

From the Classroom

Using biotechnology, CSI, and zombies to promote science education in one of America's most challenging regions

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is the co-creator of a nationally recognized forensic biotechnology program at James Enochs High School in Modesto, California. He became a teacher after a successful career in business. Acting on a challenge from a guard at a local juvenile justice center to help change the lives of the incarcerated students, Mr. Menshew returned to school and obtained his teaching credential and ultimately his M.A.Ed. and certification by the National Board for Professional Teaching Standards. Mr. Menshew has garnered many honors including being selected as the 2009 BIO Teacher of the Year, 21st Learning Centers Teacher of the Year, and California Foundation for Lifelong Learning Teacher of the Year, and Amgen Excellence in Education Award. Mr. Menshew's passion for education has led him to create learning opportunities for his students that have resulted in superior standardized testing schools, multiple scholarships as well as college and university admissions leading to STEM degrees.

ABSTRACT

This paper examines the creation of a forensic biotechnology program that engages students, promotes science learning beyond the classroom and makes available novel STEM opportunities to an area which previously had little biotechnology educational offerings. Findings indicate improved student performance in comparisons with non-program students in the same school site as well as district and state. Students connect with core science concepts through the use of their existing interest in popular media topics such as Crime Scene Investigation and zombies. Highly motivated learners then have shared their engagement in STEM learning through numerous public science outreach efforts and vertical articulation from grades K to university promoting science education.

Numerous graduates have reported real-world academic value to their participation in the program. Scholarship and college/university applications are enhanced by program participation.

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INTRODUCTION

CALIFORNIA'S CENTRAL VALLEY is home to 19 counties and is one of the world's most productive agricultural regions. It holds 1% of the nation's agricultural land but produces crops comprising approximately 8% of the nation's agricultural dollar value.¹

The city of Modesto is located in the heart of the Valley's agricultural region. This city has attracted national attention for a number of negative reasons. A

former mayor of Modesto as quoted in *The Economist*, cites the "badly educated workforce" as a major reason for Modesto's woes. The article went on to describe the Central Valley as the nation's "Appalachia of the West."² In 2013, Modesto was ranked as #5 in Forbes list of "the most miserable cities in the US" with an unemployment rate of near 15% and a foreclosure rate of 3.8% — third in the nation.³ In 2006, the city was ranked as having the nation's highest car theft rate by the *Insurance Journal*, as it was the previous two years.⁴ In 2014, according to SF Gate, the web publishing arm of *The San Francisco Chronicle* newspaper, Modesto ranked #1 among with "worst places in the nation to start a career."⁵ *Health* website ranked Modesto #10 in the nation in terms of air pollution.⁶

Within this challenging environment an innovative, nationally recognized forensic biotechnology program

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has developed which has served to promote biotechnology and STEM learning far beyond the classroom.

RIGHT TIME FOR THE RIGHT SCIENCE

During the 1999-2000 academic year Modesto City Schools' educators became aware of the "Science on Saturday" public outreaches offered by the Lawrence Livermore National Laboratories (LLNL). The Edward Teller Education Center (ETEC), located at LLNL, began offering professional development workshops for K-14 teachers in a variety of STEM disciplines, including biotechnology. Through these presentations and (workshops at ETEC,) the LLNL Edward Teller Education Center (ETEC), Enochs staff became highly interested in biotechnology.

Dr. Doug Kain, a biotechnology professor at the ETEC, noticed that MCS staff had attended numerous workshops and were appearing at surplus biotechnology lab equipment give-a-ways being held in the San Francisco Bay Area. Dr. Kain was also the lead teacher in a community college biotechnology program at Merced College, 40 miles south of Modesto and was working on building more STEM opportunities in the region. Dr. Kain suggested to the MCS staff that they develop a biotechnology elective for the District. At the same time, he challenged the staff to complete the Associate in Biotechnology degree at Merced College. One accepted and was chosen Biotechnology Student of the Year upon graduation in 2006.

