Holy Name High School Laboratory Modernization

An Interactive Qualifying Project Report:

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by

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Abstract

Biotechnology and Microbiology are growing areas of biology that many high schools are starting to incorporate into their curricula. Many students are now choosing to narrow down their major in college from a broad life sciences field like biology to a more specialized major like biotechnology or microbiology. With this shift in the life sciences, high schools across the country need to adjust their labs accordingly. This report proposes how Holy Name High School can change their life science laboratories to bridge the gap between high school and university in order to prepare students for this shift to more specialized majors. From there, the paper will propose that there are grounds for a continuing a partnership between Holy Name and Worcester Polytechnic Institute in future Interactive Qualifying Projects.

1.0 Introduction

Life Science is literally defined as the study of living organisms. This area of science includes the fields of biology, botany, microbiology, biochemistry, biotechnology, and others. Around the world, revenue resulting from work in the life sciences has been increasing substantially. According to a study done by Deloitte[10] (Deloitte US), an audit and consulting firm, in 2014 global biotechnology posted revenues of 288.7 billion dollars. This represented an average annual increase of 10.8 percent over a five-year study period. Massachusetts has invested especially heavily in the life sciences in recognition of the economic potential that this area of technology can bring to the state. In 2008, the Massachusetts Life Sciences Center was founded, and tasked with implementing the Massachusetts Life Sciences Act, a 10-year, 1-billion-dollar initiative that was signed into law in June of 2008. The mission of the Massachusetts Life Sciences Center is to create jobs in the life sciences.[1] (Massachusetts Life Sciences Center). As a result, many educational institutions have started investing in the life sciences and biotechnology as well. Massachusetts is currently one of the leaders in life sciences with Tufts University, Brandeis University, Boston University, and Worcester Polytechnic Institute all among the leaders in biotechnology education and research, one of the fastest growing life science fields. Biotechnology is the use of biological processes, organisms, or systems to manufacture products intended to improve the quality of human life. Biotechnology has been around for a long time, an early example being farmers cross-breeding their crops to improve the genetics of them. Recently, biotechnology has become more sophisticated with much of the work being done at the molecular level dealing with cells and DNA. This shift in life sciences has created a rift between the high school and college levels because biotechnology equipment is expensive.

Holy Name High School is one of the institutions that has realized that implementing a biotechnology aspect to their life science curriculum will provide excellent opportunities to their students in the future. The most difficult part about implementing biotechnology into the curriculum is that labs are essential to the learning process. Biotechnology equipment is expensive, and different from the equipment used in typical high school biology and chemistry

labs. To address this problem, Holy Name requested help from Worcester Polytechnic Institute as the University has state of the art biology labs, and many experts in the fields of biotechnology and biology in general. Dr. Audette, the principal of Holy Name, requested that a group of Worcester Polytechnic Institute students create a proposal for equipment that needs to be added to Holy Name's laboratories to be able to implement biotechnology into the current life science curriculum that he could then bring to potential donors to request funding. Holy Name hopes to create excitement, and encourage their students to pursue careers in life science with improved labs.

The project will improve the general state of the labs, and Holy Name is hoping that the improvements will not only improve the quality of education at the school, but will further enhance the attractiveness of Holy Name to high achieving students. Currently the top high schools across the country are introducing biotechnology into their curricula to stay ahead of the curve, and in creating a state-of-the-art life sciences laboratory Holy Name will join this select group. With this new laboratory, Holy Name High School students will be better prepared to move into college majors like pre-med, microbiology, biotechnology and more.

2.0 Methodology

Background research will be done looking into certain High School's and college's life sciences curriculums. Research will be used to help upgrade the life science curriculum at Holy Name High School. They are interested in expanding their life science program with an emphasis in biotechnology and microbiology. In addition to the three students from WPI there will be four Holy Name students working closely on the project. Those four students will be taking an inventory of Holy Name's laboratory materials and the entire student body will be taking a survey about how interested they are in science and how an improvement in the courses might influence more students to take science classes. There will also be a survey taken by the alumni board at Holy Name to see if they pursued a career in science and would they have if Holy Name High School had offered more modernized classes and laboratory equipment when they were in school. With all the information gathered there will be a proposal for new equipment that will help Holy Name modernize their program.

2.1 Holy Name's Requests

Dr. Audette recognized that the life sciences field is quickly changing across the world, and as a result the life sciences lab needed to be upgraded to accommodate the changing times He feels that life sciences are just as important as what he called the "hard sciences" (engineering, math) because of the expanding fields of Biomedical research and Biotechnology. Holy Name already has great interest in these "hard science" fields, but not many students going on to major in Biology, which is a quickly expanding field in science today. Dr. Audette was quick to set up a meeting between us and the Holy Name science department in order to allow us to inquire about what the teachers believe could improve interest in Biology.

2.2 Major Tasks

We will bring a framework to Holy Name High school that will help them see where their laboratories are lacking and what the most important tools are. This framework also includes an insight into the minds of the students at Holy Name to see if they would be more interested in a more modernized lab and if the new lab equipment would help them learn more effectively. This will prepare the students and will keep them from falling behind once they reach a higher level. The project will also create a connection between WPI and Holy Name High School that will encourage other WPI students to start doing projects that help schools around the area. Below are the Major Tasks that were accomplished throughout the course of our IQP. Each point is expanded on throughout the course of this report.

Proposal-

- Introductory information
- Background research
- Detailed task list
- Member information

Research-

- Inventory of Holy Name Laboratory
- Information from biology teachers (WPI and NABT) about high school laboratories
- Information from Martha Cyr about high school learning

• Holy Name lab experiments • Other schools lab experiments • Learning in college
Holy Name Student engagement- • Taking an inventory of their laboratory • Helping the WPI students survey the current students at Holy Name High School • Learning how to be prepared for college • Hands on project that encourages them to pursue a career in the life sciences
Final Report- full project report including: • Abstract • Introduction • Background Research • Research on high school learning techniques • Research on laboratories at multiple schools • Research on Laboratory Equipment • Methodology • Surveys we give to the students at Holy Name • Inventory of Holy Name's Laboratory • Goals and Deliverables in the form of a brochure (attached in the appendix) • Conclusions • Thoughts from each group member

Table 1. List of Major Tasks.

3.0 Background Research

High School education is constantly changing, and as a result certain high schools sometimes have trouble maintaining up to date laboratories. There are many factors that go into high school science education, a few include style of learning, learning environment, and the quality of laboratories the students have available to them.

3.1 Flipped Classroom

To start our research, the group thought it would be a good idea to learn about high school education, and the teaching styles that are employed in today's classrooms. We contacted Martha Cyr, who is the director of K-12 Outreach at WPI. We learned a lot about how high school classrooms are evolving. College has long been formatted as a flipped classroom, where students are expected to learn the simple topics outside of the classroom in a textbook or online, and the complex topics are taught in the classroom, where students can ask the teacher questions[13] (Cyr). High schools have slowly been moving towards this style of teaching because you can teach more in depth concepts to the students, and Dr. Audette confirmed that flipped classrooms have been implemented throughout Holy Name. However, this style of learning tends to be difficult for high school students who haven't developed good study habits yet, and many students complain that "the school is supposed to teach them, not a book," so as college students we can reinforce that flipped classrooms are typically the way that college classes are run, like their teachers say.

3.2 Biotechnology in Other United States Schools

One way to gain insight into how the high school life sciences curricula are changing across the country is to look at how some of the top high schools in the country are implementing biotechnology themselves. Information on the biotechnology programs at Henry M. Gunn High School in Palo Alto, California, and Sturgis Charter Public School in Cape Cod, MA is included below.

3.2.1 Henry M. Gunn High School

Henry M. Gunn High School is located in Palo Alto, California. Palo Alto, California is in the heart of Silicon Valley, which makes it one of the leading science schools in the country. Recently one of their students was a finalist in the U.S. National BioGENEius Challenge, a competition to "provide high school students the opportunity to compete and be recognized for outstanding research in biotechnology. Students have the opportunity to apply and compete for top honors in the Global Healthcare Challenge (Medical Biotechnology), the Global Sustainability Challenge (Agricultural Biotechnology) or the Global Environment Challenge

(Industrial/Environmental Biotechnology)[12]" The competition is run by the biotechnology institute. The student's project identified a treatment to minimize infections for patients with Multiple Sclerosis. Students' entries into projects like this promote interest in the life science fields.

Henry M. Gunn High School promotes learning in the fields of the sciences in another way. If you search "Gunn High School biotechnology," the first link is a page on their website with a description of the biotechnology class that the students can take at school. The description is as follows:

> "This course will introduce students to the theoretical aspects of Biotechnology (Cell Biology, Microbiology, Molecular Biology, Immunology) and societal issues arising from this new technology. Hands on laboratory activities will reinforce theoretical information and teach lab safety, data analysis, the scientific method, and related computer skills. This course will include topical speakers from biotechnology industry and research and field trips to visit nearby biotech industry sites and labs"[6] (Henry M. Gunn High School).

With information right on their website, not only can the students at Henry Gunn High School find out about the class outside the school, but their parents can also find out, and encourage them to sign up for the class.

3.2.2 Sturgis Charter Public School

Sturgis Charter Public School is located in Hyannis, MA, which is on Cape Cod. Sturgis Charter Public School does not have a dedicated biotechnology class, but rather they have started to integrate biotechnology and microbiology into their normal biology classes via a grant from the Massachusetts Center for Biotechnology Education[11] (Gold). Also, they have some pictures of students conducting biotech experiments on their school's social media pages. This helps bridge the gap between the students and institution.

