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ABSTRACT

The Health Sciences and Technology Academy (HSTA) is a partnership between teachers, faculty at West Virginia University, high school students, and local communities that aims to increase the college enrollment rate of underrepresented students and the number of health care providers in the medically underserved rural communities of West Virginia. HSTA provides academic enrichment (science, math, and technology) and leadership development for these high school students through on-campus summer institutes and extracurricular after school science clubs. This paper describes the goals and workings of the program, and features in-depth perspectives of three exemplary community-based student projects: (1) "Bacterial Counts in Undercooked Hamburger"; (2) "Hike for a Healthy Heart"; and (3) "Is There Too Much NOx in the Air We Breathe?" (Contains 16 references.) (WRM)

PARTNERSHIPS TO PROMOTE PROFESSIONAL DEVELOPMENT AND INQUIRY LEARNING IN THE HEALTH SCIENCES

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Science teachers, who give providential thought to expanding their role as an educator, can reap benefits through programs such as the Health Sciences and Technology Academy (HSTA). Through HSTA, teachers partner with faculty at West Virginia University (WVU), high school students, and local communities across the state of West Virginia. The mission of this campus-community partnership is to increase the college-going rate of underrepresented students, and the number of health care providers in the medically under-served rural communities of West Virginia. HSTA provides academic enrichment (science, math, and technology) and leadership development for these high school students through on-campus summer institutes and extracurricular "after school" science clubs. The students gain from the informal science education opportunities and "the power of informal learning experiences" (NSTA, 1998, p. 154), as advocated by the National Science Teachers Association. The secondary science and math teachers who facilitate this informal science learning are enriched by their associations with faculty in higher education, and participate in on-going professional development offered through HSTA (Bock, 1996, Rye, 1998, Rye & Chester, in press). These opportunities enable teachers to become aligned with the "Changing Emphases" as set forth in the National Science Education Standards (National Research Council, 1996), e.g., "teacher as source and facilitator of change" (p. 72).

Program Participation and Scope

HSTA was initiated in two West Virginia counties in 1994, and has expanded to 20 counties. Over 400 secondary students (24% African American, 37% low income) and 50 teachers currently participate. Most of the teachers are certified in science; a small number are certified in other areas (e.g., mathematics and health occupations). At a summer campus institute, teachers complete professional development activities offered by post-secondary faculty (e.g., in education and the health and natural sciences) on the use of technology and inquiry-based instructional models that embed scientific ways of thinking and experimental design. In the following weeks at the institute, teachers work alongside faculty to practice these strategies by engaging students in analogous learning activities. These activities place a principal emphasis on relating science to human health through problem-solving, enabling teachers and students to gain exposure to science research skills, as well as university settings and personnel.

The community-based component of HSTA utilizes after-school science clubs as a vehicle for students and teachers to collaborate with faculty at West Virginia University on projects of student choice. According to the National Science Standards, "Teachers [should] select science content and adapt and design curricula to meet the particular interests, knowledge, skills, and experiences of students" (National Research Council, 1996). Following a problem-based approach, students conceive their project, investigate the problem, and present their findings at the annual HSTA Community Symposium. HSTA teachers, HSTA curriculum coordinators, post-secondary faculty, community health professionals, and local experts, work with the students to help them relate their project to health problems, and to set forth experimental designs. Accordingly, many of the projects that emerge through HSTA programming address contemporary health-related issues in the students' community.

Professional Development Leading to Classroom Reform

HSTA teachers are the most important learning resource for participating students (Rye, 1998). Rye portrays a model of teaching articulated through HSTA professional development, which emphasizes a paradigm shift from teacher-centered to student-centered instruction. One of the problem areas is ensuring student choice, which is vital to engaging student interest and maintaining it over the long haul. This concept is especially difficult for those teachers who are hesitant to apply science education reform strategies, so on going workshops and modeling is crucial. In their club environments, HSTA teachers are encouraged to use several inquiry-based approaches, one of which is the "three P's of science" (Peterson & Jungck, 1988, Rusbolt, 1994): problem posing, problem probing or solving, and peer persuasion. Collaborations among faculty in the health and natural sciences enable teachers to learn a variety of scientific techniques, such as DNA manipulations, histology preparations, and more broadly, experimental design, which enhance their understandings of the nature of science, and how to pose and solve problems.

