

BOCES-University Partnership as a model for Educational Outreach: K-16 STEM Professional Development¹

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Abstract

This paper introduces our partnership model for educational outreach among higher education and local school districts utilizing the Board of Cooperative Education Services (BOCES) as the primary partner and liaison. This partnership has many aspects. Its primary professional development activities have been under the umbrella of the St. Lawrence County Mathematics Partnership and its recent successor the St. Lawrence County STEM Partnership program.

The role of BOCES and the nature of Clarkson University are described within the context of our geographical and demographic environment. The breadth of our partnership programs is outlined. The major part of the paper describes the specific nature of the professional development program under the new STEM partnership.

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1. Introduction

In this paper we shall describe briefly our Clarkson University/ St. Lawrence-Lewis BOCES partnership which has been very successful over recent years in attracting funding for educational outreach between a research university with a strong technical emphasis and the local K-12 education system in a rural low-income area of northern New York State. The activities have included many aspects of educational outreach all having elements of teacher professional development in the integrated mathematics and science, or STEM, discipline areas. Two programs in particular have had professional development as their principal focus.

The rest of this introductory section will give an overview of the partners and their roles, and of the geographic, economic and demographic characteristics of the *North Country*. The next section deals with the history of the partnership, including brief descriptions of the various programs and how they interact and reinforce each other. The third, and main, section will deal in greater detail with the newly started St. Lawrence STEM Partnership. This program is a successor to the previous mathematics partnership. Both have been funded under the Mathematics-Science Partnership program by New York State Education Department, NYSED. A brief summary completes the paper.

The St. Lawrence-Lewis BOCES operates a wide array of programs and services for the 18 component school districts it serves. Many of these programs are geared to individuals with unique academic and social needs, such as Special Education, Alternative Education, Career and Technical Education, and Adult Education and Family Literacy. Staff development programs, offered by the BOCES Office of Program Planning and Development, School Improvement office, SETRC, and the Teachers' Center (for whom the BOCES is the LEA) support districts, teachers, parents and students. The St. Lawrence-Lewis BOCES has developed the organizational capacity to implement and organize high level partnerships with higher education. A team of administrators, coordinators and program instructional specialists experienced in grant writing and implementation are currently on staff. Staff development networks and interagency collaborations currently exist that expand on the services available to program participants.

Clarkson University is a private, nationally ranked research university located north of the Adirondack Mountains in Potsdam, New York. Clarkson has a reputation for developing innovative leaders in science, engineering, business, health sciences, and the humanities. Clarkson University was recently ranked 7th among small research universities by *The Chronicle of Higher Education* in 2007. The university enrolls approximately 3,000 high-ability students who pursue Bachelor degree programs through the School of Arts & Sciences, Wallace H. Coulter School of Engineering, and School of Business. Approximately 400 of these students participate in Master and Doctoral programs primarily in the STEM disciplines. Clarkson students from all levels and disciplines join academic and non-academic programs in an effort to gain real-world experience in a cooperative team-based environment. Some of these opportunities include the 14 SPEED (Student Projects for Engineering Experience and Design) teams, REU (Research Experience for Undergraduates) programs, McNair Scholars Program, Co-ops and internships, Professional and Student Organizations, Clarkson Honors Program, Study Abroad, and Athletics.

St. Lawrence County is located in Northern New York State along the Canadian. The total land area of the county is 2,685 square miles. It comprises thirty-two towns, thirteen villages, and one small city. There are eighteen rural school districts, which include very small districts of 350 students K-12, to a few larger districts of 2,000 students. All St. Lawrence County School Districts share the same problems of limited resources and a high needs population.

The communities to be served by this project are characterized by unemployment levels well above the state average. Figures from New York State Department of Labor puts St. Lawrence County's unemployment rate at 10.4% as of March 2004 compared to the state average of 6.5% for that same month. Per-capita income is well below that of New York State in general. Recent figures put St. Lawrence County at an average income of \$27,004 in 2000 compared to the state average as a whole of \$40,004. According to *Socioeconomic Trends*, the overall poverty rate is 17.7% as compared with 14% for all other rural counties in New York State. According to the St. Lawrence County Planning Office, personal income has grown at a rate that is 12% slower in the county than statewide. The *Kids Count* Data Book reports that 25% of children in St. Lawrence County live below the poverty level. According to SUNY Potsdam's Rural Services Institute, in 2000 there were 4,680 persons (9%) over the age of 25 with less than a 9th grade education and another 9,897 persons (19%) with a 9th to 12th grade education, but no high school diploma.