3.3 Science Fairs around Worcester

There is a Massachusetts State Science and Engineering Fair (MSSEF) that has many rewards and benefits for students from High Schools in Massachusetts. Students can experience the real world discovery process by working on a real world problem and coming up with a solution through an invention or design.

This fair is open to the top 400 students in Massachusetts and the best scientific research and engineering design. There are $500,000 given in scholarships and prizes each year, meaning it is a huge opportunity for High School students to receive monetary benefits that will help when they go to college. Students can also compete for the "Fish & Richardson Patent Award" that provides for legal expenses to patent your design. There is first a regional science fair which for northeastern Massachusetts is at Somerville High School for high schoolers and the University of Massachusetts Lowell for middle schoolers. Each regional fair can send 40-50 students from their region to the Massachusetts state fair. Registration is in March and this fair is a great opportunity for aspiring engineers to get a taste of the real world. The MSSEF promotes inquiry-based learning and workplace skills such as communication, teamwork and a strong work ethic. Science fair involvement requires a broad range of essential life and career skills: reading, writing, math, critical thinking, ethics, communication and graphic arts. Students must use all of these skills when conducting research, analyzing data and presenting their projects to expert judges and mentors. Even if a student does not make the State Fair, the regional and school fairs are also an educational experience. Students can present their ideas and take in other ideas to broaden their knowledge of science in general.

The regional science and engineering fair for Central Massachusetts is held at WPI. From this regional fair the top 40 projects will move on to the MSSEF and the top 5 will be invited to participate in the International Science and Engineering Fair. The Worcester Regional Science & Engineering Fair encourages scientifically talented Worcester area high school students to enter the annual fair held at Worcester Polytechnic Institute. It is not necessary for a school to hold its own science fair in order to enter the Regional Fair. Students involved in research or independent study projects may enter directly. Each school may send up to twelve projects to the regional fair each year. Students must inform and consult with their science teacher and

school before beginning a science research project. They also need to make sure they have filled out all the forms they need to start their project which can be accessed by using the MSSEF online wizard that leads them through an account process[12] (MSSEF).

3.4 Massachusetts Biotechnology Education Foundation

A great resource that can help students plan for a career in STEM is the Massachusetts Biotechnology Education Foundation (MassBioEd). It has a lot of information about the possible career paths for students looking to be in the biotechnology field. For each career possibility listed on their website (massbioed.org), MassBioEd gives a description of the specific topic then gives a suggestion to where someone in the specific field would be able to find work[8] (MassBioEd).

3.5 Career Opportunities

Biotechnology is an emerging field of Biology. As an innovative field of industry, lengthy research and development efforts are needed before products can be delivered to the marketplace. In its initial research and development phase a biotechnology company requires individuals with advanced degrees, but as the company moves into a manufacturing phase more individuals with good basic science and laboratory skills are needed, and science friendly high school graduates or individuals with an associate's degree can find entry level employment in the industry.

The number of firms devoted to biotechnology research and manufacture of products is growing. Industries that apply biotechnology techniques include human therapeutics and diagnostics, veterinary, agricultural, food processing, aquaculture, chemicals, waste management, energy and environmental protection, and forensics, the application of medicine and science to law. Government and universities also employ individuals educated in biotechnology[10] (Deloitte).

Proficiency in life sciences is an important skill for both high school and college students because it gives them direction. It gives them an idea about what they could be doing for rest of their life if they decide to pursue a career in whichever field they choose. It is extremely important to recognize these opportunities and take advantage of them because STEM is a fast growing field of study for the entire country. According to the U.S. Department of Commerce,

occupations in STEM fields are expected to grow by 17% by 2018 which is almost double the rate that non-STEM occupations are growing[22] (U.S. Department of Commerce). In addition to that, according to the U.S. Department of Labor, by 2018 there will be over 1 million job openings in STEM related fields in the U.S.

3.6 The Massachusetts Life Sciences Center

The Massachusetts Life Sciences Center (MLSC) is an organization that implements initiatives to support innovations, research, development, and commercialization in the life science area. Through their programs, they have helped Massachusetts become one of the global leaders in life sciences. Their mission is to continue to strengthen Massachusetts' reputation as the hub of the life sciences. MLCS is also driven to use their investments to inspire innovation in science and business as well as to use the funding to discover new and improved treatments for patient care.

The Massachusetts Life Sciences Center has already invested approximately $575 million in state funding and as a result has created thousands of jobs in the commonwealth. Their two main areas of the state have been Boston, Massachusetts, with $150 million in funding, and Central Massachusetts, with a total of $139 million in funding. A list of some of the current funding programs are as follows: Accelerator Loan Program, International Program, the Internship challenge, and STEM Equipment and Supplies Grant Program[1] (MLSC).

One of the programs funded by the MLSC is an Accelerator Loan Program. This program was founded to support new companies that are still in the early developmental stages. The loans will typically go to companies that promote new jobs and have potential for rapid growth, private equity financing, and technology commercialization. Each loan has a cap of $750,000. The Massachusetts Life Sciences Center has already funded more than $21.7 million to 31 companies[1] (MLSC).

The International Program grants between $50,000 and $200,000 to Massachusetts companies. These companies should support research and development with companies on foreign soil. The goal is to help support these cooperating organizations make scientific and commercial breakthrough.

The MLSC also has a program dedicated to improving the future talent force in the life science industry. This program focuses on current college students and recent graduates by provided them with hundreds of new internship opportunities to small businesses. The internship usually runs between May 1st and April 30th. Companies are allowed to hire up to 2 new interns and are reimbursed by the MLSC for the intern's pay rate of to $17 per hour.

Middle and High schools who are in need of new life science equipment can apply for the Stem Equipment and Supplies Grant provided by the Massachusetts Life Sciences Center. The new equipment is used to increase the interest in students in the STEM fields. The MLSC has already donated $12 million to over 100 different middle and high schools in Massachusetts. The two most funded areas of the state is the Greater Boston area with $2.6 million already donated and the south east section with $2.5 million in funds[1] (MLSC).

3.7 Massachusetts Life Sciences Center Internship Challenge

Pursuing a career in STEM allows a student to have many opportunities in Massachusetts when they get out of college. One of these many opportunities is the Internship Challenge. The Massachusetts Life Sciences Center (MLSC) offers this great opportunity that is trying to place college students and graduates in paid internships across Massachusetts. The program's goal is to enhance the talent of young workers for Massachusetts companies in the life science field. It is designed to create hundreds of paid internship opportunities each year by assisting small businesses in hiring young, talented students or graduates. By doing this the MLSC is grooming the new wave of workers needed by the life science industry.

Objectives of the Internship Challenge include giving the young talent practical experience in their field, enhancing opportunities for mentoring, enabling more students to explore career opportunities despite the challenging economic environment, and providing a peer network through educational and informational networking events to students interested in working in the life sciences. Students or recent graduates that are looking for either a part or full time internship have to first fill out the online application, which includes their resume and a cover letter. While the applications are accepted all year long, they will expire after six months if it is not renewed. The companies that are involved in the Internship Challenge have

to register with the MLSC first and once they have been approved they will have access to the MLSC database of prospective interns. Then the company will be able to view resumes, interview possible candidates, and select interns that fit the company's needs. Each company is allowed to hire up to two interns in a Program Year which is from May 1st to April 30th. Companies will also have the option to hire up to two additional interns that are enrolled in a 2-year/community college or certificate program. The MLSC will reimburse eligible companies for pay rates of up to $17 per hour for a total reimbursement of no more than $8,160 per intern at the conclusion of the internship. The most important aspect of this program is that since it has started in 2009, the MLSC has placed over 2,000 interns at more than 500 companies in Massachusetts. In addition to that in 2012, the MLSC received an $800,000 grant from the U.S. Department of Labor to expand the Internship Challenge over 4-years as part of the $5 million Metro Boston Skilled Careers in Life Sciences (SCILS) initiative to grow and maintain the area's life sciences workforce.

3.8 High School Labs

A high school science teacher from a Massachusetts High School contributed a few of her life science labs to the project, along with a student from a Massachusetts community college. The high school labs are examples of the standard high school for the state. The college lab is a more rigorous lab intended for a more intense class. Holy name ultimately wants to transform the quality of their lab experiments into entry-level college labs.

The list of materials specified in the lab report are not much more than a few beakers, test tubes, and supplies that can be picked up from a local super market. Having a high prestige science program requires having up to date lab equipment. Often times when students take a lab based class for the first time, they are unfamiliar with the tools used in the experiments. The students with prior knowledge of the equipment will be able to get a jump start over those who have never used it before. This is why having modernized lab equipment is crucial to obtain a high reputation for the life sciences program.

There are also a vast amount of lab experiments available online through different organizations that could be used at Holy Name. Some of these labs are outlined below, along

with some specific biotechnology textbooks that could be used if Holy Name wanted to implement a biotechnology specific course.

3.8.1 List of Current Biology Labs from Biology Department at Holy Name

The labs listed below were given to our group from the science department at Holy Name High School.

Introduction to the Microscope:

Students learn how to use the microscopes and to make wet-mount slides.
Materials: Slides, Cover slips, water, colored thread, newspaper letters, and a piece of hair.

pH Lab:

Students test the pH of different substances when different amounts of an acid (HCl) and a base (NaOH) are added to them in increments of five drops up to thrity drops.
Materials: Beakers, pipettes, 0.1M HCl, 0.1M NaOH, water, vinegar, Ginger ale, and Milk of Magnesia.