Collaborations with faculty in education and HSTA curriculum coordinators provide HSTA teachers with various workshops and graduate courses to further integrate health science content, theory, and practice. The workshops acquaint teachers with computer techniques, new software, and other advanced technological practices they can take back to the classroom and clubs. For example, at the 1998 Fall workshop, teachers completed a "colony transformation experience" as part of an introduction to a molecular biotechnology curriculum (Hildebrandt & Brown, 1998) that is designed for high school students. A recent thrust has been directed to increase use of students' projects in teachers' classrooms: Teachers are invited to design integrated science modules that embed project themes, field-test the modules in their classes, and amend the modules to insure successful future application. An example of such is the ongoing module development project entitled "Ultraviolet Rays and Global Changes" (http://nt-hsta.hsc.wvu.edu/health/uvproje/nebulae.htm). HSTA students across the state have gathered data daily on the UV-B high. With this database, students can examine how various variables (e.g., latitude and season) affect ground-level UV intensity, and then relate these results back to health in their community. HSTA Teachers and a curriculum coordinator are preparing a UV module complete with related investigations, which is to be field-tested this spring. The framework being used in the modules is an outgrowth of a NSF statewide teacher enhancement program, the Coordinated and Thematic Science (CATS) project. Since it incorporates the state's instructional goals and objectives, this module framework is "teacher friendly." HSTA curriculum coordinators guide teachers to incorporate pedagogical techniques such as the learning cycle and concept mapping into the design of these modules, to insure an atmosphere of meaningful learning for the students (Odom & Kelly, 1998). HSTA teachers are positioned to observe how these strategies increase their students' reasoning abilities and achievement in future high school science courses. Other model programs, across the country, which espouse to successful reform-based science education use similar tactics and guidelines (Dickinson, 1997; Johnson & Lawson, 1998; Radford, 1998).

Additional incentives for teachers that are an integral part of the professional development include the opportunity to earn tuition-waived graduate credit and then a master's degree in secondary education (Rye, 1998). To date, eight teachers have completed their degree and approximately 12 others are pursuing such. Of those who have earned their degree, most have elected to stay with HSTA. Program evaluation data from questionnaires administered by the project evaluator--the West Virginia University Office of Health Services Research--suggest that teachers are transferring inquiry-based techniques to the classroom: On a scale of 1 (not at all) to 5 (a great deal), over 70% of teachers (n=30) responded "4" or "5" in respect to using the 3P's and concept mapping in their regular teaching.

Extended Investigations Facilitated by Teachers

The number of community-based science projects facilitated by HSTA teachers has grown concomitantly with expansion of the HSTA program, from approximately 35 projects during the 1995-96 programming year to 100 during 1997-98. An inductive analysis (Patton, 1990) of all projects (n = 100) carried out during the 1995-96 and 1996-97 programming years revealed that the majority were health-related, and yielded 47 different themes (Chester & Rye, 1997). Themes that accounted for at least seven projects, along with example titles, were (a) bacteria ("The effect of cooking temperature on the growth of bacteria in hamburger"), (b) dietary intake ("Comparisons of dietary excesses and deficiencies via two analysis programs"), (c) drinking water quality ("Lead? pH? A water analysis of 3 [area] schools"), (d) fat content of foods ("How much fat is in french fries"), (e) senses ("Do you remember smells better in the morning or the evening?"), (f) stream water quality ("The effects of [industrial] production on the water quality of Salt Lick Creek"), and (g) teen health ("Noise induced hearing loss: How does music that teenagers listen to affect their hearing?). Collapsing of themes through a logical analysis (Patton, 1990) revealed that they could be accounted for by four broad categories: human nutrition (33 projects), risk factors for disease (27 projects), environmental quality (24 projects), and physiological processes (10 projects). Most of the projects carried out during 1997-98 also could be accounted for by one of these four categories, however, there was a greater diversity of projects--including investigations into microwave leakage and the portrayal of smoking in movies--and several in the area of plant growth, e.g., "The effect of UV [light] on the germination and growth of marigolds."

