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Science Educators Technology Sharing Initiative: The Effectiveness of a Constructivist Model of Technology Integration in a High School Science Department

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Michael Phillip Huber

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SCIENCE EDUCATORS TECHNOLOGY SHARING INITIATIVE: THE EFFECTIVENESS OF A CONSTRUCTIVIST MODEL OF TECHNOLOGY INTEGRATION IN A HIGH SCHOOL SCIENCE DEPARTMENT

BY

MICHAEL PHILLIP HUBER

A THESIS

Submitted to
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2006

ABSTRACT

By

Michael Phillip Huber

In 2005 Portage Public Schools in Portage, Michigan, allowed high school science teachers to have two extra hours of preparation time to engage in the development of electronic technology related activities for high school students. Through this offering, a program was developed for these teachers to create, manage, and evaluate the effectiveness of technology in the classroom. The program, named the Science Educators Technology Sharing Initiative, was run through the 2005-2006 school year. Funding for the program was provided by the school district and funding has been granted to continue the program for the 2006-2007 school year. The program paired two teachers for two hours a semester to increase their understanding of how the technology can be used, development of activities that use the technology a well as manage and maintain the technology inventory. The program was evaluated from both teacher and student perspectives for both perceptions of technology and the level of its use in the classroom. The analysis of the data indicates a strong statistical correlation of an increased use of technology in the classroom through the school year.

DEDICATION

This master's thesis is dedicated to science teachers everywhere, and specifically to the staff at Portage Northern High School; may we continue to open our students eyes to the world that is around us. It is also dedicated to Heather, with whom I have joined on this great adventure called life.

ACKNOWLEGEMENTS

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From the Department of Science and Mathematics Education: Merle Heidemann, my thesis advisor, Helen Keefe who helped in the development of the survey instruments., Ken Nadler, and of course, Margaret Iding in the Graduate Office without whom no one would graduate.

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From the science teachers at Portage Northern High School (In clockwise fashion): Michelle Merz, Chris Armitage (Thanks for "tech-ing" with me), Angelique Biehl, Donna Hertel, Daniall Poulsen, Kathy Mirakovits, Chris Riker, Paul Surya, and Rich Mayer. Their interest in technology, experiences with technology, and grace in allowing me to interrupt their classrooms to collect personal and student statistics is greatly appreciated.

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INTRODUCTION

If you walked into Portage Northern High School in Portage, Michigan on any given school day you might get a chance to see a cart of laptop computers rolling down the hall pushed by a teacher eager to get back to his/her classroom. You could walk by a classroom and see students engaged at the front of the room with a teacher highly respected for their personal attention to student needs – including those proprioceptive learners. If you wandered downstairs (affectionately referred to as the underground) to the science department you might pass a class of students strewn throughout the hallways shaking Slinkies ™ in a desperate attempt to understand wave motion. By happenstance, you could pass a class with light bulbs, temperature probes, sand, water, and some consternation about how to clearly demonstrate the differences in the heat capacity of the sand and water, and its impact on the weather patterns in Michigan. If you look deeper, you might see a teacher or two wrestling with laptops and a Vernier LabPro working with a flask filled with algae and gas sensors attached. Technology, and particularly electronic technology, is employed in these classrooms and in classrooms throughout the country in an attempt to foster better connections to content and to prepare students for their futures.

Electronic technology in the learning environment has becoming a ubiquitous force in education. Many booths at the 2006 Michigan Science Teachers Association state conference were selling or promoting electronic based learning materials and strategies. Teachers rush like lemmings when new software and hardware is presented for use in the classroom. The marketing of electronic technology for education is a strong force for change in the classroom.

However, questions arise surrounding the use of technology in the classroom: Does technology improve student learning? Does technology offer an opportunity to prepare for students' future better than other methods? Does technology require deliberate implementation for success or will its presence in the classroom improve the educational environment? What is an appropriate use of technology in education? These are not simple questions. The debate that surrounds them is as old and varied as the technologies in question.