In 2004, staff took the idea of a biotechnology elective to the district Director of Secondary Education, Dave Cooper, who himself was a former science teacher and had a son-in-law who worked in the biotechnology industry. Mr. Cooper had been looking for ways to enhance the district's science offerings. He determined that if the new course was developed, it would be offered at Modesto's newest institution, James C. Enochs High School then being built. He formed a program development team led by himself, the interim principal of James C. Enochs High School, mathematics teacher Philip Jaramillo and life science teacher Dave Menshew. At the same time, a steering committee was formed consisting of the study team, as well as industry and higher education representatives. This group included Dr. Kain, Dr. Elaine Johnson Director of Bio-Link, a National Science Foundation funded organization that promotes U.S. biotechnology education, Dr. Tom Pugh Director of Enology Research at Gallo Wines, and Kirk Brown, teacher at Tracy High school, site of a biotechnology elective program. Also selected was Michael Coats, principal of Enochs High,

along with science educator Dan Iverson, the Science Department chairperson.

SUPPORT FROM THE BEGINNING

Over the following months, several meetings were held by the program development team and steering committee, with several visitations to other biotechnology efforts within the Bay Area and beyond. Substantial support was provided in terms of curriculum direction by Ellyn Daugherty of San Mateo High School, who had been selected as a Biotechnology Industry Organization's Teacher of the Year in 2004. Dr. Johnson of Bio-Link helped to form numerous industry and college/university connections which would prove vital to the program in succeeding years. She also provided opportunities for program staff to attend a variety of learning experiences in the Bay Area including Bio-Link Summer Fellows. This immersive week-long residential experience held at University of California/Berkeley gave staff the opportunities to work with the authors of the adopted texts as well as broaden their understanding of biotechnology topics. She included teachers from Enochs High School in the development of the Bio-Link Depot, a resource where biotechnology companies in the San Francisco Bay area could donate surplus materials for use by local science teachers.

Dr. Katy Kormsmeier of the Bay Area Biotechnology Educational Partnership (BABEC) networked with the Enochs team, becoming a key steering committee member who arranged numerous learning opportunities and material donations as well. Biotech Firms such as Amgen, Bayer, Genentech, Life Technologies, Novartis, VWR and others have supplied the Enochs program with donations of materials estimated at more than \$450,000 during the past 8 years through Bio-Link and BABEC.

Support from other organizations began to expand the network and depth of the program. Early members were the Santa Clara County Biotechnology Educational Partnership (SCCBEP), followed by the East Bay Biotechnology Educational Partnership (EBBEP), the California State University Program for Research in Biotechnology (CSUPERB) and BayBio, a biotechnology industry organization. Each offered Forensic Biotech program staff the chance to attend workshops, consortia meetings and network with Bay Area industry and educational leaders. This worked to deepen the nature of the program's offerings.

LLNL became a key player in staff training and curriculum develop with one of Enochs High teachers completing all four levels of the ETEC STEP program culminating with a summer internship as an ETEC

research associate working on cancer research in the LLNL Biosciences directorate.

Other organizations joined to support the program; for example, Stanislaus County Partners in Education (SPIE) provided an internship at Gallo Wines and later with the Stanislaus County Coroner's Office. This introduced new dimensions in lesson design in depth by rooting them in industry applied learning opportunities in both biotechnology and forensics. At Gallo, teachers participated in yeast crossings and cell mortality studies, enology protocols, and real time PCR. At the Coroner's Office, teachers have assisted in numerous autopsies and learned fundamentals of law enforcement investigations. As a result of this partnership, the program has added an optional senior experience where graduates have the opportunity to observe and in some cases assist in an actual autopsy.