Testing for Organic Compounds in Foods:

Students use different reagents to test foods to see if they contain carbohydrates, lipids, or proteins.
Materials: Beakers, Test tubes and test tube rack, hot plate, Benedict's solution, Biuret's solution, Indophenol solution, Lugol's iodine solution, brown paper bag pieces, Vegetable oil, Apple juice, Potato, Bread and Orange juice.

Are Corn Seeds and Kidney Beans alive:

Perform a tetrazolium test and a germination test on corn seeds and kidney beans to see if they can be considered alive. The tetrazolium will turn pink or red in the presence of hydrogen on the corn seed or kidney bean if they are alive. In the germination test, the corn seed or the kidney bean will grow a cotyledon or an embryonic leave if they area live.

Materials: Corn seeds, kidney beans, Tetrazolium reagant, Petri dishes, forceps, scalpels, paper towels, pipettes.

Cells and Movement of Materials:

Diffusion through Dialysis Tubing: A starch solution is put into dialysis tubing, and each end of the dialysis tube is tied off. The dialysis tubing is placed in a beaker of water that has Lugol's iodine solution added to it. Let the dialysis tubing stay in the beaker overnight, and observe the next day to see if any diffusion has taken place.

Materials: Beaker, Dialysis tubing, Lugol's Iodine solution, 15ml Starch solution and water.

Diffusion through a Balloon: A test to see if certain substances smell, such as vinegar or vanilla extract, can permeate through a balloon that acts as a selectively permeable membrane.

Materials: Balloons, pipette, Vinegar and Vanilla extract.

Osmosis Lab**:** This lab is used to demonstrate if certain substances will move into or out of an egg. First, an egg is placed in vinegar for 48 hours. Than, it is placed into water for 24 hours. Last, the egg is placed in syrup for 24 hours. Each time the circumference and the mass of the egg are taken, along with observations.

Materials: Beaker, egg, scale, Vinegar, water, and syrup.

Microscope Cell Lab:

Students make their own slides and view some prepared slides under the microscope of different cells. The goal is to prepare their own slides correctly, and to pick out different features and parts of the cell from various different cell types. The students make an onion skin slide and a cheek cell slide. The onion skin slide is prepared using Lugol's iodine solution, and the cheek cell slide is prepared using methylene blue. The prepared slides to be viewed are the plant cell, the paramecia, and frog and human blood. The students, also, use hand held microscopes attached to the computer to view skin cells on the computer.

Materials: Slides, cover slips, pipettes, onion skin, cheek cells, Lugol's iodine solution, methylene blue, salt solution and prepared slides (plant cell, paramecia, and frog and human blood).

Exercise and Pulse Rate:

Students design their own experiments to test the effects of different exercises on pulse rates. The students are responsible for determining the pulse rate of the test subject before exercise and after exercise, what exercises will be performed, how many trials will be performed, and what the time length for each trial will be.

Materials: Pulse rate monitor or a pulse rate app.

**The students, also, perform dissections on the earthworm, the starfish, and the frog.

Cellular Respiration in Peas:

Comparing O_2 and CO_2. Students measure the amounts of O_2 and CO_2 over time, for peas of different conditions (germinating, in cold/warm temps, in water), using data to explain the process of cellular respiration.

Materials: peas, vernier oxygen sensor, vernier carbon dioxide sensor, 2 vernier brio chambers, 2 Labquest interface

Pineapple Enzymes and Jell-o Molds:

Students mix prepared pineapple (cooked, frozen, blended, sliced) with jell-o to test the performance of the fruit's enzymes, ultimately explaining the effects of a denatured enzyme

Materials: test tubes & rack, beakers, Jell-o, fresh pineapple, canned pineapple, boiling & ice water, spoons (or stirring rods).

3.8.2 Possible Biotechnology Labs for Holy Name

The first possible lab to run asks "How can we use genetic engineering techniques to manipulate heritable information?" This lab is a bit more complicated, and would be useful in an AP biology class, which Holy Name just started this year. The equipment needed is a bit more complicated. It requires inoculation loops, petri dishes and multicolored micro centrifuges. This lab investigates the E. Coli bacteria to express new genetic information using a plasmid system and apply mathematical routines to determine transformation efficiency. This lab also allows the students some freedom to select a factor of their choice and determine its

effect on the mutations of observable phenotypes or investigate if bacteria take up more plasmid in certain environmental positions. (AP collegeboard).

Another possible biotechnology lab that could be used is an Introduction to Electrophoresis. Electrophoresis is one of the major tools of biotechnology, and is used to separate DNA or protein molecules. Based on the charge that is applied to a gel containing some material or particles, the researcher can extract the molecules that they would like to study from the rest of the material. This is most commonly used to analyze DNA or RNA. A lab on modernbio.com describes a good introduction for students to learn electrophoresis. After conducting the electrophoresis, the students can then use dyes to learn about how drugs and chemicals bind to DNA. This is a common technique used in microscopy, which is the field of using microscopes to view objects that can't be seen with the naked eye[4] (Bokor).

Learning about DNA is essential to the field of biotechnology. A relatively simple one is replicating DNA. The purpose of replicating DNA is that only a limited amount of DNA can be harvested from DNA extraction, but if scientists can replicate that same DNA, the scientist can essentially have access to as much DNA as he or she pleases[4] (Bokor).

3.9 AP Biology Curriculum:

The framework for Advanced Placement (AP) curriculums are generally the same across the country. College Board is the organization which developed the advanced placement program in 1955. College Board overseas all 38 AP programs and examinations. One of said AP courses is AP Biology. The AP Biology curriculum consists of what they term: the "4 Big Ideas"[7] (The College Board). The first topic is the process of evolution. Big idea number two covers the building blocks of cells and energy. The third topic is all about living systems. And the last big idea goes over the interactions of biological systems.

The AP Biology curriculum lists a set of requirements that the program must follow. The teacher must base the curriculum from the most recent version of the course and exam description. The teacher must also use a biology textbook for the course that has been published within the past ten years. The student directed lab experiments should allow the

students to partake in two labs per “big idea” and labs should take up 25% of the time spent in class. This leaves plenty of time to integrate the new life science laboratory into the AP Biology curriculum. Along with the lab experiments, the students must be provided with opportunities to meet the learning objectives described within the four big ideas. Lastly, the students should be provided with opportunities to connect what they have learned to social issues to better improve the scientific literacy of the students.

Part of the AP biology requirement consists of an AP examination for the students. The examination is composed of multiple choice questions along with five open response questions[6]. The topic of these questions comes directly from the big four ideas. Students are not required to memorize equations; however, they are expected to apply the knowledge learned in the course to answer questions about concepts in the biology course. For the open response questions, the students must be provided scientific evidence and reasoning to support their claims. The scoring for the AP exam is based on a one to five scale, 5 being the highest and one being the lowest. If the student scores high enough on the exam they may be entitled to college credit if the school accepts the score.

3.10 Biotechnology Textbooks

A search for an introduction to Biotechnology textbook brought back a lot of results. There are many different books in different price ranges, but upon further research, a syllabus for a certain High School’s biotechnology course popped up, and their assigned textbook was called Microbiology and Biotechnology Biozone Workbook. This workbook is designed to engage the students in activities to teach the students the role of microorganisms in traditional and modern biotechnology. It is a paperback workbook that would not cost that much for Holy Name High School. The books sell for $20.95 each, but if you buy them in bundles of five which I would recommend for Holy Name they would cost $14.95 each. This book is the third edition and is recommended for grades 10-12 for biology and biotechnology[22]. This book might be the best option for Holy Name High School when they start introducing biotechnology as a new course.

Pearson Higher Education makes an Introduction to Biotechnology book that is written by William Thieman. William Thieman is a former professor of Ventura College, who chaired one of the leading biotech programs in California. The co-author is Michael A. Palladino, a molecular biologist with experience in directing undergraduate student research[23]. The books is available in a student's edition and a teacher's edition, so there is plenty of homework and test materials for teachers to pull out.

Another possible textbook is Biotechnology for Beginners by Reinhard Renneberg. This book has earned 4.5 stars and excellent reviews on Amazon.com. One reviewer, Erik Baark, said, "It is often a problem to find books that help you understand the scientific and technical intricacies of a new phenomenon… Renneberg's Biotechnology for Beginners is the best introduction that I have read recently which achieves this purpose eminently." The students may find this book less dense than most textbooks in their other classes, which would help them get the most out of the subject matter. The book retails for 50.70 USD on Amazon[16].

3.12 Meeting with Adam Epstein from WPI Admissions

With the potential of getting new life science equipment, Holy Name has the chance to break ground on some new possibilities. If they were to add an AP chemistry course, not only would they be broadening their students' possibilities, but they would also make their educational level more rigorous. Another course Holy Name could add would be biotechnology. Unfortunately, high schools don't have specific guidelines for such a course and biotechnology could range from basic information on the subject to a lab based course[2]. Holy Name could also work with Project Lead the Way, a non-profit organization, to develop a STEM curriculum. PLTW also provides development training for the instructors. If Holy Name were to team up with PLTW they could be awarded credentials from the organization that they could send to universities along with students' applications to state that they have a taken the steps necessary to be a leading school in the STEM subjects. This will not only improve the school's reputation but it would also improve their students' chances of being accepted into STEM based universities.

