Maryland Virtual High School of Science & Math

Proposal
to the
NATIONAL SCIENCE FOUNDATION

Directorate for Education and Human Resources
Division of Materials Development, Research, and Informal Science Education
APPLICATIONS OF ADVANCED TECHNOLOGIES PROGRAM

to Develop a

Maryland 'Virtual High School of Science and Mathematics'

Revision
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Project Summary

The goal of the proposed project is to establish a community of scientists, teachers and learners who are investigating real world problems in science using a variety of innovative tools. These tools will include computational tools which will allow participants to model scientific processes as well as communication tools which will allow participants at multiple locations to work together, to share information, and to retrieve information from remote sources. Implementation of the 'virtual high school' project will help us determine how peer and mentor support, additional technical advice and technical resources, and a source of problem-solving activities related to science and mathematics, as well as coaching by master teachers can help teachers adapt to new technology and methods, and help to equalize the learning opportunity for all levels of students at diverse schools.

Preparing students to "do" science in the real world of the future means guiding them in "doing" science now. This project entails bringing to the classroom the same team problem solving, technology rich approaches currently used in research and business. Computational science has become a powerful paradigm to complement other approaches. Computational tools, ranging from spreadsheets on microprocessors to advanced molecular modeling tools on supercomputers, are allowing scientists to model processes too costly or impossible to investigate in other ways.

This project will support the creation of the 'virtual high school' in several ways. Interdisciplinary problems requiring many levels of expertise and solvable with computational techniques across a communication network will be developed by a team of teachers who are interested in using these problems in their classroom. Workshop training will enable these teachers to lead their students and other teachers through the team building and content learning necessary to create computational models. In addition, schools will be given access to the Internet to form a virtual community built around interest in common problems, and enriched through access to Internet resources. The common problems will include educational methodology, issues revolving around network management, and of course theme based investigations using computational science. Subcommunities of interschool research teams, student-staff system management teams, and many groups evolving from common interests will be encouraged.

As the project matures, the schools in Maryland will be linked together solving 'real world' problems. Students from different age groups, with varying mathematical and scientific backgrounds, with all levels of computer expertise, and from schools geographically distant from one another will collaborate on problems of common interest. Students will no longer wonder why they are learning disjointed facts nor will they wait impatiently to see the uses of their high school education. Instead, they will be *motivated* to learn because they are solving 'real' problems *now*.

Proposal to the National Science Foundation to Develop a Maryland 'Virtual High School of Science and Mathematics'

The Chesapeake Bay study group has an appointment to meet at 10:00 am. Tasks determined during the last meeting have been carried out during the previous few days. Preliminary reports were shared and read by the team yesterday. A teacher who is an expert in biochemistry, another versed in Bay ecosystems, and a third experienced in mathematical modeling are slated to attend. A guest from the Environmental Protection Agency is also expected to attend. One by one, the team members enter the room and greet each other. A lively discussion ranges from stream pollution data collected by one student to a background technical report provided and summarized by another. Together the team watches a computer simulation of the decline of oyster beds, which had been corrected and enhanced by two other students using this new information. A graphical display of the simulation, updated by others, leads to questions. The EPA scientist jumps in with new information on nitrogen loading and asks more questions. Together the team strategizes how to answer these questions. Based on this strategy, new tasks are assigned. One student volunteers to make sure that another mentor, a parasitologist from the university, gets the new information and will be able to attend the next meeting.

In the above (hypothetical) meeting, the Maryland students and teachers were located in schools from Garrett to Wicomico counties - their work room was a *virtual* one, created by internetworking, collaborative tools, and compressed video. Doorways from this room lead to a library of material on the subject and to government and university data bases. These students, and the students who will participate in the proposed project, were practicing <u>now</u> the communication, collaboration, and problem solving skills they will use in the <u>future</u> in the global community.

What steps were taken that finally resulted in the scenario above? First, teachers throughout the state were given the opportunity and support to create activities which would implement recommendations of standards groups such as the National Council of Teachers of Mathematics and the National Science Teachers Association using the paradigm of computational science. These teachers then built on their past successful experience in concept development and analysis in a wide variety of scientific disciplines. They supported each other with information and pointers to outside expertise in selecting the tools which would allow coupling transparent communication with modeling, computation, and visualization. Initial collaboration entailed teachers enhancing each other's effort through email and conference groups as they carried out activities that they had jointly designed in initial workshops. They then began to develop an on-line archives of activities, resources and pointers to other helpful databases. As they became more experienced with both telecommunications and the computational activities, more sophisticated communications choices were available and were used when appropriate.

This scenario would best be supported by a system of hub schools initially connected to the Internet through the regional network, SURANet, with <u>full</u> access for additional schools, as the project develops, provided through wide area network connection or high speed slip dial-in access to the hub schools. The initial hub schools will be provided with Internet access through dedicated 56kbs lines by September 30, 1994. During the summer of 1994, teachers will be able to communicate through METNET, an electronic state-wide bulletin board service (BBS) available to all teachers in Maryland through an 800 phone number, or through accounts provided by the University of Maryland. Modes of additional connectivity will be influenced by how the landscape of choices changes in the next few years. All teachers in Maryland will be able to access materials developed by the virtual high school through METNET, as well as information servers maintained by University of Maryland and by Montgomery Blair high school.

The process of gathering resources and publishing student collaborations has already begun. A preview of student work on ecosystems and modeling, may be found through Mosaic world wide web link http://goober.mbhs.edu/~mverona/current.hmtl. Pointers to other relevant resources are included.