These questions have been explored by Portage Public Schools following a large district technology bond issue that voters approved in 2001. The bond issue provided an opportunity to upgrade both teacher and student computers in labs and classrooms, purchase connected software and hardware accessories and support professional development programs surrounding the use of the computers in the classroom. This influx of technology in a short period of time was coupled with a curriculum reevaluation and rewrite process for the science department. There was a strong desire to ensure a good connection between the district's benchmarks and the technology.

This opportunity created the research questions for my master's thesis. A team of people from two high schools in the district formed questions and developed a program to answer these questions. Loosely defined, there were two overarching questions on which this thesis is based. 1. How do we develop a dynamic integrated professional development system and evaluate its change on the use of technology in the science classroom. 2. Will the student perception of the educational inclusion of more electronic technology in the classroom improve? Beginning in the 2005-2006 school year at both Portage Public High Schools, a professional development model was employed that addressed these questions. The model involves providing two science teachers with two extra hours without student contact during the school day to learn, develop, sharing, and evaluate the use of technology in their classroom.

This document investigates the application of the model, its efficacy, and student outcomes as a result of the model. The model identifies the teacher as the key to successful technology integration. If the teacher has the time, and skills to properly investigate the application of technology to the content they are teaching, then the students use of technology and his/her perceptions towards technology as a tool for learning will increase. The teacher-on-teacher model of professional development should cause the use of technology to increase. The model should also be able to identify problems quickly and shift the responsibility for solutions and learning onto the teachers rather than on the curriculum development office within the district. These traits should adequately respond to the two overarching questions and were developed by the teachers working on the professional development model.

RESEARCH SETTING

Portage Northern High School, a public school, is the site for the model research. The school is located in southwest Michigan adjacent to Kalamazoo, MI in the city of Portage. The greater Kalamazoo region is a 300,000 person urban to rural population base, the bulk of which resides in the city of Kalamazoo. According to Standard and Poor's SchoolMatters database (2006), Portage Northern High School had 1348 students during the 2005-2006 school year. Racially, the student body is comprised of 86.7%

Caucasian, 6.9% black, 4.3% Asian / Pacific islander, and 1.2% Hispanic persons. The percent of students considered economically disadvantaged is 13.0% (this includes free and reduced lunch students). This number is smaller than the state percentage of 35%. The median family income for the district is $71,549. Again this value is better than the state average of $62,535. Both Portage Public Schools' high schools are a part of the International Baccalaureate (IB) program. The IB program is a highly rigorous, well delineated curriculum for juniors and seniors.

The science department at Portage Northern during the study consisted of ten full time teachers. The teachers primarily have a single curricular area of focus, then a secondary area in which they may teach one or two classes. The department has six teachers with M.A. or beyond, three teachers working on their M.A. or M.S. and one teacher with a B.S. degree. All of the teachers in the department are considered highly qualified (according to NCLB) within the area that they teach. The entire department is regularly engaged in professional development outside the classroom and over 50% of the teachers have presented at state or national conferences. Two teachers have received national awards of excellence in education.

THEORETICAL FRAMEWORK

Nationwide integration of electronic technology (henceforth referred to as technology) has led to mixed improvements in overall student performance since the mid 1980's when educational technology began to be implemented in elementary and high school education in the United States. The Trends in International Mathematics and

Science Study (TIMSS) showed a significant increase between 1995 and 2003 in both mathematics and science scores. (Gonzales, et al., 2004, tables 7 and 8) While causality between the increased test scores on the TIMSS and technology in the math and science classrooms is not implied, there is still the possibility that the presence of technology in the classroom has played a role in this trend. Todd Oppenheimer takes an opposing viewpoint very seriously in his book, The Flickering Mind: The False Promise of Technology in the Classroom and How Learning Can Be Saved (2003). Oppenheimer interviewed and visited a number of successful (and unsuccessful schools) and investigated their use of technology in the classroom and its apparent effects on the students (Oppenheimer, 2003). He highlights some impressive failures, including a $100 million dollar 1996 initiative in New York City to provide computers for the sixth through eighth grade classrooms. The teacher he visited was not using the equipment in his classroom due to lack of tech-support afforded by the district. The teacher was unable to solve the problems associated with using the technology, so the equipment sits dusty in the corner. In another case, early in his text, he refers to a visit he made to a eleventh grade civics class. In his visit, he watches PowerPoint presentations about the powers of congress. He highlights the fact that, "its content was no deeper or more complex than what one commonly sees in civics papers done elsewhere, with pencil and paper, by seventh and eighth graders." He appears to be defining failure as a lack of true learning, a lack of appropriate use for the technology, and poor teacher preparation (Oppenheimer, 2003).