3.13 Holy Name Prospective Students Night

At the Holy Name High School there was a prospective students' night where students that are interested in attending Holy Name came to find out more about the school. Many of the prospective students were interested when they heard about the project and wanted to know more. They were impressed by the dedication of the school to get the students ready for a college career. There were also a couple of WPI and Holy Name alumni at the event that were impressed with the project and seemed happy with the partnership between the two schools. Many of the students who came to the booth were very interested in the STEM subjects. Based off of the feedback, modernizing Holy Name's life science labs would help the high school recruit these potential students and WPI's name would be in the mind of these students as they get prepared for college. Even students who were entering the junior high level inquired about potential collaboration projects with WPI. At the moment there are none for the level but it poses a potential new relationship that can be built off of this current project.

4.0 Project Implementation

4.1 Meeting with Teachers

On January 28th 2016, a meeting was held with Holy Name High School life science teachers, Ms. Palumbo, Ms. Gray, Ms. Cox, Ms. Rabidou. The teachers will be working with the students while they collect the inventory by answering any questions the students have about equipment and materials. The four students elected to split up into two groups: one group will be dealing with the lab materials, while the other group will be dedicated to surveying of the student body.

The survey focused students will be in contact with all of the Holy Name teachers about posting an online survey for the student body to take. The teachers in the meeting agreed that the best way to collect the data is to dedicate a time for all of the students to complete the survey while in homeroom. There was an inquisition about posting a question on the survey to identify the gender and grade of each participant. The result of these polling questions would provide further information into the future students of the school.

The teachers were also very interested in a relationship with WPI, and the opportunities and resources that WPI might be able to provide to Holy Name. The biology teacher was interested in bringing her students to a WPI lab that has a photo spectrometer because the high school does not have the resources currently to acquire one, but she feels that students would be much more interested if they saw a piece of technology like this in action. Also, one of the teachers asked if it would be possible to receive donations of old equipment from WPI, as grants are hard to come by for a catholic school.

4.2 Student's Inventory of Current Science Laboratories at Holy Name

When we first met with the administration at Holy Name High School, we communicated that we needed an inventory to get started. Dr. Audette introduced the group of WPI students to four students, Jacob Duquette, Grace Lawson, James Trottier, and another student who requested not to be named in the report. These students were responsible for

taking inventory of the four rooms that science equipment is stored in. The complete list of inventory taken by the students is included in the appendix.

4.3 Biology Department Suggestions

In order to learn more about what would be in a high school biotechnology lab, the IQP team reached out via email to The National Association of Biology Teachers. The first person that was contacted was Loreen Meyer. She first recommended that our group look at the AP Biology curriculum because the curriculum has some biotechnology experiments included in it. As for equipment, she suggested gel electrophoresis equipment, micropipette guns and consumables, temperature controlled water baths, a centrifuge, and heating blocks. She also encouraged that Holy Name acquire the BLAST software, in place of a photospectrometer. Laureen Meyer forwarded my email to a few other people who added that a thermal cycler or PCR machine, an incubator oven, and an autoclave would be essential to a state-of-the art biotechnology lab.

4.4 Meeting with the Holy Name Administration

On April 1, 2016 the WPI students met with Principe Audette, Headmaster Reynolds and Mr. Anderson (director of development) of Holy Name High School. After taking a look at the current inventory list presented by the Holy Name students and the list of equipment recommended by WPI professors, the proposed budget would be around $16000 to obtain the state of the art equipment. To begin the meeting a pitch of the proposal was presented. The reaction from Dr. Audette and Headmaster Reynolds was very positive. They believed that they would be able to receive a total of $20000 in donations as a baseline.

In a prior meeting with the teachers of the science department, the teachers showed interest in particular pieces of equipment. They wanted to know if a photo spectrometer would be useful to invest in. The professors at WPI deemed the photo spectrometer not important enough for the school to buy and instead proposed software called BLAST which replicated the use of a photo spectrometer and the software is completely free. They also asked about an autoclave. This apparatus is a pressure chamber used to carry out experiments that require elevated temperatures and pressure that is different from ambient air pressure. Headmaster Reynolds discussed a potential auto clave that Assumption College no longer uses and could

potentially get for free. Between the unnecessary purchase and the free autoclave, this opens up some room in the budget for more equipment or renovation to the rooms.

From there, the administration inquired about what the lab equipment would be used for. Holy Name's curriculum would be more accelerated than other schools' because most local high schools do not have the lab equipment that this report is proposing Holy Name acquire. Part of the proposal includes more intense lab experiments and accelerated curriculums. Most of the proposed equipment is used for biotechnology style courses this opens a door for Holy Name to introduce a new biotechnology course. From the survey taken by the Holy Name students (see survey results for more information) the results show that the upcoming upper classmen would be inclined to partake in a biotechnology course if the school would be able to revamp the lab equipment.

Finally, they discussed how they would use the proposal to improve the science department. They wanted to use the money to improve the aesthetics of the classrooms either equally across the current rooms or use it to revamp one room as the "Life Science Learning Center". After much discussion they seemed to prefer the latter option. The life science learning center would be a state of the art multi-purpose lab room. Since most of the equipment is easily portable they would store the tools in there and teachers would be able to check out the equipment if the room was not available. The next step for Holy Name would be take this entire proposal to other donors in hopes that after seeing this improvement, they might be more inclined to donate more money to put towards more renovation of the other class rooms.

4.5 List of Suggested Equipment

Below is the list of suggested materials for Holy Name High School. The list was compiled from suggestions from biology staff from WPI and outside research. Holy Name will be sufficiently prepared to integrate biotechnology labs into their science curriculum. A further, more thorough, list that was provided to Holy Name is included in the Appendix.

Item	Quantity	Price	Estimated Total Cost
BioClave Mini (8L) (autoclave)	1	$3,060.00	$3,060.00
Ready Pouch 2% Agarose Gels	4	$80.00	$320.00
Gel Electrophoresis Tray	40	$30.75	$1,230.00
TAE Buffer for Electrophoresis (1L)	5	$85.25	$426.25
Carolina Gel Electrophoresis Chamber	4	$269.95	$1,079.80
Electrophoresis Power Supply	4	$108.00	$432.00
Vernier Gas Pressure Sensor	4	$83.00	$332.00
Vernier Temperature Probe	4	$29.00	$116.00
Vernier pH Sensor	4	$79.00	$316.00
Centrifuge mini centrifuge tubes (500 ct.)	1	$69.00	$69.00
Capp Rondo Centrifuges CR-68X	2	$399.00	$800.00
classroom micropipette 20-200uL (8 ct.)	1	$995.00	$995.00
classroom micropipette 2-20uL (8 ct.)	1	$995.00	$995.00
MultiGene Mini Personal Thermal Cycler 18x.5mL tubes (PCR Machine)	1	$2,725.00	$2,725.00
5L general purpose water bath	2	$386.00	$772.00
Heating Block (compatible w/ four different sizes)	1	$735.00	$735.00
Thermal Cycler tubes (500 ct.)	1	$54.00	$54.00
250 mL beaker	15	$5.30	$79.50
400 mL beaker	15	$6.20	$93.00
600 mL beaker	15	$7.85	$117.50
250 mL Erlenmeyer Flask	10	$6.40	$64.00
500 mL Erlenmeyer Flask	10	$7.95	$79.50
Lab Companion Incubator (economy model)	1	$1,275.00	$1,275.00
Plastic Petri dishes 20/pk	5	$6.15	$30.75
Plant light banks	2	$218.25	$436.50
BLAST software (genetic sequencing)	1	Free Software	
Total:			**$15,357.80**

Table 2. List of Suggested Materials

*****Highlighting Refers to Related Materials*****

4.6 Holy Name Students Survey

4.6.1 Why Survey?

The students at Holy Name participated in a school-wide survey created by our IQP team in order to gain a better understanding of the students' wants and needs at Holy Name High School. Below are the full breakdowns of how the students answered each question. For each question we received 312 responses out of a total enrollment of 571 students, which is enough to make some valid conclusions based on the data. The breakdown of students involved

4.6.2 Results

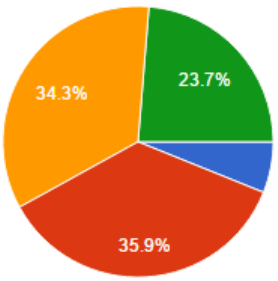
What Grade are you currently in?

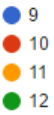
9 —6.1% (19 students)

10—35.9% (112 students)

11—34.3% (107 students)

12—23.7% (74 students)

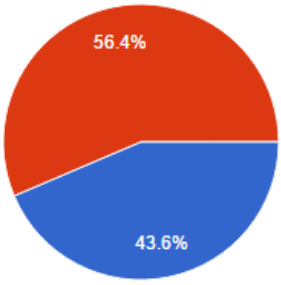




Male or Female?

M—43.6%

F—56.4%



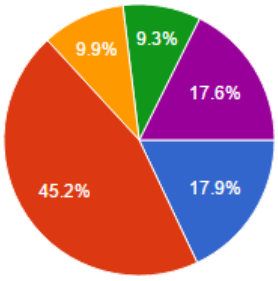
What is your favorite area of science?