These extended investigations represent a major thrust of HSTA community-based programming, and accordingly, teachers' evaluation of HSTA programming reflects the utility of this component. For the 1997-98 year, the mean ratings (1= nothing/not at all to 5 = a lot/very) of teachers as to what they have learned from being involved in HSTA community programming, and the overall effectiveness of that programming, were $M = 4.285$ ($n = 35$) and 4.107 ($n = 28$), respectively. Mean ratings of teachers on these parameters for previous years, as reported by Rye (1998) and Rye & Chester (in press), are approximately as high or higher, and provide evidence that these extended investigations are meaningful program components. In justifying the rating of what was learned from participating in HSTA, one teacher simply put it this way: "I always learn along with the kids." Another was more explicit: "Until HSTA, I, a veteran teacher of 24 years, never really understood experimental design. Now, after using *Students and Research* [Cothron, Giese, & Rezba, 1993], I finally understand and am able to act. Students truly know what significant research is."

Teachers' Stories

Herein we provide in-depth perspectives of three exemplary community-based student projects, authored by the teachers who facilitated the student research, during 1996-98. In these stories, teachers have discussed (a) how the project was conceived (problem posing), (b) how the problem relates to human health and/or community issues, (c) project implementation (problem probing or solving), and (d) presentation of the findings to others (persuasion). The stories also provide the teachers' perceptions of what students gained from the experience and how facilitating the project contributed to their own professional development. These stories convey how programs such as HSTA can result in positive changes in teacher practice and improvements in student attitude and achievement.

Bacterial Counts in Undercooked Hamburger

Science projects at the middle school and early high school levels are a learning experience for both teacher and pupil. This is because the classroom science investigations at and below this level generally consist of a series of steps which the students can follow mindlessly--a sort of "cookbook approach" to science where the student follows a step-by-step procedure, records data, and answers a few questions related to the investigation. The young science student has had very little experience with problem posing, problem solving, or persuasion--the 3P's of the scientific method (Peterson and Jungck, 1988). The teacher quickly learns that many aspects of the scientific method are simply beyond the scope of most young students.

In order to prepare a science project, a student must be able to solve a problem scientifically. The first step in the problem solving process is to pose a problem. Although the young science student may not be visually impaired, he probably does not question what he sees.

Unfortunately, observation without question can not become science. In order for the student to begin an investigation, he must be able to ask questions about what he sees and, more importantly, formulate hypotheses to guide his research. Therefore, we began the 1996 school year by presenting the students in our HSTA club with a few simple experiments designed to help them make observations, ask a few questions, and draw some important conclusions.

During the first few months of the year, our HSTA club performed quite a few interesting investigations. One of the experiments was "Hamburger Sizzler" (Campbell & Myers, 1997), an investigation which was designed to compare bacterial growth in raw hamburger to that in undercooked and well-done meat. The actual experimental procedure for "Hamburger Sizzler" did not allow the researcher to differentiate among different strains of bacteria and only provided data on the number of bacterial colonies which could be cultured from samples of raw, undercooked, and well-done hamburger.

Our initial research indicated that bacteria could be found on both raw and undercooked hamburger. This supported the student's initial hypothesis that the longer the meat was cooked, the fewer bacteria would be found. A few of the students were interested in determining if any of the bacteria could be *E. coli* 0157:H7, a deadly strain of bacteria mentioned in some of the background information provided in the "Hamburger Sizzler" investigation. The students had begun a scientific investigation in which they merely followed a step-by-step, cookbook procedure and were about to expand that procedure to consider an important community problem: to determine if the hamburger they were consuming contained dangerous bacterial contamination. Solving this project (the second of the 3P's) would require a great deal more work.