In a longitudinal study done at the University of Arkansas, the results of an analysis on technology in varying classrooms on learning were "dubious" at best (Du et al, 2004, p38). Even well developed teacher programs, such as the Teaching Mathematics with Technology Project (TMTP), which had a component of teachers continuing to dialog using online tools, failed to thrive despite positive evaluations by participants in the program (Stevens & Hartmann, 2004). Juxtapose these results against the results from an Iowa program to improve mathematics scores using technology to increase peer exchange of ideas among lower socio-economic status students. The results showed that the achievement gap closed through the use of technology. Ironically, the technology in use was primarily employed by teachers to share best practices (O'Connell & Phye, 2005). The varying results and methodologies should cause educators to reflectively pause when looking to technology to be a "saving" factor in their classrooms and schools. When teachers have limited experiences to employ them in the classroom, and subsequently, the presence of the computers has limited to no educational value. (Oppenheimer, 2003, p 63-95)

The question of sufficiency can be raised. Is technology a necessary and sufficient factor to the success of our students at the K-12 level? For technology to be necessary, it *must* be used in order to teach on that particular subject or content. When the technology is sufficient, it *can* be used to teach that subject. While technology might be sufficient, is it advantageous to *always* use technology when given a choice? What are the criteria that are employed to decide when to use technology as the method for delivering the experience or content to students? A technology-necessary approach is utilized by the Peck School in Morristown, New Jersey. Pamela Livingston (2005) highlights the total integration of technology into curriculum down to the fifth grade with a one laptop to two students ratio. There were no data indicated in this article or a prior article written by her as well to illustrate the outcomes of such an integrated program. (Livingston, 2004) Questions of necessity are obviously going to be presented favorably in pro-technology journals (e.g. Meridian, a middle school technology journal, Learning and Leading with Technology, Journal of Teacher and Technology Education) dedicated to the evaluation and advancement of technology in the classroom. Can an adequate balance between necessary and sufficient factors drive the optimal employment of technology? There are other approaches to the teaching of the science and mathematics concepts that have obviously been around longer than the use of technology. Oppenheimer cites the example of the simple tools of string, straws, and protractors given to students to do trigonometric work within the city as a non-technological approach to mathematics teaching and learning (Oppenheimer, 2003). Are educators too quick to adapt technology when its true abilities are unknown and thus create a system that is ineffective at increasing student learning. This balance can be used to create a stronger connection to increased student learning and more appropriate use of technology in the classroom.

A constructivist approach to education is marked by the process of building knowledge. "Learning involves constructing one's own knowledge from one's own experiences" (Ormrod, 2003). There are multiple constructivist centered curricula in all areas of study at the high school level. Four reformed, constructivist based, mathematics curriculum were developed as a result of a 1992 NSF grant (Schoen & Hirsch 2003). Using an inquiry-based model (a model that focuses on problems or questions posed by instructors and then shifts responsibility for answers onto students) when developing a new curriculum or model creates a solid foundational framework for any program.

Inquiry based programs create strong correlations to student success (Mao & Chang 1998). Freedman (1997) illustrates that ability of an inquiry based laboratory program to foster better attitude towards science and higher student achievement. In a college biology course for non-majors, an inquiry based program led to better performance on a similar test as the lecture/lab experiment format (Lord, 1997). Why then, when looking at professional development for high school science teachers, is there a rarity of constructivist approaches? It appears that we ignore our own best classroom practices when we learn from our peers. The common professional educator, while didactic, is relatively embedded in a lecture-listen format. If the constructivist approach is reasonably successful for our students, why should teachers engage in older, less successful models of learning for their own professional development? The effectiveness of a properly designed professional development has been shown to positively impact classroom teacher behaviors. Davidson-Shivers investigated the effectiveness of an instructional design model that utilized an inquiry approach for teacher professional development centered around educating college professors on the use of PowerPoint™ software in their classrooms. The results showed an increase in the use of PowerPoint™ in the classrooms (Davidson-Shivers et al, 2005). If a problem-based inquiry model is successful for students and for educators, an effective model for the technology professional develop within the high school would employ these traits.