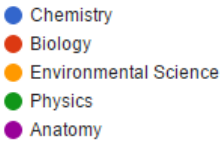
Chemistry—17.9%

Biology—45.2%

Environmental Science—9.9%

Physics—9.3%





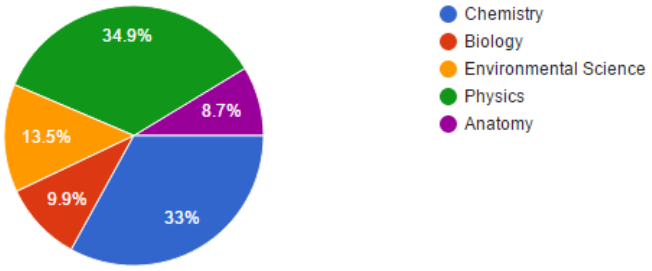
What is your least favorite area of science?

Chemistry—33%

Biology—9.9%

Environmental Science—13.5%

Physics—34.9%



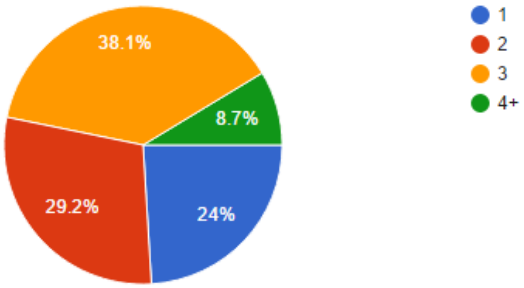
How many science classes have you taken in your high school career?

1—24%

2—29.2%

3—38.1%

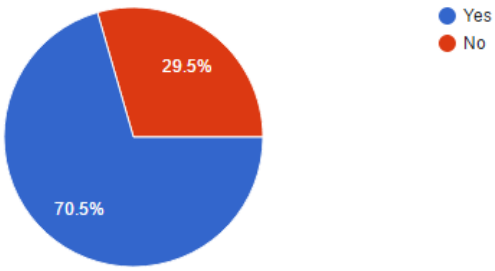
4+--8.7%



Would you be more willing to take higher level classes (AP Biology, AP Chemistry) if the labs were more interesting and modernized?

Yes—70.5%

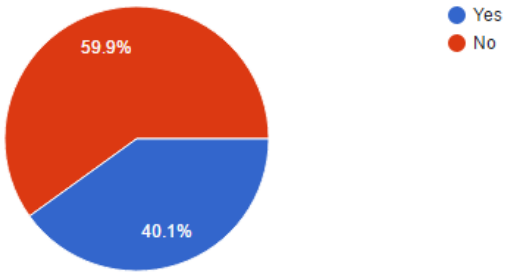
No—29.5%



Do you know the types of labs and experiments that will be conducted in each class before you sign up for it?

Yes—40.1%

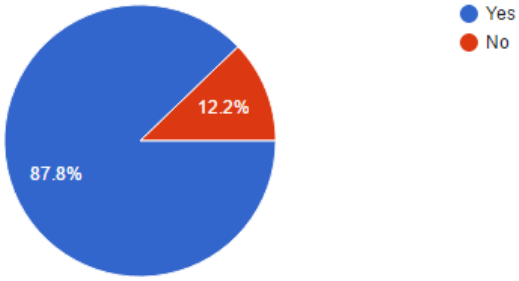
No—59.9%



Would you be more attentive in class knowing that what you're learning is leading up to an interesting and exciting lab exercise?

Yes—87.8%

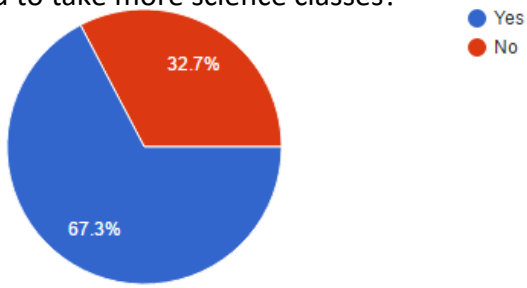
No—12.2%



Would a relationship between Holy Name and a university strong in the sciences like Worcester Polytechnic Institute (WPI) encourage you to take more science classes?

Yes—67.3%

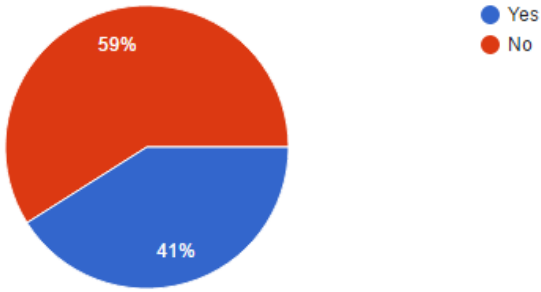
No—32.7%



Would you take a microbiology course if Holy Name offered it?

Yes—41%

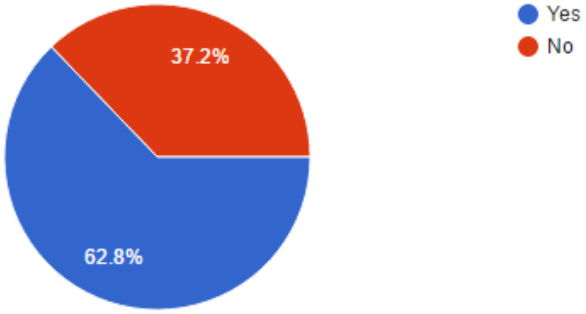
No—59%



Would you take a biotechnology course if Holy Name offered it?

Yes—62.8%

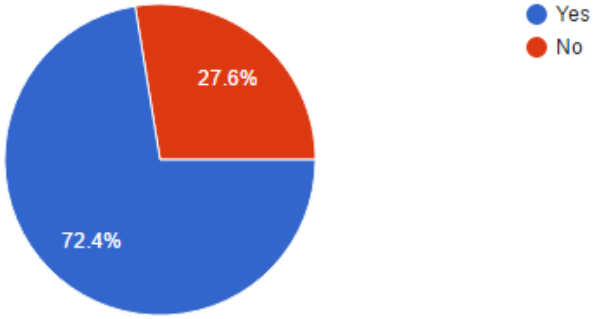
No—37.2%



Would you take a course where you could use electricity to separate DNA from different organisms?

Yes—72.4%

No—27.6%



4.6.3 Survey Conclusions

The majority of the participants in the survey were tenth (35.9%) and eleventh (34.3%) graders, which was what we were looking for as they are the students that are starting their college searches, and will be benefited the quickest from improved life sciences facilities at Holy Name.

45.2% of students said that their favorite class in the science department was biology. This shows that there is strong interest in biology at Holy Name, but in the comments for the question “What is your least favorite part about science class,” one of the students answered, “All we do is take notes, it should be a more exciting environment with more interactive and hands-on work. Notes are great and all, even needed. But as a High School student, I don't want to sit in class all day and take notes, I would much rather do labs and other such processes to learn.”

A number of other students also commented that they would like the classroom to be less lecture-based. Upgraded lab facilities would not only improve what students learn, but also

improve the students' attitude about learning. Labs make classes less of a chore and more fun and interesting. Plus, the labs offer a different perspective on the material that the students are learning in class. Labs can be an extremely effective tool in driving home course concepts.

Biotechnology is a new class that could be offered at Holy Name at some point in the near future. Biotechnology is a class heavily influenced by laboratory experiments. When asked "Would you take a biotechnology course if Holy Name offered it?" 62.8% of students said that they would, which is plenty of interest to justify starting a new course. Interestingly though, when asked if they would take a microbiology course if Holy Name offered it, 59% said no. Microbiology and biotechnology are very similar fields, so if Holy name does decide to introduce a new course, they should call it biotechnology. One method of study often used in biotechnology is electrophoresis, which is a technique used to separate macromolecules based on size. 72.4% of students that participated in the survey said that they would be interested in taking a class where they could do this.

Another number that stood out was that 67.3% said that a relationship between Holy Name and a university strong in the sciences like Worcester Polytechnic Institute (WPI) would encourage them to take more science classes. This proves that a WPI IQP is beneficial for the students attending Holy Name, and WPI students can make a lasting impact on the Holy Name students by showing genuine interest and explaining some of the paths a science student can follow. This could open up doors that high school students didn't know they had.

4.7 Biology Lab Layout

When designing a laboratory layout, there are an infinite number of approaches. The layout has a major influence on the dynamics of the lab room. With each set up there are pros and cons that the teacher has to consider. Since the designs are not permanent, it may be in the best interest to use a certain arrangement depending on the topic of the experiment. This section will discuss three common layouts: The semi-circle, clusters, and column rows.

The semi-circle offers a greater range for the instructor to move around freely and have easy access to each student who might have a question. It also provides a clear line of sight to every student. Thus encouraging the students to pay attention in an appropriate manner. The semi-circle also keeps the side conversations to a minimum by limiting the number of peers each student can talk to by the ones to the left and right of them. One con of the semi-circle layout is the loss off a group dynamic. In this setup, it is very difficult for the class to maneuver into clusters for group work. Time they could spend learning will be lost moving into groups and then back into a semi-circle.

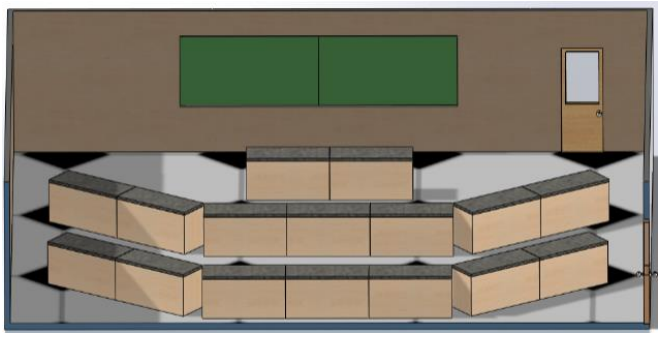


Figure 1. Semi-Circle Seating Arrangement.