SCANNING ELECTRON MICROSCOPE PARTNERSHIP BROADENS PROGRAM

During the 2011 academic year, staff attended Hitachi scanning electron microscope training at one of the program's partners, Ohlone College in Fremont, CA. Arrangements were made to bring a TM3000 desktop device with a magnification of 35,000x to the campus for a summer training and curriculum development day. Two experts in SEM from Hitachi, Dr. Robert Gordon and Dr. Nancy Weaver, along with Dr. Johnathan Krupp from nearby Delta College worked with a team of eight program students. These highly motivated teens gave up a summer's day to develop the crime scene scenario that was used in class to train their peers. The Hitachi SEM was used to provide images of evidence samples that were then compared with others from crime scene and suspects. The device returned the following January for a week wherein all classes in the program interacted with it, as well as numerous other teachers and visiting dignitaries including school board members and the county superintendent of schools. It returned again in 2013 for a three week period and was used to gauge parasite infestation in a salmon raising project with the California Dept. of Fish and Wildlife that produced 177 Chinook salmon fry from 180 eggs delivered. These were released to a local river.

The use of the Hitachi TM3000 attracted the attention of the International Society of Optics and Photonics, with the invitation to submit a paper which was accepted for publication in 2014. It will be presented in September in Monterey, CA at the Scanning Microscopes 2014 meeting.

U.S. DEPARTMENT OF LABOR TAKES NOTICE

The establishment of the Enochs High Biotechnology Program triggered other events. Soon after classes began in 2007, the local workforce development agency Alliance Worknet approached staff to participate in an application to the U.S. Department of Labor for a \$220,000 Regional Innovation utilizing National Emergency Grant funding. Enochs High staff were contributors on the grant and served on the resulting life science and educational committees for the next three years. The firm of Frost and Sullivan was retained to study the viability of bringing more life science firms to the region. Called the Regional Biotech Diversification Plan, the focus of the study was to examine a region of the Central Valley which included Merced, Stanislaus, and San Joaquin counties. The findings, released in 2008 showed that the region faced both constraints and offered possibilities. Constraints include the minimal number of firms identified as having biotechnology as their principle focus and educational institutions to support them as is seen in the San Francisco Bay Area. At the same time, the tri-county region offers excellent transportation hub possibilities, much lower land and construction costs. In addition the overall cost of living would contribute to a less expensive workforce. It was the recommendation of the study that the region representatives lever their affordability and available development space to attract biotech manufacturing operations while encouraging the same kind of STEM promotion and education already in development in the Enochs High School Forensic Biotech Program.⁷

At the time of this paper, the region is still trying to induce biotechnology firms to consider relocating to the tri-county area. Since 2006, Kohl's and Long's Drugs/CVS, then Grainger Industrial Supply and Affinia Auto Parts in 2011, followed by Amazon in 2013 have all located major distribution centers in the area, utilizing 3.7 million square feet of warehouse space. To date, no biotechnology firms have followed.⁸

ADDITION OF FORENSICS TO THE PROGRAM

As the program was being developed, the decision was made by Mr. Cooper to add a forensic emphasis to engage the students. This required an additional skill set by the teachers who would be teaching the courses as their training was principally in life sciences. In support of this new emphasis, SPIE arranged for teacher internships with the Stanislaus County Coroner's Office as discussed above. To further reinforce student achievement,

the decision was made by Mr. Cooper to use a spiral curricular model aligned to the California State Standards for Integrated Science years 1-3 to satisfy state testing requirements.

First researched by Jerome Bruner in 1960, the basis of the spiral curriculum is that even the most complex concepts can be taught to learners if it is revisited each year over their learning career.⁹ In practice at Enochs High School these meant students would be taught biology, chemistry, Earth science and physics each year.

At the same time, teachers were expected to develop forensic biotechnology units and lessons designed to be highly engaging, building on existing student interest in popular media stories of crime and investigation. The staff were well qualified to do this. Among the teachers was one with National Board for Professional Teaching Standards certification, two holding Master's Degrees in Education with an emphasis on curriculum and Instruction. Course approval for the sequence grades 9-11 was submitted to the district and accepted. California State University and University of California approvals were also sought and granted.