The families residing in these isolated, rural communities are individuals who are severely disadvantaged both educationally and economically. Many are confined to generational welfare with five-year public assistance clocks expiring; are teen parents; are learning disabled; are without high school diplomas; are without marketable job skills; are lacking an understanding of effective parenting skills; are without transportation; and have little or no understanding of how to help their child academically and socially. The children of these economically and educationally disadvantaged adults will remain trapped in this cycle without intensive, high quality educational intervention. Many children live in a one-parent household where the head of the household is working 10 to 12 hours at minimum wage to survive. The closing of Paper Mills and Mines have forced adults in rural communities to drive over an hour away to larger population areas to get employment. This leaves young adolescents alone for hours before and after school with little or no supervision.

When assessing the educational needs as a "whole" in St. Lawrence County there is an obvious contradiction in poverty and wealth. St. Lawrence County has some of the poorest and neediest rural K-12 schools in the state, while at the same time; it is one of the richest areas in colleges and universities. There is a wealth of diversity, leadership, academic rigor and excellence, and a vision for a global future within the four institutions of higher education located in St. Lawrence County. Over the last four years all eighteen St. Lawrence County School Districts and St. Lawrence-Lewis BOCES have focused on building partnerships, creating consortiums and identifying and sharing resources.

The educational outreach activities at Clarkson are coordinated through the Office of Educational Partnerships which was created in 2005 as a result of the growth of activity and the desire to institutionalize outreach. A similar title was adopted for the partner office at the BOCES.

Institutionalization was a requirement from the National Science Foundation for the GK-12 program which places Clarkson University students in local schools for project-based learning experiences in math and science. The true partnership grew with the successor programs beginning with the St. Lawrence Mathematics Partnership (www.mathpartnership.org). The NY STEP program *IMPETUS for Career Success* followed and includes professional development alongside the student-centered activities based on the mathematics and physics of roller coasters. The latest component is the St. Lawrence STEM Partnership whose funding was announced in June 2007 and has already held the first few of its professional development Teachers' Institutes. These and other programs are described in greater detail below.

2. History

In this section, we will describe briefly some of the educational outreach programs that led to and then benefited from the partnership between Clarkson University and the St. Lawrence-Lewis BOCES. These include programs whose focus is not just teacher professional development. The intention here is to illustrate the way in which all the activities interact and reinforce. As with our integrated approach to STEM education, we also see the various programs as parts of an integrated whole with beneficial synergies among almost all the pieces.

Clarkson University's educational outreach activities have their origins in the NSF-funded GK-12 Project-based Learning and its companion *Partners in Education* program. Clarkson's GK-12 program was initiated by Dr. Susan Powers in the Civil and Environmental Engineering Department. The primary goal of these programs is to enhance both graduate student and K-12 education through bringing graduate (and some undergraduate) STEM students into local schools. The initial 3-year funding was followed in 2003 with a 5-year GK-12 site grant. For the renewal greater mathematics content has been incorporated. Peter Turner joined the PI team for this renewal which also had St. Lawrence University as a partner institution. The inclusion of more mathematics was the seed for a growing emphasis on integrating mathematics, science and later the whole STEM field within project or problem-based learning wherever possible.

The professional development aspect of the NSF program is less central than with the others described below. The K-16, or even K-20, professional development was still important as many of the teachers were initially less familiar with the project-based approach, and with the interplay between the different discipline areas.

During 2003-4, the first BOCES partnership program was started. That first partnership was with a different BOCES (for Franklin-Essex-Hamilton counties, FEH) and was focused on using technology and applications to enhance middle school mathematics education. Turner and Fowler were the Clarkson partners in the FEH program which finished in July 2007. The *triad* model of a lead teacher with two partner teachers in a single school, which is described in greater detail later, had its beginnings in this program. The Roller Coaster project which inspired the *IMPETUS for Career Success* was also an offshoot from a project developed by one of the teachers, Ms Kitty Matthews, in that FEH program.

The St. Lawrence County Mathematics Partnership was funded as a three year MSP program by NYSED. The program served approximately 227 teachers and 6,431 students in sixteen rural St. Lawrence County School Districts. This partnership included all 17 St. Lawrence County School Districts, St. Lawrence-Lewis BOCES, and the science, technology, engineering, and mathematics (STEM) departments at Clarkson University and SUNY Canton, and the Education Departments at SUNY Potsdam and St. Lawrence University to enhance both content knowledge and teaching skills of teachers teaching math.

One of the major project activities is to improve teacher quality through an effective professional development model. The initiative has created the foundation for 88 small professional learning communities within the school districts, and the technical education facilities of St. Lawrence Lewis BOCES. Within each of these small, professional learning communities, there is a Lead Teacher who has received 60 hours of professional development in year one focused on math instruction, standards and the integration of such, project-based learning, problem-based inquiry and/or technology. This lead teacher has completed the small learning community with two other teachers within their buildings. This is the basis of our *Triad* model for professional development communities.