1.0 Project Objectives

The proposed effort seeks to form a 'virtual high school' on the Internet where students at locations throughout Maryland can learn science and mathematics, by participating in collaborative application projects using computational science, guided by teachers and other mentors. The project proposes a *systemic change* in the delivery of interdisciplinary mathematics and science education, and has three participant groups:

- The Science, Mathematics and Computer Science Magnet Program of Montgomery Blair High School, which has developed a collaborative teaching approach based upon computational science applications; this approach seeks to:
  = Involve a proactive, collaborative approach to planning and using computational science involving Maryland schools, teachers and students and focusing on teacher ownership during all phases
  = Apply an approach consistent with the Maryland School Performance Program (i.e., a group approach to process-oriented problem solving) to all levels of students located in a variety of school environments
  = Support computational science applications with Internet based data, tools, and communication resources with which the magnet program has extensive experience.

- Interested high school teachers and students in Maryland who will be involved as collaborative participants in the 'virtual high school'; the project proposes to:
  = Establish an on-going process for engaging and involving teachers, schools, and students in Internet based computational science problem solving
  = Focus on the ability of teachers to mentor peers through online focus groups, video, and site based coaching
  = Investigate the ability of students to contribute to the community as part of a research team, through expertise in system management, and through mentoring peers who join the community from their own school and other schools
  = Result in resources such as printed teacher and student guides to sample investigations, enriched by online archives of annotated student work

- Government agencies, business groups, network groups who have a concern for the ability our schools to respond the promise of technology will be enlisted to:
  = Serve on an advisory board which will inform the project of multiple perspectives and opportunities for collaboration.
  = Provide resources such as the networking know-how of SURANet, the computational science expertise of National Institute of Health and National Institute of Science and Technology, the databases of United States Geological Survey, National Center for Atmospheric Research, National Oceanic and Atmospheric Administration, and the software and computer time of the National Education Supercomputer and others
  = Supply surplussed or new equipment, over and above that provided directly by the project, to the schools most in need
  = Alert and encourage employees of opportunities to mentor teachers and students in the area of the scientists' expertise

A systematic evaluation process will be carried out during all phases of the effort to ensure that the proposed project addresses questions involving project design

- What are effective means of initiating, carrying out and monitoring a project driven by teacher collaboration in multiple locations? Does telecommunications provide a cost-effective means of implementing collaborative projects for resource–limited schools? What mix of in person meetings and online contact is appropriate to carry out a collaboratory/mentoring approach between teachers /students? How can working groups from different schools best be established?
- Can guidance and peer support in the use of techniques such as computational science activities be extended to more teachers, students and schools (in a broader geographic area) in an effective manner? What lessons can be learned to enhance further uses of the Internet in such collaborative projects among schools?
- What hardware/communications configuration and on-going technical support is required for teachers to participate in a collaborative state-wide approach? What methods can be used which fit with budget constraints of typical school districts?
- How has the influx of these technologies changed the way that teachers and students spend time in the affected classes? Has change migrated to other classes?

student learning:
- Can an approach involving computational science modeling (planned and carried out on a networked multi-locational basis) prepare students for real-world applications of math and science? Is such an approach applicable for different levels and backgrounds of students?
- Can students learn new mathematical and scientific concepts in an involved, participatory manner through problem-solving techniques?
- Can non-traditional delivery methods be used to help students learn new math and science concepts in a cost-effective manner?

and materials development
- What combination of printed materials, online archives, and pointers to other resources will best document the project and aid in dissemination?

The proposed effort will take advantage of a number of related efforts being carried out in Maryland to provide a coordinated approach to using information technology, including:

- The Governor's Information Technology Board, created in 1993 as a policy group to assess user needs and establish an integrated approach to implementing information technology in Maryland
- Announcement of a program by the Bell Atlantic to interconnect every high school and college in the state with fiber-optic cable
- Initiation of a project to provide better regional and statewide access to libraries (Project Seymour - now Sailor), including sharing of scarce materials
- Upgrade of METNET, Maryland's electronic service for teachers; the service is being upgraded in terms of both equipment and access to the Internet (the primary METNET interface for Maryland schools will be Enoch Pratt Library in Baltimore, which has a direct host relationship to SURANet and the Internet)

In Montgomery County, three other efforts will inform, and be informed by the Virtual High School project:

- Montgomery County Global Access Plan will configure seven prototype schools with ethernet local area networks (lans) capable of efficiently carrying TCP/IP protocol. Computers on each lan will access a high storage capacity server providing local information to the school at high speeds. A single dedicated communication circuit will connect the school lan through a router to another router at Montgomery Blair High School. Eventually, all secondary schools in Montgomery County will be interconnected. This wide area network (wan) will be connected to the current Internet gateway at Montgomery Blair High School. The Blair line will be upgraded to T1. Training and technical support have been integrated into the Global Access Plan. Materials developed by the Maryland Virtual High School Project will be easily available through the Blair server.
- The BEKS Consortium is an effort to equalize curriculum, resources and facilities in Montgomery County neighboring high schools. A steering committee comprised of the principals and cluster coordinators and/or their representatives from Blair, Einstein, Kennedy, and Springbrook High Schools and the project coordinator have met five times since September, 1993. This group has discussed in detail issues involving the consortium concept, instructional program delivery, use of technology, and collaborative school management. Students at Blair, under the leadership of Susan Ragan and another staff member have developed a user-friendly world wide web server for BEKS, have trained core groups of students at each of the schools, and are in the process of training teachers to use the system to share ideas, resources and lesson plans. The student leadership and online community building developed through this project will be an example to build on for the virtual high school. The materials developed through the virtual high school will be disseminated through the Blair BEKS server.
- Event Based Science is a project supported by the National Science Foundation which will benefit from a collaboration with the Maryland Virtual High School project. Modules have been developed for middle school science involving events such as oil spills, hurricanes, earthquakes, and floods. Several of the teachers for

the Maryland Virtual High School project teach 9th grade physical or earth science. Materials from the Event Based Science modules may be integrated into computational models, and making such materials available online will foster commuication among participants locally and at field test sites such as Los Alamos. In addition, pointers to relevant information may be collected on the Blair server, and close to real time information during an event may be available through the Internet, including data from government databases and correspondences from students in the areas where such events are taking place.

