!*, coauthored by the principal investigator Mike Fellows and by Nancy Casey (a long-time collaborator now employed by the C-3 Group of the Los Alamos Labs).

2 Contract Objectives and Accomplishments

In this section we describe our accomplishments towards each of the objectives listed in the Statement of Work.

2.1 Development and Dissemination

The workbook *This Is Megamathematics!* (approx. 100 pp.) has been

- written, revised and corrected
- printed, with more than 1,200 copies distributed to more 400 interested individuals, and in bulk to organizations such as DIMACS, the Family Math program of the Lawrence Berkeley Laboratories, and Mathematics Departments actively pursuing projects in mathematics education reform
- refined and demonstrated in classrooms, including classrooms in Idaho, British Columbia, Michigan, New York, Montana, Wisconsin, Washington, Peru, El Salvador, and New Zealand during visits to these states and countries by the principal investigator and Nancy Casey
- adapted to hypertext format and made freely available on the world wide web
- translated in part into Spanish

2.2 Experimentation with Classroom and Other Presentations

A substantial amount of effort was directed to trying out the materials in classrooms and at events such as Family Math Nights at elementary schools that involved also parents. Other forums for presenting and experimenting with the materials and developing them further included Cub Scout and Girl Guide events and leadership networks, and events with university students. The principal investigator and students supported by the contract

generated over 400 hours of such activities in British Columbia. This is important for developing a community of teachers and others familiar with the materials. This has had a substantial impact in B.C., particularly since Victoria is the capital city. It has led to the principal investigator being invited to serve on the Province mathematics curriculum committee.

2.3 Communication at Forums on Mathematics and Computer Science Education

MegaMath has been the subject of presentations and classroom demonstrations by the principal investigator during the contract period at the following forums:

- Columbia Teacher's College
- Education Department, Rutgers University
- Mathematics and Computer Science Departments Joint Colloquium, University of Washington
- Washington Middle School, Seattle
- Mathematics and Education Departments Joint Colloquium, University of Calgary
- New Mexico Vocational-Technical Institute Colloquium, Albuquerque, New Mexico
- Mathematics Department, University of El Salvador, San Salvador
- Mathematics Department (and demonstration for visiting school classes), University of El Salvador, San Miguel
- Mathematics Department, San Marcos University, Lima, Peru
- Demonstration and lecture at Collegio Gauss, Lima, Peru
- Mathematics Department Colloquium, University of Illinois at Chicago
- 1994 SIAM Discrete Mathematics Conference, Special Session on Mathematics Education

2.4 Computer Games

MegaMath was described in an invited talk by the proposer at the 1994 Computer Games Developers Conference. A very large number of requests for Megamath materials were generated by this presentation, and it appears that the ideas have been successfully transmitted to this potentially powerful audience. It was originally envisioned that the contract would support some prototype games to be developed. Effort was subsequently shifted to game concepting and design, and the communication of these ideas to professional game developers (who have the massive resources needed for commercial game development). In other words, it seemed we would have greater impact by focusing on the design possibilities for games based on MegaMath ideas and materials, and the communication of these ideas to the game development community. This seems to have been quite successful: new commercial products (e.g. by Broderbund) that are about to be released have made use of these ideas.

2.5 Additional Materials

Some new materials have been developed, but rather than further separate workbooks, most of this has been incorporated into *This Is MegaMathematics!* (or the electronic version on the web, which is more extensive than the printed workbook).

2.6 Publications

The main new publication resulting from the contract work is the paper: "What About Content? A Critical Review of the NCTM Standards and a Job for Discrete Mathematics," coauthored by Fellows and Casey. This is an effort to connect the MegaMath approach to what is currently a very important initiative in mathematics education reform. (This is to be published by DIMACS / Conference Board of the Mathematical Sciences).

2.7 Science Museum Connections

In Canada, almost all universities host Science Summer Camps for elementary and jr. high students, and the local organizations that run these camps have an umbrella national organization. MegaMath materials have been supplied to the relevant (student) organization at the University of Victoria. In the summer of 1994, their presentation of these materials won first prize in the *New Presentation Ideas* competition at the annual meeting in Ottawa — this had led to many requests for MegaMath materials, which are now widely used in these science summer camps.

2.8 Use of the Internet

The hypertext adaptation of *This Is MegaMathematics* that is now freely available (and a very popular item, with several thousand copies of the workbook file having been downloaded in the last 6 months) has been one of the primary focuses of the contract, and can be regarded as one of its principal products (particularly as it incorporates much of the other development work results).

2.9 Coordination and Stimulation of Other Projects

Mega-Math materials are now being regularly used by teacher in-service training institutes organized by

DIMACS, Rutgers University, New Jersey

Family Math, Lawrence Berkeley Labs

Mathematics Department, University of Illinois at Chicago

3 Publications

1. Nancy Casey and Michael Fellows. *This Is Mega-Mathematics!*. Copyright: Los Alamos National Labs. Freely available on the Internet.
2. Nancy Casey and Michael Fellows. What about content? A critical review of the NCTM standards and a job for discrete mathematics. To appear in *Proceedings of the DIMACS Workshop on Discrete Mathematics and Mathematics Education Reform*, 1995.

4 Summary

The Mega-Math Project has aimed to function as a catalyst by generating and exploring new ideas about mathematical science education, and injecting these ideas into various contexts where they can inspire and be incorporated into other projects. It has been extremely successful in this, all things considered. The workbook consists of a selection of really deep and wonderful topics that have never before been considered as suitable for children. The presentation is in a format that teachers are familiar with and can use. It is now beautifully

presented on the world wide web, and thus is easily available to a wide audience at the grass-roots level, where it has apparently been eagerly seized.

The potential of these kinds of mathematical content for the design of computer games has been brainstormed nicely with the support of the contract and the ideas fairly successfully injected into the consciousness of the computer games industry. The presentation at the Computer Games Designers Conference was a huge success in terms of generated interest. The message was that content ideas matter for good game design, and that this content (examples in the workbook) is great for kids. This appears to have been heard. (There was apparently some surprise that the ideas were being given away for free!)

The ideas of Mega-Math have also been widely presented to academic forums in various combinations of Mathematics, Computer Science and Education. They appear to have contributed to a number of efforts in revising official school mathematics curricula, in particular in British Columbia, Montana, California and New Jersey. Mega-Math materials are now being used by the Family Math Network, which is international in scope. We have contributed to the published discussion of fundamental ideas in mathematics curriculum design. The fairly radical ideas of Mega-Math, which center on viewing mathematics education through the lens of ideas of established importance in literacy education, and powered by the mathematical content of computer science, have been successfully injected into these discussions; the effect may be slow, but we will see.

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