The learning of the lead teachers is instituted and supported by the professors from the university STEM departments, consultants from the NY State Education Department, and the Math Instructional Specialists involved in the grant. The learning of the lead teachers has been supported as well by their building principals and superintendents, who have also participated in the learning process through the workshops. The support from all parties involved solidified the groups into working units that advance the goals that the triads have developed and, as a result, raise student achievement.

The second major project that is a part of the foundation for the partnership is the addition of the Math Partnership Website, www.mathpartnership.org. This website connects the 300 teachers, partners, consultants, instructional specialists and grant coordinators across a 2500 square mile area. Participants can gain information about state standards, discuss successes and problems in instruction, register for workshops, receive information from the catalogue and have research on current practice at their fingertips and access information on curriculum, instruction and assessment. This website was built and maintained by undergraduate and graduate students at Clarkson University.

Overall, the Mathematics Partnership grant accomplished a great deal in moving toward the fulfillment of the grant objectives. The growth is evident as to the continuation of the quality professional development offered. This growth is being accelerated through the new STEM Partnership which is the focus of the next section.

Our IMPETUS (*Integrated Mathematics and Physics for Entry To Undergraduate STEM*) for Career Success program is part of the NYSED STEP (*Science and Technology Entry Program*). The purpose of STEP is to increase the number of historically underrepresented and disadvantaged students prepared to enter college, and improve their participation rate in STEM related fields. The major components of the IMPETUS program include professional development activities for teachers, bi-monthly academic year activities for students, and a one-

week six-day long summer Roller Coaster Camp. The IMPETUS team includes Clarkson faculty and students, St. Lawrence-Lewis BOCES administration, and teachers from the local school districts. The Clarkson members have primary content responsibility while the BOCES members take the lead on communication and coordination with the school districts.

The primary professional development activity is a five-day summer institute for teachers held at Clarkson in which teachers are introduced to the Roller Coaster Project theme, trained in the use of data and data gathering equipment, and provided with practical applications of the use of computer technology in the classroom. Instructional equipment including a miniature roller coaster setup, laptop computers, data acquisition apparatuses and software is supplied to the schools. Support is provided to teachers through in-school mathematics and physics activities to be incorporated into the regular curriculum, as well as the established contacts made with Clarkson faculty and students.

Academic year activities include once-a-month on campus programs run at Clarkson and once-a-month Clarkson faculty and student fellows visits to the local school districts. The in-school program includes activities based on the roller coaster project and sessions designed to provide students and parents with information on college and career preparation in STEM fields and the financial aid and the college admission process. The on-campus program includes information sessions designed to help answer career questions, and motivate students towards STEM professions. A career fair was held with several Clarkson Faculty representing many STEM disciplines designed to answer such questions as, "How does math & science fit in the real world?", "What is a mathematician, scientist, or engineer?" and "What are the different fields of engineering?". We celebrated π Day on March 14th (3/14) where students visited booths and participated in challenges all dealing with the number π , and students attended a "Chemistry Magic Show". Future activities will be designed around the recent addition of a Virtual Roller Coaster (VRC) which was purchased by Clarkson and the STEP program. This VRC will allow for students to design their own thrilling roller coaster, test its design for safety and then actually ride it, all while on campus.

The summer camp focuses on the integration of the mathematics, physics, and computing involved in designing a roller coaster. The roller coaster theme is used to motivate interest and excitement among the participants by providing a scientific experience which is designed for three separate levels (7-8, 9-10, 11-12 grades). The first three days of the camp are held at Clarkson where students participate in laboratory-based activities where they learn how to use data gathering equipment, to measure the friction associated with a toy car and make predictions for its performance on a series of challenge tracks, and to use a software package to actually design their own roller coaster. The fourth day of the camp is a field trip to the Six Flags Great Escape, amusement park in Lake George, NY for practical experience on roller coasters and for scientific data collection. The fifth day of the camp is dedicated to analysis of the data collected from the park and the students are given time to develop posters describing what they learned during the week. During the final day of the camp the student's parents, teachers, family members and friends are invited to campus for an exhibition and awards day.

Funding for the IMPETUS program was first awarded in June 2006. 27 students participated in a pilot summer camp which ran in August of 2006. During the first academic year of the program

the enrollment reached a total of 76 students. Two separate week long summer camps ran in August of 2007 which had a total of 48 students participate and currently 73 are enrolled in the program.