Summary

The project is being developed as one part of an overall *systemic* effort to enhance science and math education in Maryland through the integration of computational mathematics with science . To meet its objectives, the project must demonstrate that a wide variety of high schools can benefit from the use of high-performance computing capability and sharing of resources through telecommunications, with the focus on teachers as 'doers and owners' of the effort, and on the students and 'doers' of science.

2.0 Project Design

High-performance computing has revolutionized science and has the potential to revolutionize science education. Drug firms use molecular modeling programs to earmark potential candidate compounds; virtual wind tunnels have replaced real ones for preliminary testing of airfoils; using powerful graphics tools, students can visualize processes that may take millions of years to occur in real time, or that occur at the temperature of liquid oxygen or the interior of a star. Simulations that were possible using only the most powerful computer ten to fifteen years ago can be done with a spreadsheet program on a personal computer today.

Computational science complements theoretical and experimental science. Observation and experimentation have long motivated the development of scientific theory. The theory expressed through Newton's equations of motion is validated when real world data fits these equations. Computational science developed as human beings sought to explain more of the world around them. Applying Newton's equations to an airplane in a varying atmosphere entails building a computational model which may include factors such as wing shape and humidity. Varying factors in the equations produced by this more complicated theory leads to different results. Carrying out such an approach using methods of numerical solution and visualization allows researchers to "see" how closely these results approach reality. This leads to a modification of the model and the theory behind it.

A computational science approach allows students to investigate problems closer to the real world than an approach that relies on the ability of a student to find all answers analytically. In addition, a numerical approach allows, for example, students with an algebra background to model and solve problems (i.e. calculus is not mandatory). As an example, a student could consider a scuba diver who is interested in determining lung capacity at various ocean depths. In chemistry, the student would traditionally approach the problem with the ideal gas law, $PV=nRT$; after understanding this simple model, the student might collect data relevant to actual scuba diving and find that the simple model does not fit actual gas behavior. Then, more robust equations which provide a better representation of actual behavior would be developed with the guidance of a teacher, and a root finding method (corresponding to the mathematical maturity of the student) would be taught to enable the student to test the new model with data. The student would then implement the model to make a prediction of gas behavior. These results would then be compared with experimental data, and the student would reach a conclusion regarding the validity of his model. The student could then improve the model by adding additional factors to create a model which more closely mirrors the reality of scuba diving (n an underwater environment). Examples of using numerical modeling techniques to solve problems are in Appendix A; a sample model description is included in Appendix B.

Hardware ranging from simple PC's to supercomputers may be used to implement solutions to such problems. Tools developed by the National Center for Supercomputer Applications and the National Education Supercomputer now enable students to prototype models on PC-level computers and to run more complex models on supercomputers. Software tools include programming languages as well as spreadsheets, data analysis packages, specialized modeling tools and visualization software. Many math and science teachers do not have the training or experience to carry off such an approach by themselves. However, with additional training, collaborative sharing of such models, and discussion of various problem-solving techniques, teachers can build up a 'portfolio' of numerical techniques which can be correlated with the traditional scientific disciplines which employ them. It is not anticipated that such numerical techniques will be beyond the grasp of students who are progressing through a normal academic sequence. Techniques that are within the capability of students who are completing an algebra / advanced algebra sequence include:

- systems of equations
- difference equations
- data analysis and graphical representation techniques
- roots of non-linear equations
- approximations and estimations

The project efforts of the 'virtual high school' will focus heavily on and be carried out by teachers; it is an objective of the project to empower teachers to assess, discuss, and utilize new projects, topic area problems, and related support materials. The Internet has proved to be a medium through which teachers may overcome the constraints of distance and differing school cultures and administrations to work together on common projects. The 'virtual high school' will be constructed by teachers and students on the foundation of Internet connectivity.

Project Plan

The project entails a collaborative effort by Maryland teachers to form a widening community of teachers, students, and mentors. Materials will be produced to initiate problem based, information rich, computational science activities. These materials will be revised and fleshed out by online archives of student team projects and of the collaboration process itself. The overall project has been planned as three one-year integrated phases, with an assumed start-up date of July 1, 1994. Many activities in anticipation of full implementation of the project have already been accomplished.

In initial project development in 1992, letters were sent to every high school in the state solititing interest. All teachers who responded were invited to a meeting held on October 23, 1993 as a session of the Maryland Council of Teachers of Mathematics and Maryland Association of Science Teachers fall conference. This session on the proposed Maryland Virtual High School of Math and Science was also publicized in the newsletter of the Maryland Association of Science Teachers. Recently, notice of the project was publicized through the MDK-12 listserv sponsored by the University of Maryland and through METNET.

Schools currently identified for initial participation were selected with the aim of maximizing diversity with respect to many factors. These factors included geographical location and setting (urban, surburban or rural), demographics of the student body, background of and level of courses taught by the interested teachers, and administrative and scheduling factors. Maximizing the number of different counties represented was also a consideration. The project team will be face with wide variety of issues inherent in working with these diverse schools. This will provide the project team, local educational agencies, and the state of Maryland with relevant information for the involvement of a greater number of schools in networking and computational science in subsequent years. The schools have been asked to commit to use the computational science modules that will result from teacher collaboration. See Appendix C for agreements of participation by the schools. Two teacher from each school will work with the project team for the first year, starting in July 1994, to implement cooperative computational science activities among their students. The schools will be provided with full Internet access.