Another arrangement is to set up the lab benches into small groups scattered throughout the room. Having the desks set up in clusters is great for a class with ample group work. The students will be able to communicate at a minimal voice level and can combine the desks for optimal work space[5] (Chinappi). However, with this organization, students may be easily distracted by side conversations. Another con is the teacher may find themselves talking to the back of students. If a classroom rules are set in place these cons can be avoided but may not solve the problem all together.

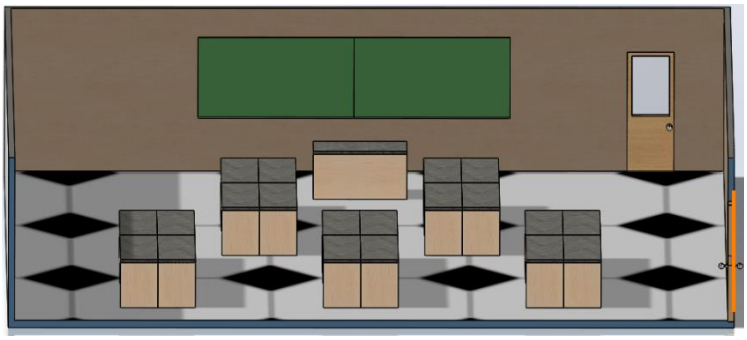


Figure 2. Clusters Seating Arrangement

The last common arrangement is the traditional rows and columns. The teacher won't be talking to the backs of students with this setup and separating the students will

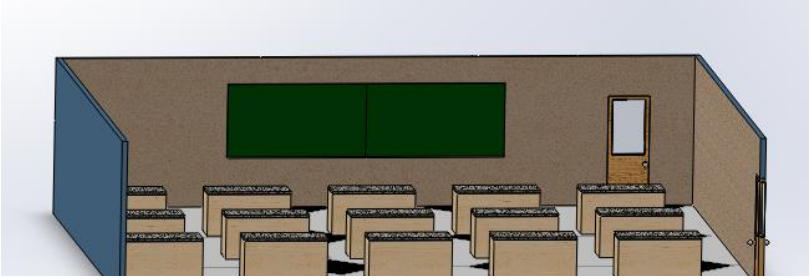


Figure 3. Rows and Columns Seating Arrangement

reduce the interrupting conversations from the students[5] (Chinappi). But this layout takes up a lot of space so the teacher will not be able to walk around as easy and the students in the back rows may be at a disadvantage to the ones in the front because the board will be father away making it harder for them to see. Also if the teacher doesn't project loud enough, the students may not hear valuable information. If the teacher wants the students to collaborate on a good deal of work, the rows could be set up in pairs. Without a seating arrangement for this situation, students might sit next to their friends and distract each other from the lesson.

5.0 Conclusions

5.1 Benefits to Holy Name High School from this Interactive Qualifying Project

In addition to a few of their students collaborating with WPI students and getting experience working on a college level project, Holy Name is receiving an inventory of lab materials used in college level Biology, Chemistry, and Biotechnology courses. This inventory will help the administrators at Holy Name get a better grasp of the course work that they should be teaching in High School to get their students prepared for college. It will also help the teachers at Holy Name create a more interesting curriculum with more experiments that will help get the students more engaged in the classroom. Also involved in the proposal are a bunch of opportunities that students looking to pursue a career in STEM could take advantage of such as the science fairs for high school students and the internship challenge that allows college students to get good experience in their area of study. These opportunities could help students at Holy Name get more involved in the growing area of STEM and show them how many prospective jobs there are waiting for them if they pursue a career in STEM. This could also increase the interest level in the basic STEM courses that Holy Name offers and even the courses that they are trying to implement. Holy Name will also receive a brochure that has the suggested materials for experiments in biotechnology. There are also descriptions of the experiments and how the materials are used in the experiments to help Holy Name understand how to implement these new experiments into their curriculum. Also there are survey results showing the interest levels of the Holy Name students in the different classes incorporated in

the life sciences. This will help Holy Name see how they should organize their curriculum to help their students become more engaged in the material.

5.2 Benefits to Worcester Polytechnic Institute from this Interactive Qualifying Project

Worcester Polytechnic Institute's interactive qualifying project (IQP) foundation was designed to allow the students to achieve a better understanding of cultural and social world around them. WPI believes that these tools make the participants better engineers and scientists. But what does the school as a whole get in return? In regards to the collaboration between the undergraduate students and Holy Name, WPI was able promote its already recognized reputation by aiding Holy Name High School in expanding its life science department. Not only does the project spread the name of WPI around the community, but it also endorses the STEM curriculum to potential engineering students. And with more potential engineering students comes more applicants to engineering schools such as WPI. If one were to consider how many IQP projects happen at more than 25 project around the world, not including on-campus projects, it would come to no surprise that WPI's reputation is growing rapidly thanks to hundreds of projects such as this one.

5.3 Suggestions for Future Projects with Holy Name High School

Students from WPI could try and create a framework for introducing an AP Physics course or engineering courses at Holy Name High School. They could start by researching engineering courses currently used in other high schools around the country and comparing those curricula. Then they can take their knowledge and research about WPI introduction engineering courses and figure out the best curriculum possible for Holy Name to implement in the classroom. They would also need to get a survey of the interest level of the Holy Name students in engineering to figure out if the courses will be useful. This will allow Holy Name students to become more prepared for an engineering career, and it could introduce them to the level of difficulty of a college course. The AP Physics course is an important introduction into how forces interact with each other which is helpful in many engineering fields. Implementing an AP physics course would help Holy Name students get a head start in college. The WPI students could also try to find a way to implement their system by finding funding or

other High School programs that encourage integration of new or updated courses into the curriculum. Project Lead the Way is a good example of one of the programs that can help implement new courses and also show the teachers' ways of teaching the material.

Another possible Interactive Qualifying Project is students from WPI could go and measure the impact of the Wind Turbine at Holy Name High School. There has already been a project to see what the impacts would be if a turbine is built at Holy Name, but now that it is built, students could go and work with some students at Holy Name to measure the output of the wind turbine. They could also compare the results that they get to the hypothesized results given by past WPI students. There could also be research into how wind turbines normally effect the environment and they could compare that to the environmental impact of this specific turbine. They could find out the times of year that the turbine generates the most power due to weather conditions and figure out how the energy can be used most efficiently. They can also take a look at how the wind turbine helped Holy Name with heating costs and suggest things to put the money that was saved due to the turbine in.

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Appendix A – Proposal for New Life Sciences Laboratory

Proposal for New Life Sciences Laboratory

At Holy Name High School

In Collaboration with Worcester Polytechnic Institute

What are the Life Sciences?

The life sciences are, as the name suggests, the areas of science that study living things. Anatomy, biological engineering, neurobiology, and biotechnology are all life sciences, just to name a few. “Life Sciences” is a very broad term, and an area of science that is expanding quickly throughout the world. Biotechnology, the use of living systems and organisms to develop or make products, is a newer life science field that leads to excellent career paths.

Why is Holy Name Creating a Life Sciences Laboratory?

Recently, the life sciences have been evolving, just as technology in general has been rapidly improving. The newer fields like biotechnology and microbiology are growing especially quickly. To combat the rapidly expanding knowledge gap, college has changed to encourage students to specialize in one area of biology that the student is especially interested in. This enables the student to take more classes directly applicable to their future careers, therefore closing the knowledge gap. Since the college curriculum is changing, high schools across the country need to evolve in order to ensure their students are prepared for higher level education.

Laboratories have long been a part of the science curriculum in high schools, but the types of laboratories that are run in college now require new equipment. Biotechnology combines engineering reasoning with biology to improve people’s lives. However, biotechnology requires relatively expensive, sophisticated equipment. This is where Worcester Polytechnic Institute came in, providing a team of students to research what equipment would be most useful in a new life sciences laboratory.

Holy Name Students’ Involvement

The Worcester Polytechnic Students worked alongside current Holy Name High School students during the course of the project. Jacob Duquette, Grace Lawson, and James Trottier, along with a student who chose not to be named were the Holy Name students chosen for the project. The students worked alongside Holy Name science department teachers to record a complete inventory of the science laboratories, which was necessary so that the WPI students could create an equipment list specific to Holy Name High School, not just for a general life science’s lab. The Holy Name students also helped the WPI students with a survey to see how a new life science laboratory would influence current student’s interest in the sciences at Holy Name.

Worcester Polytechnic Institute's Involvement

As part of a Worcester Polytechnic Institute student's graduation requirement, he or she must participate in an Interactive Qualifying Project (IQP). Generating a list of suggested equipment and supplies for a state-of-the-art life sciences lab at Holy Name was one of the projects selected for this year. This was a good match for an IQP, as WPI has a well-regarded biology and biomedical engineering program, with students and professors alike receiving national recognition for their advancements in biology. The team of Worcester Polytechnic Institute students were able to utilize the expertise of professors and state-of-the-art facilities at WPI to create a list of the most vital biotechnology equipment needed at Holy Name.

Complete List of Equipment and Supplies

Below is the complete list of equipment and supplies. If Holy Name were to receive funding for everything on this list, they would have plenty of equipment to implement biotechnology into the science curriculum. Since the quantities of equipment are somewhat limited by price, most experiments would have to be done in four to eight groups of two to four students, which are small enough groups for each student to gain experience with the equipment, as well as learn the theory behind each experiment.