When developing an effective model of technology professional development, adequate time must be considered. In a study "...elementary teachers indicated that their greatest barriers to computer use were (a) too much curriculum to cover, (b) lack of time in daily schedule, and (c) high stakes testing. (Franklin, 2005) An effective professional development program in secondary science was a two-year effort for 91 secondary schools in a comprehensive study. Not only was there adequate time for the professional development, but inquiry based practices were used for the professional development. (McGregor & Gunter, 2006) This factor was key when developing the model for Portage Public School. If a rich professional development model was to be used, adequate time needed to be included in its model.

The connectedness of all of these professional development principles was identified in a Mid-Continent Research for Education and Learning (McREL) report in 2005. The report surveyed over 37 different reports on professional development programs. "Based on the synthesis of our research, professional development that is most likely to positively affect teacher instruction is: of considerable duration, focused on specific content and/or instructional strategies rather than general, characterized by collective participation of educators, (in the form of grade-level or school-level terms), coherent, [and] infused with active learning rather than a stand-and-deliver model." (Snow-Renner & Lauer, 2005) These factors are further reinforced by the recently released National Science Teachers Association position statement on professional development. All of the same aspects are included in their analysis of positive professional development (NSTA Board of Directors, 2006).

If a model of professional development for the use of technology in the high school science classroom seeks to answer the questions of increasing student learning effectiveness, and developing a rich professional development structure it should employ the factors of time, teacher importance, a collaborative approach, and inquiry based professional development. These aspects create the theoretical framework that this thesis is using to establish and evaluate the model of technology professional development for science teachers at Portage Northern High School.

HISTORY LEADING TO IMPLEMENTATION

The impetus for the implementation of this thesis program occurred during curriculum re-evaluation phase during the 2003-2004 school year. Portage Public schools were undergoing the science curriculum review and making changes to the benchmarks and to the course delineations as well. This is part of a seven year process that is normal for Portage Public Schools (PPS).

Deliberate inclusions of technology in the science classrooms occurred with this curriculum cycle. Individualized benchmarks that included technology had not been included in the science courses despite being included as outcomes within the greater district curriculum. With the technology bond issue providing available money for the purchase of technology, we wanted to follow through on the appropriate use of the technology in the classrooms. Teachers were already familiar with most technology available for teaching certain aspects of the curriculum. PPS wanted to make sure that the technology could be more coherent throughout the district and standardized to meet technology outcomes. Collectively, a budget decision was made to provide each high school with 45 wireless equipped laptops with wireless printers specifically for use in the science classrooms. The Information Technology (IT) department at PPS was also provided with funding to support the technical aspect of the equipment being purchased. A list of the equipment purchased is in appendix C. This equipment serves as the foundation for the application of technology in the classroom. The key pieces of technology include forty-five wireless laptops with internet connections, preloaded science oriented software, and Vernier LabPro ™ equipment with various probes.

The science teachers radically revamped the PPS science curriculum. We began following a "physics first" model of curriculum. The rationale and framework for this decision is a thesis unto itself and will not be discussed here other than to cite a few papers that delineate the reasoning well (Bardeen et al., 1998). The new model in the high school was radically changed from the classic Biology-Chemistry-Physics decided on by the Committee of Ten in 1892. (Sheppard & Robbins, 2005) The freshman and sophomore years are now highly structured. Students experience a semester of physics and a semester of chemistry their freshman year. Their sophomore year is a semester of biology and a semester of earth science. All of these courses have an honors option as well. During the Junior and Senior years, students can return to take further courses in science in any of the aforementioned areas, and in forensic science and environmental science. Students also have the choice to pursue IB level coursework in physics, chemistry, or biology. Preliminary data on this is still pending, but anecdotally, teachers have positive feedback on the effectiveness of this curriculum system.[1]