2.1 Year One - Establish participant communication and technical infrastructure

2.11 Prepare for workshops and future collaboration

A prerequisite to collaboration is an understanding of the strengths and constraints inherent in each school setting. A site visit will be made to each school during the summer, and an interview conducted detailing the teachers' experience with computers, his/her particular interests in science, the availability of equipment in the school, the limitations of schedules and room use, and course expectations. This will enable the project team to plan workshops more effectively, as well as determine with the teachers, the best implementation for network connectivity.

One of the lessons learned in earlier workshops in computational science, is that although most participants have the necessary background to work with such activities, they feel that unhurried individual review of such topics enhances their appreciation of material presented. The most frequent suggestion made in an evaluation of such a workshop (see Appendix D) was that reading material be provided to participants several weeks in advance. The project will provide materials for teachers early in the summer. This material will include an Internet Guide, numerical methods overview, and information about software tools, as well as documents which detail standards considered to be important by various science education organizations such as the National Science Teachers Association (NSTA), the American Association for the Advancement of Science (AAAS), and the National Council of Teachers of Mathematics (NCTM). Curricular guidelines and other material from the American Association of Physics Teachers (AAPT), the National Science Foundation (NSF), the National Association of Biology Teachers (NABT), the Society for Industrial and Applied Mathematics (SIAM) and the Consortium for Mathematics and its Applications (COMAP) will also be included.

METNET and Enoch Pratt Library, University of Maryland accounts and Montgomery Blair's computational science gopher and world wide web servers (see Appendix E) will allow teachers to immediately begin investigating and discussing computational science activities. An archives of project ideas initially to include past SuperQuest proposals, activities used at Blair, and information about public domain modeling tools is available and will be enhanced. Teachers will participate in online forums established to determine preliminary educational objectives and guidelines for initial activities to be developed during the fall. Guidelines for on-line communication will be drawn from previous research by Margaret Riel of AT&T and others. Teachers will respond to readings and preliminary network investigation through group discussion using their temporary network link. Discussion will also revolve around current classroom practices and use of computers, and will further inform all project participants of common and divergent course levels, kinds of computers, and other factors to be considered in facilitating collaboration. Compensation for participating teachers has been built into the budget for the summer work which will include the site visits, reading, and online discussions.

The project staff will also strengthen and increase initial contacts made with groups who can support and collaborate with Maryland Virtual High School teachers and students. Such groups include National Institute of Health, United States Geological Survey, National Institute of Science and Technology, National Security Agency, NASA Goddard, and the University of Maryland. Informed by online discussions and site visits, the staff will prepare an agenda and training materials for the first workshop session, as well as make final arrangements for the installation and systems training for each school's Internet connection.

2.12 Carry out teacher workshops

A series of workshops will involve teachers in a collaborative effort to investigate problems using numerical techniques themselves , and to develop such applications for use in the classroom. An underlying goal of this collaborative process is determination of factors that contribute to the successful implementation of computational science projects in the classroom through creating a reflective community. Development of computational science activities will be a vehicle for the analysis of these factors, and later evaluation of the classroom implementation of these activities will add to this knowledge.

Two teachers will attend the fall workshops from each of the six schools participating in the virtual high school project. The actual training effort will be located in the

Montgomery County area (perhaps at University of Maryland, Shady Grove, or National Institute of Health) and include two three day sessions hosted by Maryland Virtual High School staff in September and October. Lodging (if necessary) and meals will be provided, substitute fees will be paid and teachers will be compensated for Saturday work. Advance arrangements have been made for individual computer support for each participant, including Internet access.

The September and October workshops will include the following program areas (the outline and schedule of a previous workshop on computational science is contained in Appendix D):

- Establish program goals, priorities and responsibilities; the intent of this activity is to foster ownership of the program by the lead teachers.
- Using curricular resources provided and gathered by the group during the summer, participants will develop criteria for the development and evaluation of the computational science models.
- Determine general format for modules, and specific curriculum components which will be consistent with individual disciplines; this will include identification of potential topics in the various disciplines.
- Introduce teachers to professionally developed modeling tools produced by the National Center for Supercomputer Applications, the staff of the National Education Supercomputer, and others.
- Provide advanced network training (lead teachers will already have used the Internet during the summer as described above). Introduce teachers to supercomputer use.
- Conduct sessions with teachers as problem solvers on selected computational activities; include review of relevant numerical and modeling techniques.
- Initiate development by each participating teacher of two pilot computational science modules in his/her discipline for use by students during the following school year. Teachers will be encouraged to join forces in this effort. Each module will develop and use a specific computational technique, and will include a series of activities which are developmental in terms of scientific content and algorithm complexity (the activities will be consistent with student abilities and available hardware and software platforms at participating schools.
- Establish initial evaluation criteria and instruments; this will include creating the format for teacher logs to be kept during the pilot testing year, and will be an on-going process during the life of the project. An evaluation consultant will attend the October workshop to become familiar with the project and to advise participants in establishing such criteria.

The project team will develop supporting material to provide teachers hands-on guidance in the use and incorporation of computational resources such as the Internet, software libraries, and accessible on-line materials. A video log will be prepared of key portions of the fall training program. A library of video training sessions, including familiarization with METNET and the Internet, will be made available for use by any teacher in Maryland. During the year, the 'virtual high school' project coordinator will be able to use these materials, in conjunction with supplementary workshops to introduce other groups of teachers to the computational science working consortium.

Lead teachers will have a commitment as program 'emissaries' to implement their problem modules during the following year, subject to their particular hardware and software constraints and classroom schedule. These lead teachers will become the core group who will be the main testers, evaluators, and agents for continued growth of the program. It is anticipated that the program will be enlarged by twelve additional teachers in Year 2.

In November, teachers will attend the education program of Supercomputing 94 in Washington D.C. , which will complement the training received during September and October. Appendix F includes the education program from Supercomputing 93.