Implementing a project to determine if *E. coli* were present in hamburger required some special considerations. First, the students were going to have to learn sterile techniques in order to culture bacteria. Any bacteria found in the hamburger samples would have to be treated as if they were potentially pathogenic species. Second, special nutrient media would have to be used to culture the *E. coli*. Although the instructor was aware of several selective media useful in identifying the presence of *E. coli,* at this point no one knew whether or not any of the special media could differentiate between harmless strains of *E. coli* and the deadly *E. coli* 0157:H7. Therefore, special safety precautions, and expertise from a medical clinic, would be necessary in the culturing and examination of bacteria.

Research about *E. coli* on the Internet and assistance from the Rainelle Medical Center, our local clinic, provided the students with background knowledge about the rare strain of *E. coli* known as 0157:H7 which had been responsible for several deaths in the Western states. A member of the staff of the Rainelle Medical Center suggested a selective agar, which would not only grow *E. coli*, but would also allow an expert to determine if any of the colonies were the deadly 0157:H7. This agar, called MacConkey II agar, was purchased and used along with the assistance of the local medical center to complete the experiment.

The HSTA students modified their hamburger experiment to determine if there were *E. coli* bacteria on raw hamburger. Finding that there were *E. coli* on the raw hamburger samples, they set out to determine if cooking the hamburger killed the *E. coli* bacteria. They also incorporated procedures to determine if any of the samples of hamburger would contain the dangerous *E. coli* 0157:H7.

Our results using plain nutrient agar indicated that there were live bacteria in raw, undercooked, and even well done hamburger. Only one sample of well-done hamburger showed bacterial contamination, but the selective agar test indicated that those bacteria were not *E. coli*. The students compiled the data in tables and analyzed it using graphs. After gathering their data and recording it, the students wrote a report in which they attempted to persuade others that their hypothesis had been supported--the third of the 3P's.

After completing the investigations, the students were obviously aware that eating undercooked hamburger was dangerous. Their hypothesis (raw hamburger will contain *E. coli* but proper cooking will kill that organism) was supported. They also learned that it is important to carefully clean dishes, utensils, and surfaces that have been used in handling raw hamburger. More importantly, the students learned that they could gather information about a community problem using the proper scientific method. Simply cooking hamburgers at different temperatures became a means to gain invaluable experience in making observations, forming hypotheses, designing experimental procedures, gathering data, drawing conclusions, and persuading others--all aspects of the scientific method.

Facilitating the *E. coli*/food poisoning HSTA student project has contributed to my own professional development. The first major challenge I had to overcome was to motivate the students to devote an hour and a half a week of their own time to do research. The discovery of the "Hamburger Sizzler" lesson provided our club with an investigation that held the students' interest and sparked their imagination for several weeks. Perhaps the most important lesson I learned was that students will work on anything in which they are interested. Illuminating a young scientist's mind merely requires a spark of interest. Once the students were actively involved and eagerly questioning each and every result obtained, the job of teaching scientific procedure was made easy.

Young science students are weak in problem posing, problem solving, and persuasion--three important areas of the scientific method. Facilitating the young science students in becoming stronger in these areas requires experiments that are interesting and meaningful to the budding scientist. Providing our young students with such research opportunities is one of the main challenges facing science teachers who wish to improve students' research skills.

Hike for a Healthy Heart

The Hike for a Healthy Heart project was a result of the HSTA student's experience at the HSTA summer institute. During the institute, the students were exposed to a gross anatomy lab.

It was during these sessions that they noticed the diseased hearts of so many of the cadavers and learned that West Virginia led the nation in heart disease. Upon returning to their clubs the following fall, the students were concerned about the rate of heart disease they had discovered and were curious as to whether the state trends were also true in their own county. It was during this time that the club came up with the research question "What is the leading cause of death in Webster County?"