The Math Partnership also provided the means to renew the MATHCOUNTS program in St. Lawrence County in 2006, and double participation in the Adirondack Regional Science Olympiad in 2007. Turner and Fowler serve as the local coordinators for MATHCOUNTS and Ramsdell is the Regional Coordinator for the Science Olympiad.

MATHCOUNTS is a national middle school mathematics competition that incorporates teacher coaches, students, volunteers, and industrial sponsors. In the context of the Math Partnership, local teachers participated in profession development workshops to learn more about the contest, becoming a MATHCOUNTS coach, and numerous resources available through the program. These resources include problem solving strategies, guidance in algebraic reasoning, a large bank of practice problems, a more detailed *Problem of the Week*, and extended interdisciplinary activities. As part of the program, Clarkson University students served as assistant coaches to help design and execute the after-school training sessions with the middle school teacher coaches.

A local competition has been held each November, open to all students who want to participate, as a start to the training session. The official local competition takes place in February with the winning teams advancing the state and possibly to the national competition. In 2006, about 60 students, from 6 schools with 8 coaches participated. In 2007, these numbers grew to about 65 from 8 schools using 10 coaches. This represents a welcome rebirth of the program after it had died out in 2004-5. Further growth is anticipated this year.

The Regional Science Olympiad is part of the National Science Olympiad Program, a organization devoted to improving the quality of science education, increasing interest in science, and providing recognition for achievement in science education to students and teachers. This contest consists of Olympiad style events which test student's knowledge in fields such as health science, astronomy, entomology, geology, and biology and their experimental skills in physics and chemistry. Students were also asked to design and construct a robot, a weight bearing structure, a model airplane, and an egg transport device. Local teachers participated in a profession development workshop to learn more about the structure of the Science Olympiad competition, how to become a coach, and the resources available through the program.

Participation in the regional event has more than doubled in both schools competing and student participants. Approximately 150 students from 13 North Country and area high schools competed in 15 challenging events.

3. STEM Partnership

Following the successful implementation of the **St. Lawrence County Math Partnership**, which was funded through a NYSED Mathematics and Science Partnership grant, the same consortium of St. Lawrence County school districts continues to partner with Clarkson University to expand and improve STEM education in our 17 school districts. The MSP 2004-2007 grant served 300+ teachers and directly affected 6,400+ students in seventeen rural St.

Lawrence County School Districts. Partners also include the Diocese of Ogdensburg, St. Lawrence-Lewis BOCES, and STEM departments at Clarkson University. This partnership has allowed us to customize our efforts, to use the partnership as an innovative laboratory and as an opportunity for coalition building. It has also provided on-going assessment of the needs of all participating schools as well as provided essential data on student achievement, teacher quality and the needs of at-risk populations.

Key components of the STEM Partnership include:

- Summer institutes for teachers taught by STEM faculty at Clarkson University that integrate STEM topics and apply these concepts to relevant and real world problems;
- Scientifically-Based Research , SBR, workshops for teachers throughout the school year to improve pedagogy for increased STEM integration and enhanced rigor and relevance;
- TRIADS of STEM teachers from area school districts who will work together to bring cross-discipline projects and activities to their students; and,
- Peer review and sharing of new curricular units through conferences and web sites (NYSATL Peer Review Process).

This partnership addresses the need for the program in the economically disadvantaged region, justifies its approach through a review of current education research literature, and entails an implementation that will positively impact hundreds of teachers and thousands of children. The Clarkson University Summer Teacher Institutes share common features. They all actively engage teachers in learning about new trends in science, technology, engineering, and mathematics that they can implement in their classrooms to energize their students' interest and enhance their understanding of current STEM disciplines. All topics will integrate mathematics and technology with science and engineering concepts in project-based approaches that make meaningful connections with students' lives. The institutes will model best teaching practices of inquiry-based learning and will involve real-world problem solving and critical thinking skills. There are several objectives that are common to many of these institutes and workshops and which are addressed in slightly different ways appropriate to the specific subject content:

1. Improve teacher understanding of math and science topics, and of newer branches of science, engineering and technology to help them develop the innovators of tomorrow;
2. Provide a deeper appreciation of how STEM disciplines work together, using appropriate technology to solve real problems and understand natural phenomena;
3. Provide opportunities for teachers to develop curricular materials that include engaging hands-on activities integrating the key concepts and activities of the workshop;
4. Empower teachers to use a scientific thought process to integrate STEM and broader disciplinary knowledge and skills; and,
5. Create and share projects which will be class tested and peer-reviewed, assisted by mentoring from Clarkson University faculty and students.