Funding was sought from the California Department of Education under Specialized Secondary Program (SSP) funding. The initial grant was awarded in 2006 in the amount of \$75,000 with additional funding to be supplied through 2008 for a total of \$125,000. Additional funding was given increasing the amount to \$250,000. This was subsequently used to equip the lab classroom, send teachers to training and other curriculum development expenses. All reports were accepted as satisfactory and all obligations met.

START OF INSTRUCTION

Classes began in 2006 with 156 students and two teachers. The classes were all freshmen, with the design that the teachers would move up with their students in what is called a "looping" format. This multi-year teaching approach has shown benefits of teacher-student relationship continuity.¹⁰ This model also promotes the small learning community (SLC) which has been shown to enhance learning. Specifically "a large body of work in the affective and social realms overwhelmingly affirms the superiority of small schools."⁹ Students learn better in smaller schools. Today's high schools, which are designed to maximize the numbers of students who are taught on a given site, can contain well over two thousand individuals. SLC creation is seen as one way to address this issue. Enochs High School was designed to educate over 2400. The student program population in 2014 is approximately 380.

INITIAL METRICS WERE ENCOURAGING, STAFFING A PROBLEM

At the end of the first year, 86% of those who began the program moved up to the second year. Students in the program had grade point averages 0.48 higher than other students at the school. This trend continued in years two and three.¹¹

However, the demanding nature of teaching integrated science was difficult for the teaching staff and proved to be an important factor in program continuation. For example of the two teachers that taught the first year of the program, only one returned to continue, choosing instead to teach no program classes at the site. This pattern was repeated the next two years with three staff members only teaching one year and then leaving. Finally, in the fourth year of the program a second teacher was recruited and stayed for two years leaving after the second.

NEW DIRECTION FOR THE PROGRAM

The turnover in teaching staff became a determining factor in the direction of the program. Since credentialing in California and most states determines who can teach which courses, if a suitable candidate cannot be found, a course cannot be offered. During the 2011-2012 academic year there was only one teacher in the science department who was willing to teach the course as an integrated model and the number of students, now over 300, would make this impossible. It is worth noting that the new Next Generation Science Standards have a similar approach to science teaching. Going outside of the department was problematic due to the collective bargaining agreement.

The compromise was to depart from the integrated science model for years 1-3 of the now four year program. Teachers would now teach previously approved core science already aligned to state standards and tests and accepted by the district. This solution solved many problems simultaneously. Teachers who had attempted to teach the integrated science model and left signed onto the new model. The year three course (Forensic Biotechnology 3) would be resubmitted for CSU/UC approval. A year four seniors' course that had been previously introduced became the Forensic Biotechnology 4.

As mentioned above, initial funding was from California Dept. of Education SSP monies. Ultimately the decision was made to seek California Partnership Academy funds to continue the program past the SSP limitations. This provided approximately \$82,000 in

operating capital. The application was successful but this funding has been declining \$52,000 for the 2014-2015 academic year and isn't certain due to budget changes in the CDE.

LESSON DESIGN AND APPROACH

The approach used by staff to teach the students is to integrate the use of forensic activities to engage the learners. For example, under the integrated science model previously used, a simple magnesium oxide formation lab common to many high school and college chemistry labs becomes a mystery to be solved when a Russian cosmonaut arrives home dead but covered in the substance. In another case, the students are testing samples taken from wells in a community reporting health issues possibly linked to groundwater contamination. In addition to staff created lessons, a forensic consultant has been employed to broaden the scope of the program's lab activities, ultimately creating complete sets of lessons for earth science and biology. Through a series of tests and discussions, students offer solutions to a real world problem. While forensics is used as the engagement tool, the students learn university level biotechnology skills and best lab practices. Students perform experiments directed at solving a crime or exposing an issue rather than simply doing a protocol with expected results. As will be discussed below, this approach will go hand in hand with the Next Generation Science Standards.