2.13 Complete Internet installation, systems training, and workshop followup

During this same time period, the main school server, router and 56kbs line will be installed at each school. A high end personal computers running the LINUX (UNIX variant) operating system, which will handle school gopher and web servers and email accounts, will be supplied to each school. In addition, each school will receive a laptop computer with built in ethernet connection and modem, enabling teachers to use it to best advantage both at school and at home. For schools that lack sufficient computer hardware to fully support the project, every effort will be made to work with business and government agencies to obtain donations of new or good, late date, surplussed equipment.

The best configuration for connecting other school computers and local area networks to the router will be determined by school officials with advice from the project team as requested. The project team will be responsible the cabling and connections necessary for the pc server and laptop to act as Internet hosts.

One of the barriers to school networking is the time and cost associated with the upkeep and management of school hosts. As regional network provider, SURANet will help schools trouble shoot problems that may occur. In addition, a computer science student from a local university will act as an additonal consultant on site at each school. These undergraduates, along with students from the Blair magnet program who have become skilled in handling network/host system management and in training other students, will lead an online mentoring and support group for student sysops from the pariticipating schools. The lead teachers at each school will remain final authorities in the implementation of management and access policies, and systems training will be provided on site to teacher participants and other interested staff.

To the extent that the schools have hardware and/or software deficiencies beyond equipment supplied directly by the project, maximum effort will be made to address these problems via other available grant programs, or by participation of interested companies and agencies. During this time, online communication will include both workshop followup as well as questions concerning operation of the school hub.

2.14 Begin implementation of 'virtual high school' (Fall 94)

Installation of the 56kbs line will establish a 'hub' high school in several regions of Maryland, so that 'lead teachers' might eventually support other interested teachers in the area and will then become the means for additional Maryland schools to participate and interconnect into the 'virtual high school'.

Lead teachers at each of the hub schools will integrate at least one computational science activity into curriculum during the first semester of the 1994-1995 school year. They will be encouraged to work with peers at the same school and at other participating schools in investigating different facets of an interdisciplinary problem. Typically, teachers will introduce students to relevant Internet resources, and to project team email conferencing as well as to personal email. Computational tools will include spreadsheets, Stella II modeling software (to be provided) and public domain software. Teachers will communicate difficulties and successes to the teacher forum and to subcommunities working on the same problem. These messages will be echoed to METNET and to the MDK-12 list as appropriate. Teachers will also maintain a project log. Fifteen substitute days for planning (including workshops) will be available for each teacher each semester. The 'virtual high school' project staff will work together with lead teachers to support the activities they have developed with materials such as

- module packages, with printed explanations, exercises, interactive computer tutorials
- library routines which are platform independent and module independent
- source code implementing the model to be used at the discretion of the teacher
- test data sets for which experimental results are known, or directions for collecting data to validate the model

In addition, as a result of the project, all Maryland high schools will have access to these materials in print as well as a through the computational bulletin board service enhanced to provide students and teachers across the state with the ability to work on and discuss the same problem. The project will serve as a clearinghouse of other opportunities available to Maryland teachers, such as contests, other training programs and public domain software.

Students from each of the schools will have an opportunity to attend the student day of Supercomputing 1994 in Washington D.C. on November 16.

The project staff will work together with lead teachers to present information about the Internet, computational science, and the 'virtual high school' project to parent and community groups such as the Parent Teacher Association, the School Board, and Chamber of Commerce. Information about models of community collaboration with school networks, such as the community network componenet of the Boulder Valley Networking Project, will be available. The expectation is that such efforts will alert the community to additional opportunities and mobilize support for continuation of the project. Lead teachers and staff will also seek to build a collaborative relationship with local chapters of teachers professional organizations such as the Science Teachers Association.

2.15 Continue 'virtual high school' during second semester (Spring 95)

An additional workshop will be held in the early spring of 1995, providing the opportunity for in depth evaluation of the project so far, as well as planning for implementation of a new computational module by each teacher.

Again, fifteen substitute days will be provided for teachers to attend the workshop as well as work at school sites in planning implementation of Internet and computational science activities resulting in completion of the additional module.

In addition, project staff will carry out a mailing and METNET solicitation in the Spring of 1995, to all teachers and schools not yet involved in the program. In this solicitation, references, project examples, and an update of the status of the program to date will be included. Opportunities for project participants to display and discuss their work at science fairs and symposiums will be actively pursued. Teacher paraticipants will present information about the project at MICCA. Student sysops and inter-school project teams will have an opportunity to meet at the University of Maryland, College Park in May. Students will exhibit their work in a poster session and attend seminars presented by computational scientists. Maryland teachers and others interested will be invited to visit the exhibition.

2.2 Year Two - Complete initial year of 'virtual high school' operation

The basic progression in each year involves supporting teachers who have already been involved in the project and continuing the outreach and solicitation of teachers and/or schools who have not yet become involved in the project.

2.21 Determine new school participants and support for other schools

- Many factors will determine additional schools to be added to the project. These will include connectivity options, preliminary evaluation of the applicability of the project across the spectrum of classes involved the first year, as well as opportunities to extend the project model.

2.22 Establish inter-school communications infrastructure and workshops

- Establish communication with new teachers through temporary accounts at hub schools, through METNET or University of Maryland accounts. Provide teachers with materials developed during year one.
- Hold late summer or early fall workshops with project staff, year two teachers, and six of the year one teachers.
- Hold additional regional dissemination meetings directed by year 1 teachers with the assistance of the project staff.

2.23 Implement computational science applications at participating schools

- Teachers will implement at least one computational science module in the classroom during each semester. Students will be brought on line as part of inter-school project teams. Student sysops will be mentored and trained by experienced peers.