Item	Quantity	Price	Estimated Total Cost
BioClave Mini (8L) (autoclave)	1	$3,060.00	$3,060.00
Ready Pouch 2% Agarose Gels	4	$80.00	$320.00
Gel Electrophoresis Tray	40	$30.75	$1,230.00
TAE Buffer for Electrophoresis (1L)	5	$85.25	$426.25
Carolina Gel Electrophoresis Chamber	4	$269.95	$1,079.80
Electrophoresis Power Supply	4	$108.00	$432.00
Vernier Gas Pressure Sensor	4	$83.00	$332.00
Vernier Temperature Probe	4	$29.00	$116.00
Vernier pH Sensor	4	$79.00	$316.00
Centrifuge mini centrifuge tubes (500 ct.)	1	$69.00	$69.00
Capp Rondo Centrifuges CR-68X	2	$399.00	$800.00
classroom micropipette 20-200uL (8 ct.)	1	$995.00	$995.00
classroom micropipette 2-20uL (8 ct.)	1	$995.00	$995.00
MultiGene Mini Personal Thermal Cycler 18x.5mL tubes (PCR Machine)	1	$2,725.00	$2,725.00
5L general purpose water bath	2	$386.00	$772.00
Heating Block (compatible w/ four different sizes)	1	$735.00	$735.00
Thermal Cycler tubes (500 ct.)	1	$54.00	$54.00
250 mL beaker	15	$5.30	$79.50
400 mL beaker	15	$6.20	$93.00
600 mL beaker	15	$7.85	$117.50
250 mL Erlenmeyer Flask	10	$6.40	$64.00
500 mL Erlenmeyer Flask	10	$7.95	$79.50
Lab Companion Incubator (economy model)	1	$1,275.00	$1,275.00
Plastic Petri dishes 20/pk	5	$6.15	$30.75
Plant light banks	2	$218.25	$436.50
BLAST software (genetic sequencing)	1	Free Software	
Total:			**$15,357.80**

Figure 4. List of Suggested Materials

8L Mini Bioclave

Figure 5. 8L Mini Bioclave.

The autoclave is essential when students start using materials that can only be seen on the microscopic level. The autoclave is used to sterilize laboratory equipment by creating an environment of high pressure water-saturated steam at about 250 degrees Fahrenheit. Autoclaves are slightly dangerous because of the high pressure inside of them, so an autoclave was chosen with safeties that make it much less dangerous. This is an essential piece of equipment to biotechnology, so it is worth the high price. Holy Name also mentioned that Assumption may give them an autoclave, so this could drive down the cost of the lab renovation significantly.

Electrophoresis Materials

The first thing required for electrophoresis is the electrophoresis chamber and the trays that go into the electrophoresis chamber. Both of these are pictured on the right. Also pictured are the gel combs that are used to create slits that the sample will be inserted into. To ensure that these pieces of equipment are compatible, we recommend that Holy Name orders these products from the same company. The other part of electrophoresis is the agarose gel that is used inside of the electrophoresis tray. This is essential to the process, and large amounts can be purchased at once, which drives the cost down.

Figure 6. Electrophoresis Materials.

Vernier Gas Pressure Sensor

Figure 7. Vernier Gas Pressure Sensor.

The gas pressure sensor is attached to plastic tubing, which is placed on top of a test tube like a stopper would be, and then this can be attached to a computer, and software can graph the pressure data for you. This is a useful piece of equipment for teaching Boyle's law and the ideal gas laws. These sensors can also be used in regular biology and chemistry, not just biotechnology and microbiology. Holy Name also already has two of these, but adding four more would be a good addition

Vernier Temperature Probe

Another self-explanatory piece of equipment. The temperature probe provides a digital reading of the temperature of a solution, which is more accurate than having students read the temperature off of a manual thermometer. Again, this does not just have biotechnology and microbiology applications, it can be used across the science disciplines.

Figure 8. Vernier Temperature Probe.

Vernier pH Sensor

Figure 9. Vernier pH Sensor

A pH sensor provides an accurate reading of the concentration of H^+ molecules in a solution. This piece of equipment could be useful when doing titration experiments, or analyzing the local water supply. pH sensors are essential to chemistry, but also have a lot of biological applications as well.

Centrifuge Equipment

Centrifugation is an important method of sorting particles in biotechnology. It's a simple process; basically a centrifuge spins the particles very quickly, and this centripetal force separates particles of different sizes and densities. The substance that is going to be spun goes into small centrifuge tubes that are then inserted into the centrifuge. Along with the centrifuge, it is recommended that Holy Name order extra centrifuge tubes. The tubes are relatively cheap at 1000 tubes for 18$. Again it is recommended that these are ordered from the same manufac

Figure 10. Microcentrifuge.

Classroom Micropipette 2-20 and 20-200µL

Micropipettes are used to measure very small amounts of liquid very accurately. These are essential to centrifugation and electrophoresis because typically when those types of experiments are run, the experimenter is dealing with very small amounts of whatever substance they are experimenting with. The number recommended is 16 (8 of each capacity) because it would be nice if every student in the class could get to use one, and also the micropipettes are especially fragile. Breaking them is not uncommon.

Figure 11. Micropipettes.

Mini Personal Thermal Cycler (PCR Machine)

A thermal cycler is able to change temperatures almost instantly. This machine has an important place in biotechnology and microbiology as it is used to replicate DNA via the polymerase chain reaction. Basically, the thermal cycler can use the four basic nucleotides, and via large changes in heat, produce a genetic sequence. This machine is relatively expensive, but not only does it have an important place in a biology lab, it also demonstrates that the lab is at the state of the art to prospective students. As with the centrifuge, replacement tubes will eventually be needed, so those are added in as well.

Figure 12. Mini PCR Machine.

Heating Block

Heating blocks are used when holding a constant temperature is essential. The heating blocks are similar to a thermal cycler, but they do not cycle through temperatures, just hold one constant. This piece of equipment is not as essential as a thermal cycler (also known as a PCR machine), but it still has many uses in a biotechnology lab, as energy in the form of heat is often used to break down or accelerate the breakdown different substances.

Figure 13. Heating Block.

5L General Purpose Water Bath

This is also used to keep items at a specific temperature like the heat blocks and PCR machine, but for some different applications. It can be used in electrophoresis when the experiment requires the sample to be kept at a certain temperature while the experiment runs. The biology teachers at WPI thought this was a particularly useful piece of equipment.

Figure 14. General Purpose Water Bath.

Glassware

Beakers and flasks are always needed in a life sciences lab. From biology to chemistry, most experiments will call for beakers or flasks at some point, especially when mixing solutions. Holy Name already has enough glassware, but some new glass would look great, and also allow some older beakers and flasks to be disposed of.

Figure 15. Glassware.

Lab Companion Incubator

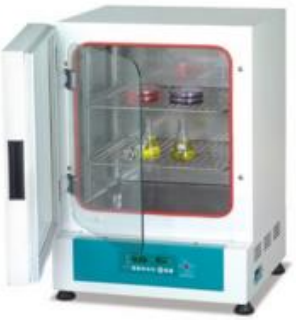

Figure 16. Incubator.

An incubator is similar to a heating block, where it maintains constant temperature, but incubators are often used for petri dish experiments where students are growing cultures. Aside from temperature, an incubator also controls factors like humidity, carbon dioxide, and oxygen content that could ruin a culture. This is also a good piece of equipment for altering environments that cultures grow in to test how the environment affects bacteria. This piece of equipment is more useful in microbiology, but it has biotechnology applications as well.

BLAST sequencing software

This is a software with a large database of biological sequence information. BLAST stands for Basic Local Alignment Search Tool. When our group talked to the teachers at Holy Name, one of them asked about a spectrophotometer, which would enable a person to analyze genetic sequences in lab. However, spectrophotometers are extremely expensive, typically around five thousand dollars for quality machines, and not a good use of money in Holy Name's case. BLAST software is a good alternative to use for teaching students about genetic sequencing.

Plant Light Banks

Plant light banks are a good investment because the life sciences often deal with living organisms, and the light banks can replicate the sun's rays more effectively than typical classroom lighting. These will also enhance the capabilities of the new life science lab. Like the probes above, these light banks are also excellent for use in a standard biology lab, and have many broad applications.

Figure 17. Plant Light Bank.

What Kind of Experiments Could this Equipment Be Used for?

The most important piece of equipment in this list is the autoclave. An autoclave is a machine used to sterilize or clean laboratory equipment. With all of the expensive new equipment that Holy Name will acquire, an autoclave is important to ensure that the equipment remains in pristine shape. The autoclave works by creating a pressurized environment of dry saturated steam, a chemistry lesson in itself for the students.