DATA SHOWS RESULTS

To judge the effectiveness of the program, a three year study for years 2010-2011, 2011-2012, and 2012-2013 was done by Derek Pendley, Associate Principal of Enochs High. The measures chosen for this study were

to compare the academic performance as measured by the California State Testing and Reporting CST examinations between the students in the Enochs High against those on the same campus not in the program, and those in the district and the state. The findings are worth discussion.

As seen in Figure 1, the California Standardized Testing and Reporting (STAR) average of students who participated in the Forensic Biotechnology program achieving proficient or advanced scores on the California Standards Tests (CSTs) was 78%. This compares with non-forensic biotech students who achieved 59.7%. The non-program students in the district achieved a 46% with the state average being 47%. The STAR is the state's measure of academic performance of students annually. The stated goal of the school district is to raise student scores, hoping to have all students in the advanced and proficient categories.

As a California Partnership Academy, participating students are enrolled as a group in at least three subjects. They move throughout their day in an SLC. A comparison was done between the scores of the students in the program vs. site and district is shown below in Figure 2.

The percentage of forensic biotechnology students achieving advanced scores on the CST Science scores in 2012-2013 is 42%. This compares with 25% for non-program same site students, and 16% for non-program district wide students. Similar positive results were achieved in 2010-2011 and 2011-2012.

The English language arts scores for program students compared with site non-program and district also bear examination (Figure 3).

Here, the ELA scores showed substantial differences between program same site nonprogram and district students. For example, very few of the students in the program were below basic and far below basic in their scores. This is significant in that for all three of the years shown, one of the state requirements is that 51% of the

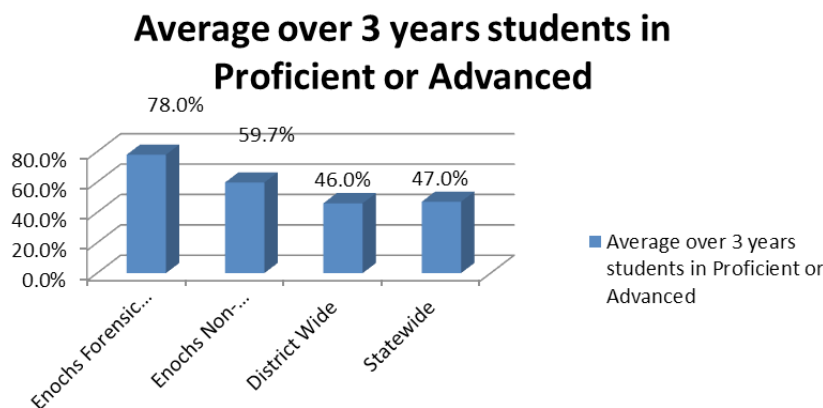


Figure 1: Averages for years 2010-2011 to 2012-2013 (Pendley 2014)