The students believed that pulmonary disease would be the leading cause of death in Webster County because of the high percentage of persons employed in the mining industry as well as those who smoked. They found however, after researching the death certificates at the courthouse and the demographic study done for the county hospital, that heart disease is by far, the leading cause of death.

This information spurred the club to use this research in posing a problem. They believed that heart disease was preventable. The problem posed - what could they do about it? Thus preventing heart disease became the target of the students' community-based project and the beginning of the problem-solving phase.

The next several months our club continued to research the causes of heart disease while trying to design a walking track that would be easy, safe, simple, and convenient to use. The students felt that if the track did not meet these specific needs it would be more convenient not to exercise. It was also important to the students that persons with heart disease could walk without becoming isolated and overexerted by climbing hills. Their planning resulted in a track that is on sidewalks, and incorporates three levels of difficulty.

When the students decided to make the walk through the residential part of town, the next step was to receive permission from the city. Students chose a representative to speak with the Mayor and contact town council members. After receiving permission and an offer of aid from the town council, the students set about to measure off the distances. Again a representative from the club was chosen to visit the Water Company to ask to borrow a specific measuring tool for this task. The West Virginia American Water Company graciously allowed us to use their equipment and offered us their assistance, as well.

With distances measured and the track decided upon, the group began designing a pamphlet to describe the exercise track and why the program was important. Next the group worked on painting signs which were color-coded according to difficulty. This was the first problem encountered on the project. To color print the pamphlet map to match the signs would triple the cost of publishing. So far the project had been relatively cost free. The group decided that they would have the pamphlets printed and color the maps themselves to save money.

The club also designed a survey that would give them a general idea of the public's awareness concerning heart disease and the personal habits that may place them at risk. Students filled out an application for the WVU Institutional Review Board and had it approved by the University so they could conduct the survey on adults. The persuasion part of the project was to get this information out and educate the public that there were simple tasks they could do to prevent heart disease. The group decided they would survey various civic groups in the county, present their findings thus far, and also explain about the walking tracks. They hoped to pique the interest of the adults and also gain some publicity in the interim. The students divided themselves into two groups. It was decided that every club member would learn all aspects of the presentation. This way a sudden cancellation of one member wouldn't throw them into a frenzy. This was a terrific experience for the club. They presented to a wide variety of audiences and learned how to "play to the crowd."

My club has learned a great deal about the causes of death in West Virginia and the nation. They have taken this knowledge a step further and have attempted to do something about it. They have learned to present findings and field questions from the audience as well as educate their audiences about the interventions that can be taken to prevent heart disease. My club has learned leadership skills, how to set and reach goals, and now has an enormous advantage over other students when it comes to science and math. What wonderful ambassadors these students have become for the HSTA program. Because our community has seen such growth and self-confidence in these "once shy girls and boys," there has been a real push and demand for more students to be given the opportunities HSTA has provided. This prompted our county Board of Education to fund a second club with "school to work" monies.

HSTA has contributed to my professional development in many ways. The HSTA program has given me the boost I needed to get a Masters degree. As a child, I had always loved science and even had a mad scientists club in a dungeon-like basement. HSTA has rekindled my love for science as being fun. During my first summer with HSTA, I felt totally overwhelmed when surrounded by some of the best professors and teachers in the state. We were bombarded with information to digest and then put into action upon the students' arrival. However, the most satisfying feeling was when I managed to facilitate instead of teach. By the end of the second week I headed home exhausted and changed forever. The second year saw us all grow as a HSTA family. I had gained confidence and had direction. The teachers and staff became close and supportive, as the curriculum intensified.

The third summer was by far the greatest experience, because I was able to work in the gross anatomy lab. I was exposed to advanced Internet training and found two areas that make me want to work on continuing my degrees and certifications. I am now one of the better trained professionals in the county in terms of computer use with web boards, video conferencing, digital cameras, e-mail, HTML, and the Internet. This training continues to be an asset for grant writing, as well. I truly believe that HSTA has taken me to a new level of teaching and instruction, as well as increased my knowledge of science content. In conclusion I feel compelled to say that HSTA has been a major force in my growth as a teacher in the junior high classroom, as an adult working on a Master's, as a professional learning from other professionals, and as a facilitator.