We began evaluating the use technology in our classrooms. Secondary teachers were divided into content areas and benchmarks that could include the use of technology were identified and marked as such. The teachers in each content area assessed their abilities and course content to identify what technology materials they would like to

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[1] Ironically, with the advent of the new Michigan standards, Portage Public Schools is almost compliant with both the benchmarks and in the amount of time in the sciences. Students will most likely have to take a mandatory further semester in biology to satisfy the year requirement for a life science plus another year of elective science.

purchase. Chemistry (my content area) teachers wished to obtain graphing software, various probes capable of connecting to data collection software (pH, temperature, dissolved gases, oxidation-reduction potential, total ions, gas pressure, colorimetric, and Geiger counters), organic structure drawing programs, Microsoft Word, Excel, and Publisher, digital cameras, and a video camera. Each content area developed their own list and then together all the content areas came together to discuss the ability to share items between content areas. A comprehensive list of probes, software, and hardware was then submitted and purchased for the schools.

This process occurred in order to consider the proper application of technology to the classroom. A careful evaluation and identification of needs and inclusion in the curriculum came before purchase of technology items. A majority of the technology items on the collective list were approved by the curriculum director. In order to meet budget constraints, equipment is generally shared throughout the department within each building.

The technology arrived in the schools between December 2004 to February 2005. The teachers at Portage Northern High School were aware of the lack of understanding how best to use the technology in the classroom. There also were bugs that needed to be worked out; both technical and non-technical problems arose during the first few months of use. Some of the wireless connections weren't operating properly, and there were problems with the software working properly with other conflicting programs on the computers.

Students needed to be taught how to check-out and check-in the laptops, teachers needed to learn how to reserve and employ the carts in their classrooms. Teachers were acutely aware that there were probes and software that they had limited experience using. Teachers that were "tech-savvy" were using the equipment more often, but still with questionable success. To help teachers evaluate and create opportunities to learn how to effectively use the technology in their classroom we needed an effective professional development program. We wanted to evaluate the professional development program and the use of technology back to the two initial questions voice at the beginning of the thesis.

IMPLEMENTATION

To create a professional development model that would work effective, our approach included the understanding that there were hurdles and roadblocks that needed to be overcome in order for the technology to be successful. Our approach evaluated the inter-connectness of the entire system, rather than focusing on the singular issue of technology in the classroom. The model reflected the best practices of the theoretical framework, fit within the budget constraints of PPS, was consistent with the core technology outcomes within the district, and (or course) was workable for teachers in their classrooms. The project was informally named the Science Educators Technology Sharing Initiative (SETSI), with the primary outcome of integrating technology into the secondary science classes to best meet student learning and the needs for a good professional development program.

PPS had money available to provide for professional development. This presented us with the opportunity to design a professional development program that could truly assist teachers in the long term use of the technology in the classroom. Some of the money was used to bring in a Vernier expert to present a day long session on ways to use the Vernier family of probes in the classroom. The training was adequate, and did allow us to see what opportunities the equipment offered the classroom. The training was not designed to offer classroom ready ideas to connect students and technology with learning.

The school district came up with a unique solution that meets the criteria of the theoretical framework. The district was willing to provide two hours (two fifty minute class periods) per day for two teachers to not meet with students, and instead focus on technology and its optimal use in the classroom. Each high school building was given the authority to design the program using these teacher resources. This was a serious financial commitment to a different model of professional development. The open-ended nature of the model allowed Portage Northern to develop a unique professional development opportunity to reflect and meet the needs of teacher professional development and effective student use of technology. The selection of teachers to participate in the program was left up to the science department themselves. In the fall semester a technology-savvy teacher was paired up with a less technology-savvy teacher. In the winter semester, two moderately technology-savvy teachers were teamed up for the project.

The science department at Portage Northern developed open-ended guidelines to place productive boundaries on the time. We decided to give teachers the two hour time block in semesters. Thus each semester there were two different teachers that have the title of "Tech-Time Teacher". Their responsibilities centered around two main guidelines of the technology. First, they are responsible for the organization and some maintenance of the equipment (mostly to communicate problems on to the IT person properly). And more importantly, they were to develop the activities that would properly integrate technology into the classroom. This time provided the tech-time teacher with 180+ hours per semester to devote to the investigation and use of technology in the classroom. This professional development time should yield positive results to teacher use of technology in the classroom, and to effective student use of technology.