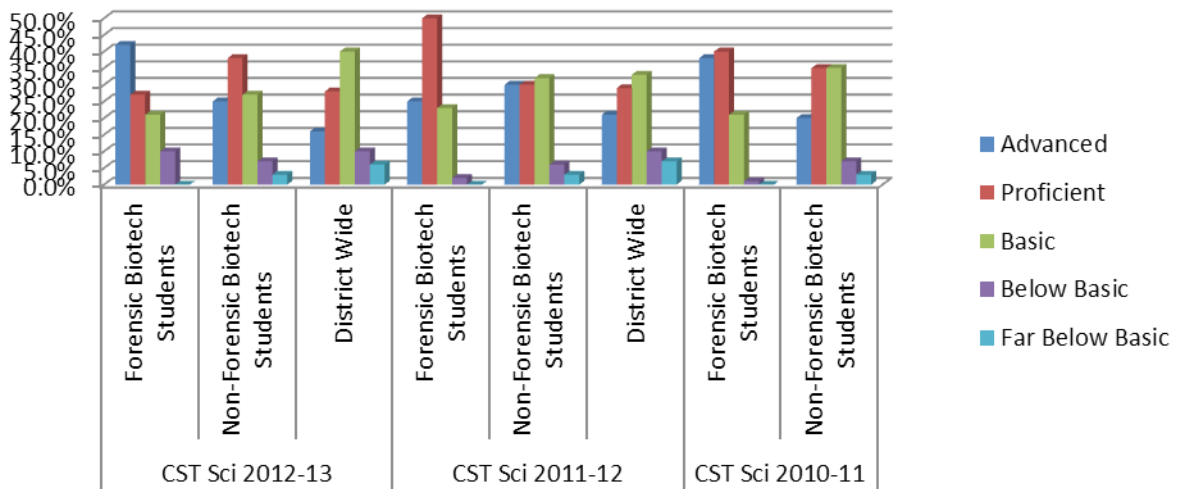


Figure 2: CST Science (Pendley 2014)

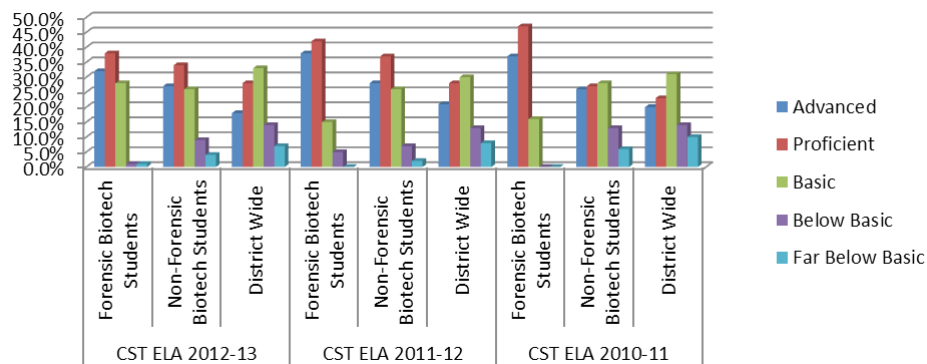


Figure 3: CST English Language Arts (Pendley 2014)

students in the program are to be considered “at risk” by falling in one or more of several categories.

Social Studies (history) scores show a similar pattern. In this case, data was only available for the 12-13 year.

In Figure 4 the total advanced and proficient scores far outperform the non-program site students. You also see much smaller below basic and far below basic of students in the program vs. other site students.

a state that requires none of them to do so. The school was awarded a Silver ranking in 2014 by *U.S. News and World Report* among America’s schools. When polled both formally and informally, students report high degrees of satisfaction with their time in the program, the ability to do investigations far beyond the scope of the textbook, and the support they received from staff.

EXCEPTIONAL POINTS OF LIGHT

Since its inception, the Forensic Biotechnology Program at Enochs High School has both attracted outstanding students as well as been an incubator for others to rise to their potential. By providing numerous innovative learning experiences both in and out of the classroom, this program has led to some interesting experiences and student performance.

For example, in 2010, two of the program’s graduates were accepted to UC Davis. Both were asked to join and

DISCUSSION OF DATA

In terms of the standardized testing, the program has shown significant results. Students in the program outperform their peers at site, district and state. They contribute to a school that has had the highest academic performance index in the region from Sacramento to Fresno for the past three years. Approximately 69% of the juniors at Enochs High School take science classes in