- As an on-going process, the Montgomery Blair team will monitor in-classroom projects, identify potential teaming and shared project opportunities and determine if additional support is required in terms of training, hardware, or communications

2.24 Extend implementation of virtual high school

- Depending on outcomes of the evaluation held during year two, additional project teachers will be recruited for year 3, and plans will be made to continue the program with the support of the state, local educational agencies, or other agencies after 1996-1997.
- Dissemination will include outreach to other areas of the country, especially to science and math schools in other states for which the outreach model may be most applicable.

3.0 Monitoring and Evaluation Plan

Evaluation of the computational science BBS, the lead teacher workshops, and the implementation of the computational science activities will focus on the effectiveness of peer support and the adequacy of the technical support provided. As part of the overall project, an internal project documentation and recording process would be carried out, using video and written records. In addition, a comprehensive evaluation program will be carried out of both teachers and students; this effort would provide an objective summary of lessons learned, student and teacher evaluations, and recommendations regarding further enhancement and implementation of the program throughout the state. Teachers who participate in the program will be asked to provide answers to questions similar to those contained in the proposed project evaluation summary in Appendix G.

The project summaries and evaluations will be provided to and discussed with the project advisory board each quarter; depending upon the interests of NSF representatives, the project summaries can also be provided to and discussed with them in an appropriate forum.

Overall Project Assessment and Recommendations:
An overall assessment will be made by project staff and consulting evaluator with the assistance of the Project Advisory Group, of the extent to which the overall project objectives have been addressed and achieved. Specific recommendations for further project activities will be included. The evaluation will address the following issues:

Technology Support
The model used by this project is a LINUX server managed by peer mentored students, overseen by project teachers and supported by undergraduate consultants. Does the model balance cost and time effectiveness? Does it balance flexibility, power, and ease of use?

Teaching Approach
Can a coalition of interested teachers create, implement and assess new approaches (specifically, use of computational science techniques to help students learn math and

science in a problem-solving manner) in the science classroom? Do such new approaches in fact help to address the need for increased overall science and math competency in the future world marketplace?

Student Population
Can students from a variety of schools, locations, cultural backgrounds and educational achievement levels benefit from the approach utilizing an interconnected 'virtual high school of science and mathematics'? What are appropriate means for measuring the effectiveness of such an approach? Does information collected for the Maryland School Performance Program (see Appendix H for a description of the Science Outcomes Model of the MSPP) provide an appropriate basis for such assessments?

Extended Application
Can the success of such new technologies and revamped approaches to math and science education have application to schools beyond Maryland? What are the appropriate recommendations for applications of the 'virtual high school' approach (as used in Maryland) in other parts of the United States?

4.0 Project Management

Mary Ellen Verona of the Montgomery Blair HS Magnet Program will be Principal Investigator for the Maryland Virtual High School and will devote full time to the project. She will be assisted by Susan Ragan and Mark Curran of the magnet teaching staff. Ms. Verona has written curriculum for a number of upper level electives in mathematics and science, and has taught mathematics, science and computer science since 1978. She has twice coached finalist SuperQuest teams and participated in summer SuperQuest training. She has given numerous workshops for teacher on computational science and on the Internet. As overall project manager, Ms. Verona will interface directly with the lead teachers and with government and scientific agencies seeking to work with the project.

Ms. Ragan, also a finalist SuperQuest coach, will work closely with curriculum development and student activities and mentoring. She will continue teaching courses in modeling and simulation and in computational methods. She will also continue outreach activities working with the BEKS project, in which Blair magnet students mentor students and teachers in telecommunications in a consortium of four neighboring high schools. She will be the contact for the undergraduate students providing technical support, and for the student system managers online support group.

Mr. Curran, Blair Magnet Research and Experimentation teacher, has been provided with a number of substitute days to assist with the Maryland Virtual High School. In addition to other duties, Mr. Curran currently teaches materials science to students at Blair and at Poolesville High School through interactive video. He will interface with SURANet, with equipment installation, and with facilities arrangements for workshops, including video.

Resumes for project staff are contained in Appendix I.

5.0 Advisory Board

In addition to guidance from Blair Magnet Coordinator, Eileen Steinkraus, and the Montgomery County Office of Enriched and Innovative Instruction, a project advisory board has been assembled that will provide important oversight for the project. The advisory board is familiar with the objectives of the virtual high school and each board member has been selected because of a leadership in education, computational science, or telecommunications. It is planned that the advisory board will meet at the beginning and end of each academic year; They will be consulted on an as-needed basis during other portions of the project. The members of the project advisory group are contained in Appendix J.

6.0 Dissemination and Extension

As explained earlier, it is planned that this project continue through July 1997. The plan is for additional schools and teacher to become involved at a low entry cost that includes sufficient technical support. More than equipment and communication costs, schools must budget the time investment necessary for teachers to take ownership of educational use of the Internet and computational analysis and modeling techniques. An addition goal is to work together with local educational agencies and the state of Maryland to create a knowledge base of options in telecommunications as well as a range of cooperative science activities and materials utilizing the Internet and computational resources. Outreach within and beyond Maryland will be carried out using print, video media, and perhaps most importantly, the Internet itself.

7.0 Work Plan

The schedule of key milestones for the project for the period Summer 1994 through Spring 1995 is included in Appendix K. More general milestones for the two year extension are also indicated.