Several of the institutes scheduled for implementation in 2007 and 2008 are summarized below.

Integrated Mathematics and Physics Projects for Middle and High Schools

The primary content of this 5-day institute comprise projects and problem-based learning which combine mathematics, physics, and computation content. Topics are adaptable to multiple grade levels and subject areas. The initial choice of topics was drawn from the (NYSED STEP funded)

IMPETUS Roller Coaster project. Further applications in other applied topics that will help motivate student work in mathematics, science (especially physics) and technology will be developed for 2008 and beyond. Topics include physics experiments utilizing data collection equipment such as sensors, mathematical modeling of scientific phenomena, and analysis of data using computer technology as well as “paper and pencil” math techniques. Activities include physics and mathematics labs, and computer software sessions.

From Contest to Classroom: MATHCOUNTS, COMAP & Science Olympiad

Activities in this 3-day summer institute are drawn from recent MATHCOUNTS and/or Science Olympiad problems. Teachers will be able to choose different content to focus on. MATHCOUNTS is targeted at grades 6-8, and Science Olympiad is primarily aimed at High School science students. COMAP (the Consortium for Mathematics and Its Applications) would be a new undertaking for local schools. It is an international mathematical modeling contest aimed at undergraduates and high schools. Teachers will participate in two additional days of follow-up and competition during the academic year. An important aspect of this workshop is helping teachers to use these resources to enrich the regular curriculum.

Summer Lego Robotics Workshop for 4th - 6th Grade Teachers

This hands-on, five-day workshop is appropriate for any 4th - 6th grade teacher interested in integrating robotics into the classroom or any school activity to enhance STEM education. Building and programming robots is a highly interdisciplinary activity that develops creative problem solving, teamwork, leadership, and project management skills. Students participating in robotics-based curricula learn about STEM careers firsthand, by solving real-world problems. A series of hands-on project experiences are used to familiarize participants with the design and construction of autonomous robots using Lego Mindstorms NXT kits and RoboLab software to program the NXT robots’ motors and sensors. A final engineering design challenge prepares participants to coach a FIRST Lego League (FLL) team within their schools, including a local FLL tournament sponsored by the St. Lawrence BOCES and Clarkson University. Each workshop participant is loaned an FLL robotics kit and will be expected to serve as a coach to an FLL team consisting of up to ten students.

Summer VEX Robotics Workshop for 7th - 8th Grade Teachers

This hands-on, 5-day workshop will train middle school teachers to use robotics as a high-profile and highly motivating tool to introduce STEM concepts into their curricular and extra-curricular activities. The objectives are similar to those of the Lego Robotics Workshop, adapted to the middle school grades. The final engineering design challenge and mock competition prepare participants to coach a FIRST Vex Challenge (FVC) team within their schools, including a local FVC tournament sponsored by the St. Lawrence BOCES and Clarkson University in December. Each workshop participant is loaned an FVC robotics kit and will be encouraged to serve as a coach to an FVC team within their own school district.

Computer Graphics: Mathematics and Technology Projects for Middle and High Schools

This 4-day summer institute will provide teachers with an introduction to the mathematical fundamentals of computer graphics and animations. This involves applications of geometry, computer technology, simple programming and computations. Activities will include background on digital camera and printer algorithms. Teachers will participate in an additional

day-long follow up workshop in the fall or winter.

Hands-on Studies of Conservation Science: Integrating Science, Technology, & Math

In this 5-day institute, middle and high school teachers will learn how to use computer modeling technology to study issues in conservation biology and ecology. The project-based teaching modules will include learning techniques in sampling, identifying, and studying organisms in the wild, microclimate measurements, monitoring of populations, and use of computer modeling to make predictions and conservation decisions. In order to make the topic relevant to students, the activities will be related to the nearby Adirondack Park. The modules can be adapted to most school resources, and can be made appropriate for middle school and high school biology, earth science (possibly), integrated math & science.

Promoting Energy Literacy: An Integrated Math, Science, and Technology Institute

We are in the midst of an energy crisis. Energy fuels our daily way of life – either directly, (to power our vehicles and machinery and satisfy our home heating, cooking, and electric requirements), or indirectly. Educating children to make them more energy literate requires the integration STEM knowledge and application, coupled with social sciences and other humanistic considerations as well. Through hands-on activities and by incorporating a “systems approach,” students will be challenged to apply critical thinking skills tackle relevant energy problems. An annual Energy Science Fair will provide opportunities for teachers and students to communicate their scientific findings.