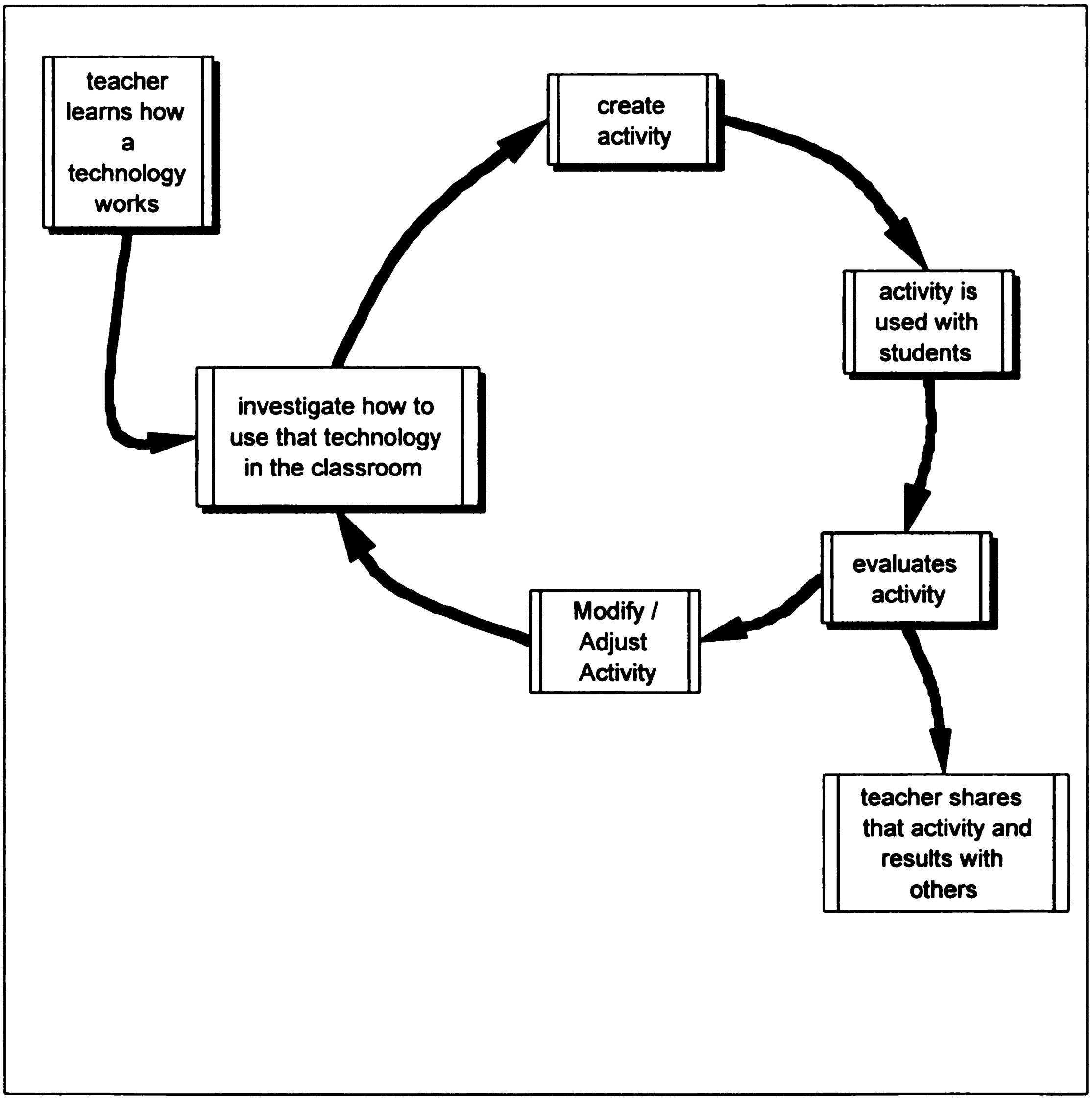

Figure 1. System flowchart for the tech-time teacher.