Appendix A

Examples of Applications of Computational Science

- Use of matrix algebra to examine *stochastic processes in genetics*

- Use of differential (or difference) equations to simulate *progression of virus infestation in a human population*

- Use of cellular automata and the formula for the distance between two points to model *the development of coat markings in zebras and leopards*

- Use of systems of equations to model *electronic circuits*

- Use of simple analysis and transform techniques to study *sunspot cycles*

- *Modeling of water flow over the skin of a dolphin*

- *Modeling of 'El Niño' weather patterns* by using a Fourier series as a means of satisfying a least squares condition, and as a means of interpolation

- Leontif input/output analysis, using matrix operations to assess raw material, manufactured goods, and production vectors in *macroeconomic analysis*

- Use of algebra, difference equations and simple physics to model *gnat behavior*

- Use of algebra to compare *strands of DNA between different species*

SUMMARY PROPOSAL BUDGET

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

ORGANIZATION
Montgomery County Public Schools

PRINCIPAL INVESTIGATOR/PROJECT DIRECTOR
Mary Ellen Verona

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates - (List each separately with title, A.7. show number in brackets) (combined summary: Years 1-3)	NSF Funded Person-mos. CAL	ACAD	SUMR	Funds Requested By Proposer	Funds Granted By NSF (If Different)
1. Mary Ellen Verona	36.0			$ 173,409	$
2. Susan Ragan	18.0			88,807	
3.					
4.					
5.					
6. ( ) OTHERS (LIST INDIVIDUALLY ON BUDGET EXPLANATION PAGE)					
7. (2) TOTAL SENIOR PERSONNEL (1-6)				262,216	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. ( ) POST DOCTORAL ASSOCIATES					
2. ( ) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)				136,320	
3. ( ) GRADUATE STUDENTS					
4. ( ) UNDERGRADUATE STUDENTS					
5. (1) SECRETARIAL - CLERICAL				93,619	
6. ( ) OTHER					
TOTAL SALARIES AND WAGES (A+B)				492,155	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				148,306	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A+B+C)				640,461	
D. PERMANENT EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $1,000.) Modems $ 5,400 Overhead viewer 9,000 PC's 63,000 Furniture 9,000 Laptops 52,500					
TOTAL PERMANENT EQUIPMENT				138,900	
E. TRAVEL 1. DOMESTIC (INCL. CANADA AND U.S. POSSESSIONS)				38,664	
2. FOREIGN					
F. PARTICIPANT SUPPORT COSTS 1. STIPENDS $ 2. TRAVEL 8,064 3. SUBSISTENCE 30,780 4. OTHER 104,400 (substitutes)					
( ) TOTAL PARTICIPANT COSTS				143,244	
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				39,000	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION					
3. CONSULTANT SERVICES				168,950	
4. COMPUTER (ADPE) SERVICES				472,600	
5. SUBCONTRACTS					
6. OTHER (rental of facilities)				9,000	
TOTAL OTHER DIRECT COSTS				689,550	
H. TOTAL DIRECT COSTS (A THROUGH G)				1,650,819	
I. INDIRECT COSTS (SPECIFY RATE AND BASE) 1.5% rate					
TOTAL INDIRECT COSTS				24,763	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				1,675,582	
K. RESIDUAL FUNDS (IF FOR FURTHER SUPPORT OF CURRENT PROJECTS SEE GPM 252 AND 253)					
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				$ 1,675,582	$

M. COST SHARING: PROPOSED LEVEL $ 1,070,500 AGREED LEVEL IF DIFFERENT $

PI/PD TYPED NAME & SIGNATURE*	DATE	FOR NSF USE ONLY		
Mary Ellen Verona *Mary Ellen Verona*	6/13/94	INDIRECT COST RATE VERIFICATION		
INST. REP. TYPED NAME & SIGNATURE*	DATE	Date Checked	Date of Rate Sheet	Initials-ORG
Paul L. Vance *Paul Vance*	6/14/			

NSF Form 1030 (1/94) *Supersedes All Previous Editions* *SIGNATURES REQUIRED ONLY FOR REVISED BUDGET (GPM 233)

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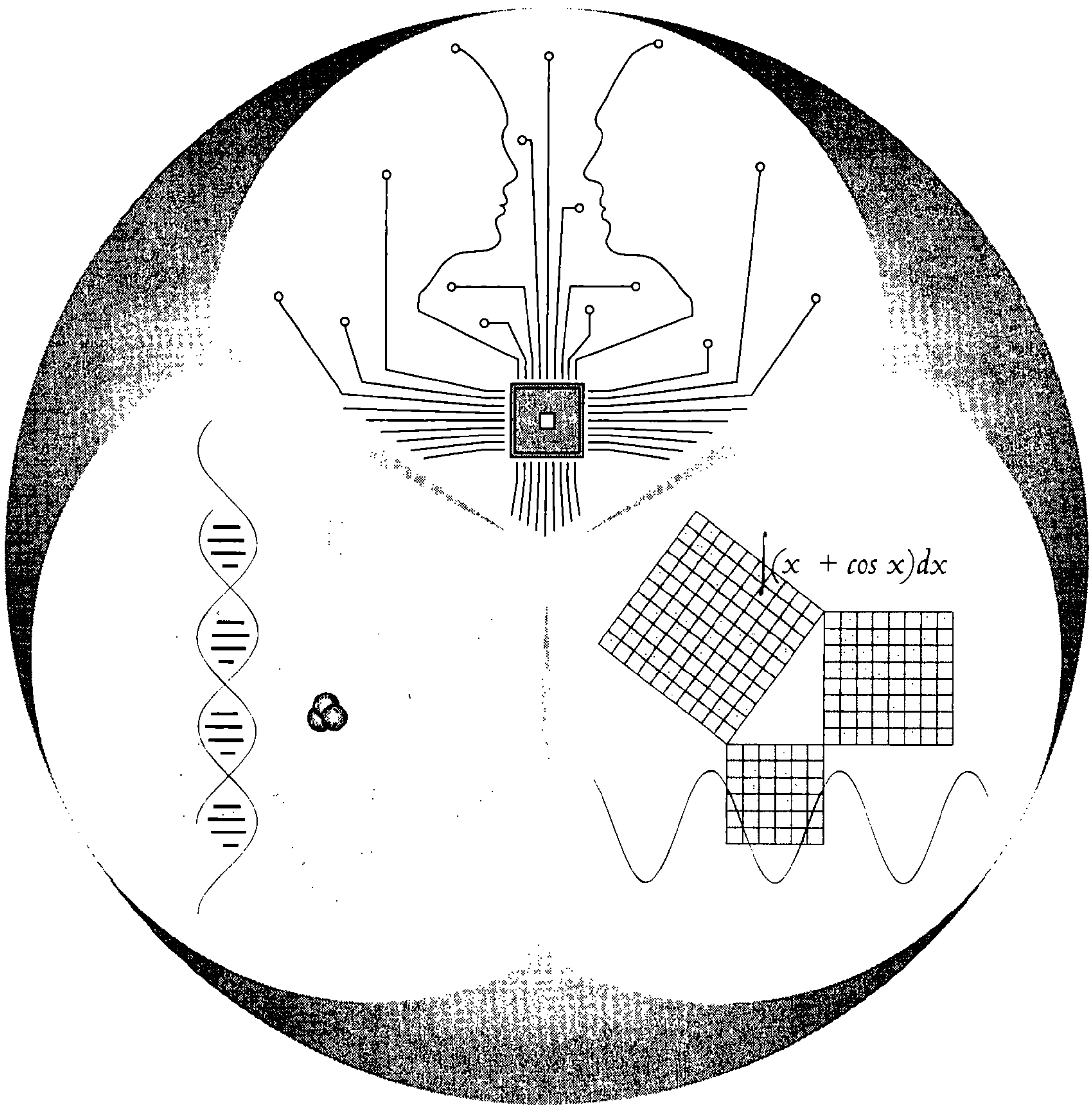
Montgomery County Public Schools