Finding NANO: An Integrated NanoMaterials Summer Institute

The term “nanotechnology” is becoming ubiquitous, but what does it really mean and how does it impact our lives? This institute will help teachers to discover how small “nano” really is, and provide activities they can use to explore the technological importance of nanomaterials with their math, science and technology students. The institute will be conducted by a faculty team who are actively engaged in nanomaterials research and education through Clarkson’s NYS- and industry-funded Center for Advanced Materials Processing (CAMP).

CSI Potsdam: A Project-Based Teacher Institute Integrating Chemistry, Biology, Physics, and Mathematics

In a 5-day institute for teachers of grades 4 – 12, participants will learn engaging hands-on *Crime Scene Investigation* (CSI) methods that integrate chemistry, biology, physics, and mathematics. The institute will be modeled using a best practices project-based teamwork approach. Chemistry topics will include chemical testing of different substances, analysis of fingerprints, and microscopic analysis of crystal structures. Biological topics will include blood type analysis and isolation of human DNA, which will highlight cell biology concepts. DNA Fingerprinting will utilize electrophoresis equipment to analyze simulated DNA samples. Microscopes will be used to analyze specimens such as fibers, hairs, and pollen, including measurements of microscopic items. Physics concepts will include analysis of trajectories and physical properties of matter. Mathematics concepts such as measurement and statistical analysis will be integrated.

Exploring Genetics, Bioinformatics, and Evolution: A Summer Institute for Middle School and High School Teachers

Genetics and Evolutionary Biology are essential life science concepts for teachers to understand.

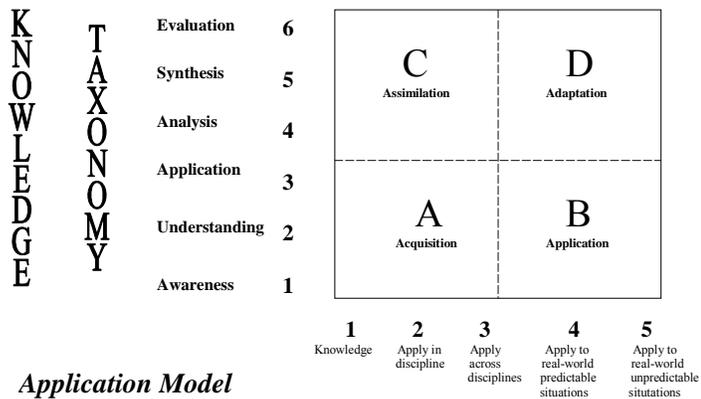
This 5-day institute for middle school and high school teachers will make connections between genetics, evolution, and DNA. In the summer institute, teachers will learn how scientists use computers in the cutting-edge field of bioinformatics to study differences in the genes of organisms. Teachers will learn inquiry-based activities that can be implemented in the classroom.

Additional institutes will be presented in subsequent years. Professional development workshops will focus on scientifically based research for curriculum planning and assessment. These will include:

Rigor and Relevance Workshops

The Rigor and Relevance Framework [1] will be used as a tool to examine curriculum, instruction and assessment. Teachers will explore the more complex ways in which individuals use knowledge, such as taking several pieces of knowledge and combining them in both logical and creative ways. They will examine ways to use the Application Model, one of action, in developing their own learning experiences for the classroom.

Rigor/Relevance Framework



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STEM Integration Workshop

The STEM Integration workshops will be teacher focus groups led by Curriculum, Instruction and Assessment specialists as well as Technology Specialists. These workshops will give TRIADs the opportunity to work together to develop cross-curricular learning units and to investigate appropriate integration of technology. Teachers trained in the Title II D grant and the Title II B Math Science Partnership grant will take on lead roles as appropriate.

NYSATL Peer Review Workshop

An essential element of the professional development model is improving classroom instruction. Participating teachers working within their TRIADs (mathematics, science and technology teachers) will develop, teach and peer review a cross-curricular learning unit. The Rigor and Relevance Framework will be used for evaluating curriculum, instruction and assessment. The development and implementation of the learning experiences will be supported by TRIAD work time built into the SBR workshops and in the classroom through the MST Specialists. The resulting peer reviewed learning units will be published on the project website and on the New York State Education website as appropriate.

The summer institutes focus on content knowledge, but it is important that they are directly linked to and aligned with the State Learning Standards. The tie-in with the standards is strong throughout the program as is illustrated in the following table.