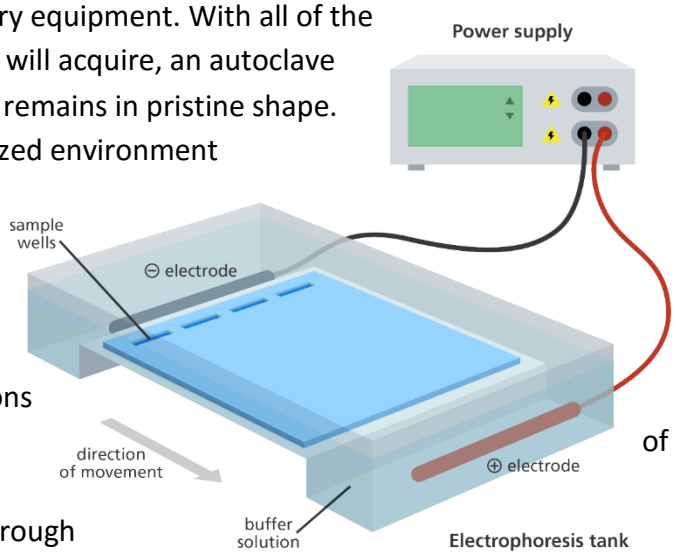

Figure 18. Diagram of Electrophoresis

Electrophoresis is one of the cornerstones of biotechnology, and an interesting method of manipulating solutions in the lab. The most common application of electrophoresis is to separate DNA fragments from a solution as it migrates through a gel medium. This scientific breakthrough made DNA manipulation a lot faster, as scientists used to have to wait for gravity to do the work that the gel matrix and electricity are now able to do. The gel essentially acts as a sifter as the electric current pulls the solution from one side of the gel to the other. Smaller molecules are able to move through the gel much easier than larger

Figure 19. Student Performing Electrophoresis in Lab

molecules, therefore causing the separation that is wanted. DNA extraction is an informative lab that high school students would be capable of conducting with relative ease. Micropipettes are also used during DNA extraction to ensure accuracy.

Centrifuges are not critical in a high school lab, but eventually as a biology student gains experience in biology, centrifuges are useful to conduct experiments more efficiently. There is also a fair amount of physics that goes into learning how a centrifuge works, so the students will benefit from exposure to that. A centrifuge separates components by density with less dense molecules going towards the axis of the centrifuge, and more-dense molecules moving away from the axis of the tube. This machine is most commonly used in DNA replication, an extremely important procedure in DNA manipulation. Replicating DNA enables an experimenter to reproduce as many exact copies of the specific strand of DNA as they would like.

Another piece of equipment used in DNA replication is a PCR machine, or thermal cycler. A PCR machine allows the experimenter to change the temperature of a substance almost instantly. This is necessary for DNA replication as large energy changes is one of the only ways to create new strands of DNA. DNA replication is a very cool process that AP biology students could learn a lot from.

Incubators are used to control the environment a petri dish resides in while growing a culture. A fun experiment for students to do is collect bacteria from either their mouths or their school by using cotton swabs, and then introducing the bacteria into the petri dish. Agar works well for feeding bacteria, which is already included with the electrophoresis materials. Once the bacteria are introduced, they should then be put into an incubator, which will regulate the environment. The incubator eliminates environmental factors out of the students' control to ensure the best possible culture results.

Figure 20. Petri Dish Culture.

Bacterial growth is relatively slow, but a fun experiment that students can monitor every day with the naked eye is growing certain kinds of plants. The light banks proposed to Holy Name are excellent at simulating sunlight, which is critical to plant growth. Many different factors can be varied in this experiment to see how they affect the growth of the plant. The students could even possibly compare the efficiency of the LED light in the plant light banks on plant growth to the sunlight outside.

How Will the New Laboratory Impact Holy Name?

As a high school with access to this kind of equipment, Holy Name students will have a substantial advantage over the average high school student across the country. As of right now, there is a lot of interest in biology at Holy Name High School, as evident by a survey done by the WPI students. To the right a pie chart is included showing that 45.2 percent of Holy Name students enjoy biology the most out of the science disciplines. Also in this survey, the students were asked if they would be interested in taking a biotechnology course if Holy Name offered it. An overwhelming majority answered that they would take the course, with 62.8% interested. Without the equipment included above, a proper biotechnology class cannot be incorporated into the science curriculum, but by implementing the new Life Science laboratory, Holy Name will build on the interest in biology and encourage students to go on to college and major in the life sciences.

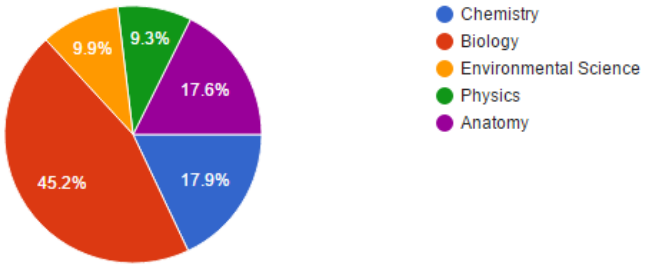

Figure 21. What is Your Favorite Area of Science?

The labs will also help Holy Name entice even more top-level students to come to their school. Prospective students will be intrigued at the types of equipment at their disposal, some of which they may have never seen or heard of before. By bringing in these students with interests in biotechnology, Holy Name can create an even better learning environment for all of their students.

Massachusetts is one of the leaders in biology and biotechnology research in the United States. With that kind of prowess in close proximity to Holy Name and the upgraded and modernized laboratory, Holy Name students will be provided with excellent opportunities as they leave for college and beyond if they decide to pursue the life sciences.

Appendix B—Students' Inventory List

Biology Room

Item	Brand	Quanity	Condition
Petri dishes		20	good/new
Sep-Pak Cartridges	Waters	50	new
Stethoscope	Graham-Field	5	good
pH strips		6 vials	new
blood simulation kit	Wards	1	old
simulated blood typing kit refill	flinn Scientific Inc	6 cases	good
blood simulation kit	Kemtec	1 case	good
microscope slides	various	multiple cases	good
test tubes	various	multiple boxes	good
titration flasks	various	10	good
dissection pans			Good
Plastic microscopes	national teaching aids inc	26 working, 2 broken	fair
Medium size microscopes	Boreal	28	good
large grey microscope	American optical Corporation	2	good
Stein-ette microscope	GRAF-APSCO CO.	2	good

Table 3. Biology Room Student Inventory.

Biology Storage

Item	Brand	Quanity	Condition
Tan light microscopes	Ward's	14	Good
Nikon Labphot	Microtech Optical Inc	1	good
microscope	Fisher scientific	5	broken
microscope	Nikon	1	good
MicroStar	AO Scientific Instruments	1	good
microscope	Barska	1	good
Microscope	olympus	1	
Lab Quests	Vernier		
ProScope Handheld Microscopes; Basic Proscope HR Kit	Vernier	3	good
Hand-grip Heart Rate Monitor	Vernier	5	good

Electrocardiograph (EKG) Sensor	Vernier	4	good
Respiration Monitor Belts	Vernier	5	good
Blood Pressure Sensors	Vernier	3	good
Colorimeters	Vernier	5	good
CO2 Gas Sensors	Vernier	5	good
O2 Gas Sensors	Vernier	3	good
Microphone	Vernier	5	good
Conductivity Probes	Vernier	10	good
Gas pressure sensor	vernier	10	good
Vernier prop counter	vernier	1	good
dissolved oxygen probe	vernier	1	Fair
stainless steel temperature probe	vernier	15	good
bio chamber 250		10	good
pressure sensor		7	fair
			1 broken
CO2 gas sensor	vernier	1	old
pH system	vernier	5	fair
			4 broken
heart rate monitor	vernier	1	fair
CBL systems	texas instruments	9	working
Light sensor	vernier	2	good

Table 4. Biology Storage Student Inventory.

Chemistry Room

Item	Brand	Quanity	Condition
Goggles		30	old/broken
electronic scales	Flynn Scientific	5	old/broken
triple balance scales	Ohaus	5	ok
Boyle's Law apparatus		1	good
Hot plates	Thermo Scientific	8	5 good/3 broken
Ring stands		20	fair

Table 5. Chemistry Room Student Inventory.

Chemical Storage

Item	Quanity
Buffer Solution	3
Bromephenol Blue	2
Iodine Solution (starch test)	3
Iodine Solution (Lugol's)	1
Iodine	2
Fromalin	1
Limewater	1
Biuret Reagent	2
Biuret Soluion	1
Benedict's Qualitative Solution	2
Sodium Chloride (1.0 m)	4
Sodium Chloride	4
Sodium Carbonate (1.0 m)	2
Potassium Iodide (1.0 m)	1
Calcium Carbonate	2
Calcium Chloride Saturated	2
Ammonium Chloride	1
Borax	2
Sodium Carbonate	1
Barium Chloride	1

Calcium Sulfate	1
Potassium Nitrate	1
Sodium Acetate	1
Barium Sulfate	1
Copper II Sulfate	1
Strontium Chloride	1
Vinegar	2
Corn Oil	2
Cabbage Powder	2
Oleic Acid 5% in isopropanol	2
Copper Sulfate (1.0 m)	2
Hydrogen Peroxide (topical solution)	1
Hydrogen Peroxide	1
FDC Yellow 5 food dye	1
FDC Green 3 food dye	1
FDC Blue 1 food dye	1
FDC Blue 2 food dye	1
FDC Red 40 food dye	1
FDC yellow 6 food dye	1
FDC red 3 food dye	1
Ammonium Chloride (1.0 m)	1
Lead Shots	2
Zinc Shot	2
Silicon Lumps	2
Tin, Reagent Grade	2
Magnesium Dioxide	2
Zinc Nitrate 1m	
Sucrose	2
Ammonium Chloride 1.0m	1
Iodine Solution	2
Methylene Blue Solution	1
Copper Metal	2
Nickel Metal	1

Tin Metal	2
Iron Metal	1
Iron Filings	1
Iron Wire	1
Mass Scales	9
Hot Plates	9
Electric Scales	1
Several Varying Flasks	>10
Varying Graduated Cylinders	~35
Racks of test tubes	4

Table 6. Chemical Storage Student Inventory.