Is There Too Much NO_x in the Air We Breathe?

Living in what we call the "chemical valley," due to a high density of industrial plants, my HSTA students were interested in what they might be breathing. In our science classes, we had been studying about stratospheric ozone and substances that contribute to the thinning of the ozone layer. Through research and discussing our project with university personnel, the students learned about "low level ozone". They were surprised to find that where stratospheric ozone is helpful, lower level (tropospheric) ozone may cause respiratory problems for humans as well as other living things. The students proposed testing the air in their valley to detect the presence of substances that might affect respiration and/or tropospheric ozone.

We made arrangements through the National Institute for Occupational Safety and Health (NIOSH) to get dosimeters for testing nitrogen oxides (NO_x). Each student received 3 dosimeters, each of which contained 2 testing receptacles. One was for nitrogen dioxide (NO_2) and the other was for nitric oxide (NO) to be measured in ppm. Each student was assigned a number that matched the number on the dosimeters so that the test results would be anonymous. The students were instructed to hang one in the room where the most "burning" would take place, one in the room where they spent most of their time, and one outside. All were to be up out of reach of small children and animals. In the school, we hung one in the boiler room, one in the second floor hallway, and one outside in a tree. After 7 days, the students gathered the dosimeters and sent them to NIOSH.

A NIOSH representative met with us to explain the results and what they meant. The students were surprised to find all the results of their tests were within safe limits. We also compared our results with those of another HSTA club further north, which obtained similar results. What did this prove? Only that the air was safe the week we tested. We are planning to run the tests again over a wider area and extended time frame. We took what results we had and wrote up our report using the "3 P's," presented at the annual HSTA fair, and even placed second in the Kanawha County Science Fair that spring.

The students were excited about the project because it reflected concerns within the community about living near the chemical plants. They learned how to research their topic using the library and the Internet, as well as about experimental design and presentation techniques. A math teacher worked with them on analyzing their results with box & whisker plots and how to find the mean.

All of this added up to a winning project and a lot of learning. Through the HSTA program, I received my master's and have been able to use the training I've received to improve my teaching techniques. The students in my classroom as well as the students I've worked with through HSTA are benefiting from my growth. It has been extremely rewarding to watch the change in my students as they grow and learn.

Discussion and Conclusions

The HSTA teacher's role as a facilitator of learning becomes dynamic, once the source of authority switches to the science experts and then to the students. Without the constraints of a classroom, there is no imperative to follow a required curriculum, hence students' interests can be honored. Further, teachers can allow an element of "fun" to enter the process of investigating a scientific problem, extending that joy to their students. Almost any investigation can be extended and offers students valuable junctures from which they can embark towards completion of a project to present at the annual HSTA Community Symposium. Because of the tremendous challenge of engaging underrepresented students in science and math enrichment, especially after a full day of school, it is critical that HSTA have such characteristics.

As HSTA increases in size and geographic location various problems surface, and finding solutions that maintain an adequate level of scientific rigor is crucial. It is important for the teachers and HSTA Curriculum Coordinators to take an aggressive stance towards professional development, ensuring that science education reform strategies are implemented. Through HSTA, teachers have opportunities to apply their professional skills and creativity through innovative curriculum design, such as the UV Rays and Global Changes modules, and the Secondary Level Interdisciplinary Curriculum (Campbell & Meyers, 1997), which was the source for the investigation about bacteria on hamburger.

HSTA students are involved in a personally meaningful learning experience, which increases their own scientific literacy, leadership skills, and awareness of how health issues can impact a community. Through the investigation of a problem, the teacher and students are able to take an additional step towards community issue resolution, thus providing a valuable "community service." The HSTA program and the evaluative research on the teachers and students involved, is an invaluable resource for designing curricula and future science learning environments.

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