Learning Standards for Mathematics, Science and Technology	Integrated Math & Sci	Contest to Classroom	Computer Graphics	Conservation	Energy	Nano	Legos / Vex	CSI	Genetics	Cyber-Civics	Health
Students will use:											
Standard 1: mathematical analysis, scientific inquiry, and engineering design, as appropriate, to pose questions, seek answers, and develop solutions.	X	X		X	X	X	X	X	X	X	
Standard #2: access, generate, process, and transfer information using appropriate technologies	X	X	X		X	X	X				X
Standard #3: applying mathematics in real-world settings, and by solving problems through the integrated study of all the mathematics content strands.	X	X	X	X		X	X				X
Standard #4: scientific concepts, principles, theories pertaining to the physical setting and living environment	X	X		X	X	X		X	X	X	X
Standard #5: technological knowledge and skills to design, construct, use, and evaluate products and systems to satisfy human and environmental needs.	X		X		X	X	X	X	X	X	
Standard #6: connecting mathematics, science, and technology; apply the themes to all areas of learning.	X	X	X	X	X		X		X	X	X
Standard #7: knowledge and thinking skills of mathematics, science, and technology to address real-life problems and make informed decisions.	X			X	X	X	X	X	X	X	X

Program activities meet all goals and objectives by:

- Developing rigorous mathematics and science curricula and learning units;
- Improving subject matter knowledge and strong teaching skills of teachers of mathematics and science, including integrating reliable scientifically-based or evidence-based teaching methods and technology-based teaching methods into the curriculum;
- Encouraging young men and women and other under-represented individuals to pursue degrees leading to science, technology, engineering and mathematics;
- Designing programs to identify and develop exemplary teachers of mathematics and science in the K-8 classrooms;
- Creating programs that bring teachers of mathematics and science into contact with working scientists, mathematicians, and engineers; and,
- Designing programs to prepare teachers of mathematics or science to provide professional development to other teachers of mathematics and science.

The teaching units are aligned with the New York State standards. Higher-order thinking skills will be a focus of the SBR workshops, based on the Rigor and Relevance Framework [1]. Rigor involves challenging students with high expectations, thoroughness, and problem solving skills. Relevance includes helping students connect their studies with the real world and thus make meaningful connections with students' lives. Incorporating both rigor and relevance in the curriculum leads to student engagement and ultimately learning and achievement of academic excellence. Through participation in these institutes, teachers will be provided with the tools to effectively integrate current STEM topics into their classrooms.

SBR workshops offered throughout the academic school year support teachers in TRIADs

(professional learning communities) as they use new content knowledge and integrate rigor and relevance to develop, create, and share cross-curricular learning units. SBR workshops will be designed as in Horsley et al.'s [4] approach, to include the key features listed earlier. These components are also central themes of the NYSATL peer review process that will be used to develop and evaluate consistent, high quality learning experiences and learning units. In order for the analysis of student work to be most powerful it needs to occur in a trusting, collaborative environment, [3] which is reinforced in the peer review process.

A key component of the project is sharing of usable peer-reviewed curricular units on the project STEM Partnership website after classroom testing, evaluation, and modification. These units will be extremely valuable for teachers across New York State. Participant teachers are encouraged to give presentations at state and local STEM education conferences, such as the annual conference of Science Teachers Association of New York State (STANYS). The Director of Clarkson's Center for Advanced Materials Processing (CAMP) has committed funds to help provide these opportunities to participants in the STEM partnership.

Throughout the academic school year and summer, St. Lawrence-Lewis BOCES MST (Math, Science and Technology) Instructional Specialists will provide professional development to all participating teachers that improves instructional capacity and that displays the four critical characteristics identified by Senge [5] and Knapp [2], which were described above.

At the end of the academic year, teachers will have the opportunity to share their curricula with other participants in a STEM Partnership Teachers' Institute Day that combines learning new content knowledge and sharing curriculum successes and challenges.

Student Academic Achievement - Student Data Base (GPRA Goal and Goal #1): As part of the 2004-07 MSP grant, a project database was created that includes information on 17,251 students in grades K-12 in all 17 participating school districts. Information on each student includes student ID, grade level, level of proficiency for the 2006 Math assessment, gender and ethnicity, and categorization as economically disadvantaged, disabled, or limited English proficiency. Class lists of all teachers in the math grant were collected and added to the database to allow identification of students who had or did not have teachers participating in the grant. This database allows for the calculation of many different statistics needed to study the effectiveness of grant activities and participation for the 2007-2010 grant period.

Poverty and At-Risk Students (Goal #2) – Math assessment data taken from the St. Lawrence County Partnership database of 17,000+ students has been disaggregated into subgroups, including the most at-risk groups of Economically Disadvantaged and Students with Disability. Out of a total number of 6,910 students in grades three through eight, 2,876 students (41.6%) are economically disadvantaged and 1,043 students (15.1%) have a disability. 55.3% of the students in grades 3-8 who are economically disadvantaged and 33.4% of the students with a disability reached proficiency (level 3 or 4) on NYS Math Assessments March 2006.