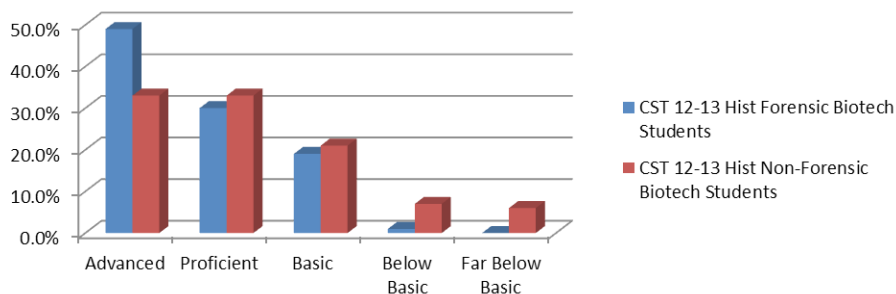


Figure 4: CST Social Studies (Pendley 2014)

work with graduate research teams in their freshman year, one in her first quarter, the second in his third. The first, Alexa Adams went on to become a Google Glass beta tester and was selected as one of *Forbes' Magazine's* 2.0 young Women to Watch for 2013.¹² She plans to do her PhD at UC Davis and will pursue a designated emphasis in biotechnology. Another student, Chris Fiscus has forgone the traditional summer job pathway of fast food and instead works for a local agriculture biotechnology company.

In 2014, two students graduated the program who had successfully completed a record eight years of science coursework. This is significant in that only two years are required for graduation in California. Of these, one was a four year competitive athlete; the other earned his Eagle Scout while still in high school.

In that same graduating class, there were 12 students completing seven years of science, 19 completing six years.¹³ 100% of the students who began year four graduated.

PROGRAM RECOGNITION

Recognition that the Forensic Biotechnology Program at Enochs High was meeting the needs of a community with a limited number of advanced high school learning opportunities came in several forms. Program and staff has been recognized with the following:

- 2007: Amgen Award for Excellence in Education
- 2009: National Biotechnology Industry Organization (BIO) Teacher of the Year
- Association of Mexican American Award for Educational Excellence
- Omega Phi Psi Man of the Year
- Certificates of Recognition by the California State Legislature and California State Assembly
- Modesto City Schools Distinguished Educator Award

- 2010: Outstanding Educational Program of the Year by the Modesto Chamber of Commerce
- 2010: California League of High Schools Nominee
- 2014: Enochs High School Lighthouse Award for Exemplar Service

PROMOTING STEM EDUCATION OFF-CAMPUS

Since the beginning of the program, there has been an interest by staff in promoting science education through vertical partnerships. This led to the creation of the “Fun with Science Nights” public science outreach program. In the fall of 2006, students and staff of the program held Enochs High School’s first event. Estimated attendance was 90 parents with 24 program students presenting core science concepts for their younger peers. The following spring semester’s event resulted in a queue down the hallway of the science building, down the stair case and out the door waiting to get into the 18 learning stations. Administration estimated the attendance at more than 225 parents and children. The massive influx of attendees resulted in a shutdown of the air conditioning system and required fans be brought in. The following year an annual model was adopted and moved to the school’s multipurpose room. The outreach has continued each year in the spring through 2014 with attendees numbering approximately 400+ according to site administrators.

During the 2009-2010 academic year the program was asked to bring its students and science demonstrations to a local elementary school and engage the students during their Science Night. This was reprised the next year, with invitations coming from other area schools. The 2013-2014 year resulted in the highest number of students being engaged with presentations from kindergarten to university. On multiple occasions, program students took the lead in presenting core science concepts. These included supporting a backpack give away to disadvantaged and underserved youth during the

weeks before classes began, to four multiple learning station presentations at several area elementary schools, to hosting three rooms of interactive science demonstrations at a local state university.