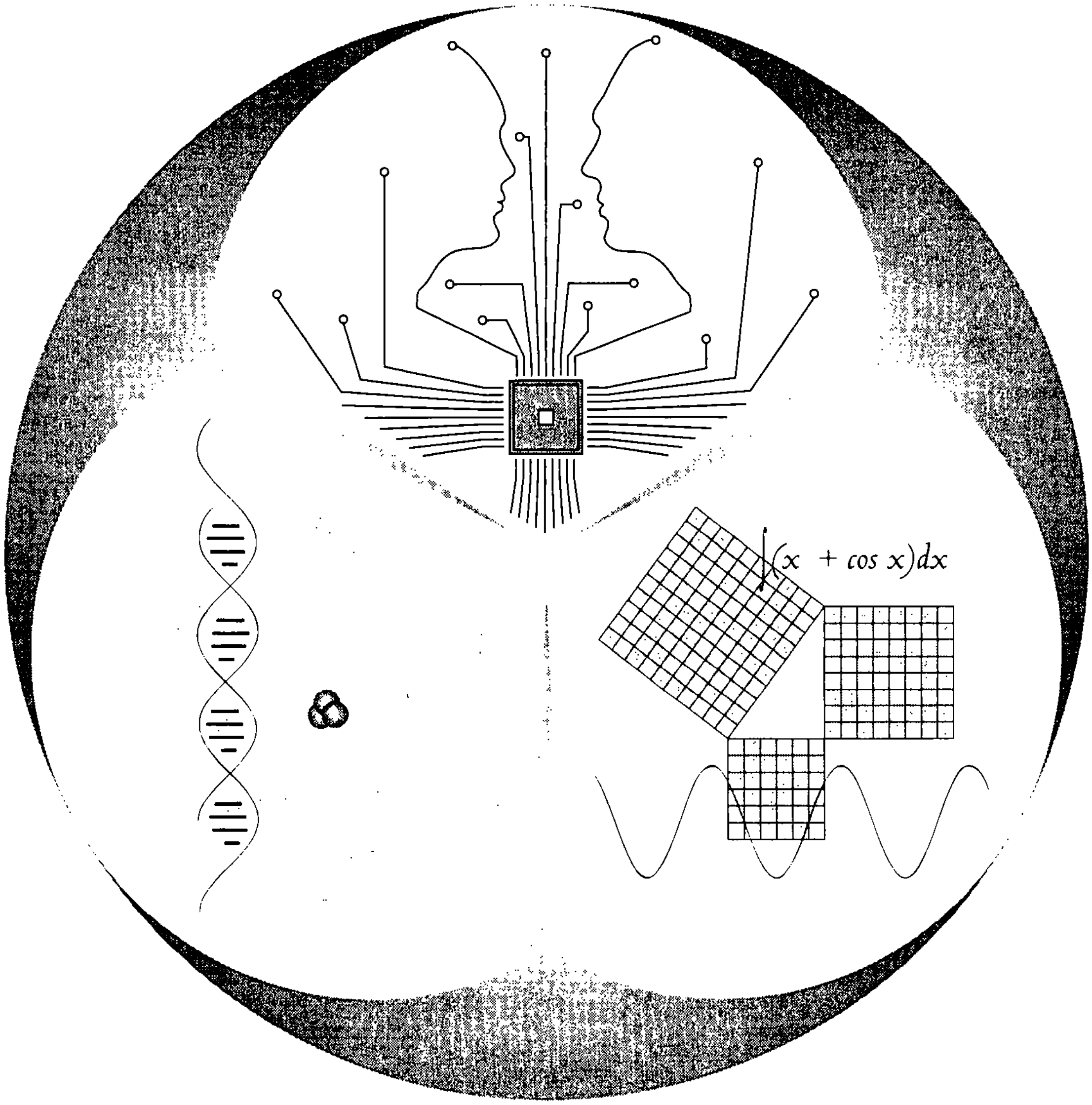
Science, Mathematics, Computer Science Magnet Program



Montgomery Blair High School • 313 Wayne Avenue • Silver Spring, MD 20910

Montgomery County Public Schools

Science, Mathematics, Computer Science Magnet Program



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