Grant initiatives have and will continue to specifically target at-risk students living in poverty through grant partnerships and student enrichment activities with Clarkson University. One such initiative is a successful STEP grant (through the New York State Education Department) written by Clarkson University that involves 96 economically disadvantaged students grade 7-12. This program includes a summer camp and monthly activities on Clarkson campus to promote mathematics and science through a roller coaster theme. MATHCOUNTS and Science Olympiad teams have also been established and expanded to include many at-risk students.

(These programs were described briefly in Section 2.) Special recruitment efforts will target special education teachers in TRIADs to improve teaching quality in this essential area.

4. Summary and Conclusions

We have described the very fruitful educational outreach partnership between Clarkson University and the St. Lawrence-Lewis BOCES. This is a true partnership that has had significant advantages for all concerned.

A question that is often asked is why an institution such as Clarkson should be interested in educational outreach activities. The simple answer is that everyone benefits. The benefits to Clarkson are at several levels.

At the institution level, there is the benefit of improving the STEM student pipeline which is vital to the institution's continuing health as well as helping to address a national need. Of course there is the benefit of funding: Clarkson's share of the various programs discussed here amounts to more than \$5M over the period in question. The intangible community relations benefit is also highly valued by the institution. At the level of St. Lawrence County, the influx of more than \$10M represents more than \$400 *per person* under the age of 18 in the county over the past six years, a significant economic boost in a region where the median household income is below \$35,000 and 50% of school students are on free or reduced lunches.

Research faculty benefit from involvement in educational programs through the ability to enhance the broader impacts of research proposals (an essential for NSF funding), through gaining access to excellent students and potential students, and through improving their own teaching skills by learning from the classroom experts with whom they interact.

The college students get the opportunity for meaningful professional experience, regardless of whether they intend to go into teaching as a profession. Professional experience of some type is a graduation requirement for the University, beginning with the class of 2010. The teaching or coaching experiences definitely enhance their own communication skills – and their understanding since such understanding is always deepened by explaining a concept to others. It also helps students discover whether, or not, they want to teach. Like the faculty, the students also gain the opportunity to pass on their own excitement in their chosen field of study.

As a longer-term benefit, any programs such as these help lead the way towards reestablishing the attractiveness of STEM disciplines and careers for young women and men. Part of this is the need to make young students aware of the range of possibilities open to them.

The partnership with BOCES is essential for achieving these goals. In a remote rural community with eighteen distinct small school districts, communication between the schools and the University is time-consuming and often difficult. The BOCES has the knowledge, expertise and personnel to handle this efficiently. Because the senior staff have extensive school experience, they typically know the appropriate individuals to contact and have ready access to

Superintendents and Principals. In a research university, with no School of Education, this coordination role would be almost impossible without the BOCES partnership.

The strength of this partnership and of the BOCES coordination role allows us to realize many of the benefits to the local school districts. Benefits specifically related to the professional development aspect include an improved teacher knowledge base in STEM disciplines through the summer institutes and other programs. These institutes also provide basic training on using hardware and software tools appropriately. The intention is to make obvious some of the opportunities for collaborative projects among disciplines and therefore to provide enriched programs to enhance student learning.

Enhanced student learning is the ultimate goal of any educational outreach program. Measurement of this requires a thorough assessment model. The large data base created by the BOCES for the Mathematics Partnership and continuing in use for the STEM partnership is enabling careful assessment of the programs at the student achievement level.

The school districts themselves gain in many ways, too. Equipment that is obtained through one program can be used in the school to benefit other parts of the curriculum. For example, the roller coaster equipment supplied through the *IMPETUS* program can be used in regular physics, mathematics or technology classrooms, too. Additional resources can be shared by taking advantage of the BOCES distribution network so that equipment that may be desired for one short project does not need to be purchased for 18 distinct school districts. In a similar way, the coaching and equipment used for the various contests will be used throughout the remainder of the school year for both in class and after school activities that can spread the benefit much more widely.

Externally funded programs for professional development are also an indirect financial benefit to the school budget, while the summer institutes give teachers and schools direct links to STEM research faculty who are then available as consultants or guest speakers.

The benefits to students in the K-12 system are many. Bringing project-based learning into classroom helps student appreciate “real-life” examples of STEM interactions. The introduction to scientific and engineering thought processes and improved problem-solving skills (starting with literacy) enable students, who may otherwise never consider a technical college major and career, awareness and confidence to pursue those objectives. This is further enhanced through campus lab visits and other field trips, and through their exposure to college student role models. All of this ultimately leads to better motivated, and therefore more successful, students.

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