ZOMBIES AND BIOTECHNOLOGY

America's obsession with zombies has provided yet another pathway to student engagement. During discussion with students during the summer of 2013, the decision was made by staff and students to pursue ways to include zombies in the lessons. For example, when approached by California State University Stanislaus to present core science concepts to the public during a Saturday science outreach, the students eagerly accepted the challenge. Students and staff designed learning stations with the apocalyptic theme by dressing the rooms to look like those in such shows as *Walking Dead*. In addition, two professional makeup artists donated their time and expertise to make the zombie presenters look authentic. Science concepts including virus structure, disease transmission were taught to a highly engaged and enthusiastic audience numbering in the hundreds during the eight hour day. Forensic concepts taught included analysis of blood spatter. Physiology concepts included perception and the sense of sight. This theme was continued beyond the public science outreaches to our senior class, asking them to bring together the different core science concepts being addressed in this engagement piece and synthesizing presentations to give them experience in higher level thinking skills and inform future instruction. Public response was highly favorable, though some younger students were a bit timid.

ROOM FOR IMPROVEMENT

While the program has been well accepted by all stakeholders, there are a number of areas for improvement and these realizations are providing the direction for the coming years.

While there have been periodic surveys of stakeholders, this has been an area that has not been consistently addressed in the proceedings of the program. While student input is sought throughout the year by way of the classroom discussions, and encouragement is made for all stakeholders to raise concerns, there needs to be a more formalized, data driven mechanism each year. This needs to be an agenda item for the following year's program operation.

The program has benefitted from considerable student input over the course of each year. For example, during the 2013-2014 academic year, former students

contacted the lead instructor 23 times, through a variety of means. Most of these interactions were principally updates on their progress in school, and to express gratitude for the skills they learned in the program, the value of the program in their continuing education. Two students returned to spend substantial time with the instructor to give first-hand accounts. One spent the day giving presentations to current year three and year four students through a PowerPoint he had prepared. Another has provided numerous experiences from her time in the military, connecting to her experiences in the program. It is readily apparent from the demonstrated fact that former students seek out our leadership team and send emails and other communiqués and stay connected. What needs to be done is establishing a more formalized quantitative process, perhaps a professional social media such as *LinkedIn* could be used to initiate the connection while they are still in our program, which may lead to more input overall in years to come.

CONCLUSION

It is anticipated that the adoption of the Next Generation Science Standards will result in new interest in the spiral curriculum model which was a feature of this program when it was first developed. Using this model will reinforce the real world applications and problem solving approach that has been a hallmark of this student learning for the past eight years. Staff have engaged well with the program's demands, but continue to be stressed by the ever increasing nature of today's educational model. For example, the yearly changes in learning management systems, coupled with rigorous testing expectations has drained even the best and most dedicated teachers. At the same time, it is also expected that funding will limit the options to continue teacher training and public outreach. While we believe the model is well proven, its continuance is by no way assured.

BIBLIOGRAPHY

1. Wikipedia http://en.wikipedia.org/wiki/Great_Central_Valley#Economy
2. The Economist: <http://www.economist.com/node/15331478> retrieved 8-10-14
3. Forbes: <http://www.forbes.com/pictures/mli45lmhg/5-modesto-calif/>
4. Insurance Journal <http://www.insurancejournal.com/news/west/2006/06/05/69163.htm>

5. SF Gate <http://www.sfgate.com/news/slideshow/Best-and-worst-places-to-start-a-career-85702/photo-6299487.php>
6. Health http://www.health.com/health/gallery/0,,20490855_12,00.html
7. Frost and Sullivan Draft Final Report 081201 Frost & Sullivan — Biotech diversification plan — draft final report
8. Modesto Bee <http://www.modbee.com/2014/05/11/3334297/national-retailer-eyeing-patterson.html>
9. Educational Partnerships on Spiral Curriculum <http://gearup.ous.edu/sites/default/files/Research-Briefs/ResearchBriefSpiralCurriculum.pdf>
10. Looping: <http://eric.ed.gov/?id=EJ756954>
11. Presentation to Modesto Chamber of Commerce State of Education Conference Modesto, CA 2010
12. Forbes 2.0 <http://www.genomecenter.ucdavis.edu/news/adams-named-one-of-5-girl-coders-under-21-to-watch>
13. Jaramillo, Stacy, Report of students completing three or more years of science at Enochs High School, May 2014

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