The tech-time teacher was given the latitude to develop and investigate whatever applications and tools they believe will benefit them and others in the classroom. Figure 1 describes the system employed to produce results from the tech-time teacher's work. The see-saw in the center of the system cycle is representative of the balancing nature that is generated by activities that are successful and activities that are unsuccessful. When an activity did not work as predicted, or had a poor outcome, the activity was modified by the tech-time teacher and then retried or tossed out. The roadblocks that face teachers when using a particular piece of technology can be overcome when the teacher has the time to evaluate the process using his/her time to trouble shoot the equipment, and refine the activity.

The entire process is highly inquiry based. Tech-time teachers investigated technology that they believed would benefit their teaching and their students (and the other teachers and students in the department). The tech-time teacher developed activities and labs that center on his/her desire to learn how that particular piece of technology can apply to the classroom. The teachers have the ability to work in tandem with the other tech-time teacher, providing for a collaborative process. Using this model, teachers would focus on the aspects of technology use that would give them the best return on their investment of time. At least one hour of the tech-time positions overlaps with the other teacher. The process outcomes from the tech-time teacher are to be shared. All items that are developed as a result of the tech-time position are shared and discussed among the science department. If a teacher developed a lab that fits well into the curriculum, then they were obligated to share that lab with the other teachers of that subject.

Tech-time teachers are available to assist the integration of technology into other teachers' classrooms by assisting with checkout and initial instructions. Tech-time teachers were also present when new equipment was introduced into lab setting. Minimizing roadblocks and fostering success when piloting a new piece of technology (e.g. lab activity) was accomplished by having another teacher present.

Focusing on the level one courses was the last guideline that the tech-time teachers were given. Teachers would then have the time to develop complex deeper activities if their initial focus was on the use of technology with freshman and sophomores. It also would give the students basic skills with some of the complex probe technology before employing it in an upper level class. The students to would also grow with the teachers' understanding and use of the technology components.

These guidelines put boundaries on the SETSI program at Portage Northern High School and are consistent with the questions raised with the professional development of technology and student effectiveness in the classroom. They also provide a framework for the evaluation of the increased use of technology by teachers and the student perceptions of technology in the classroom throughout the school year. This thesis investigates the SETSI program over the 2005-2006 school year and displays some of the developed activities and labs in appendix B.

EVALUTATION METHODS

A variety of survey tools were used to evaluate the SETSI program. Four primary tools comprised the evaluation. The survey instruments are contained in Appendix A.

1. Technology Scheduling Calendar

    The first tool employed to evaluate the use of technology is the technology scheduling calendar. The technology equipment (laptops, probes, projectors, etc.) was all reserved throughout the year using Microsoft Outlook™. When a teacher wanted to use a piece of equipment, they placed a reservation on a common online calendar within the districts Outlook™ system. All the teachers could place and see schedules on the calendar. This also served as a collection point for data. At the end of the year the calendar data were analyzed for use trends.

2. Teacher Usage Instrument

    For five weeks during the end of January through February of 2006 teacher self-evaluation on the use of technology equipment was collected. This instrument was designed to look at how a teacher reflects on his/her own use of technology in his/her classroom. This instrument measured the occurrences of both technology based activities and non-technology (electronic) classroom activities. This instrument is designed to show if a teacher is replacing non-technology components of teaching and learning with technology components by a drop in classroom non-technology activities.

3. Student Perception and Use Instrument

    Student use and perception data were collected during two different times during the school year. The students were evaluated after five weeks of school and then at the end of the first semester, approximately 18 weeks into the school year. The students checked off technology items from a long list of available technology that teachers could employ in their classroom. This was designed to determine what technology items are being used in the classroom. The item list provided a breakdown of how the students use particular components of the technology. Also included in this survey were a set of Likert scale items related to the students' perception of the use of technology, including their perception on the teachers' ability to use technology and the students' perception of the impact of technology on their education.

4. Dialog and Examples of Developed Materials

Discussions and anecdotal conversations were conducted with teachers about the tech-time program and what their needs were. Specifically, exemplary paper components of activities developed as a result of the tech-time program were collected and used in analysis of the SETSI program. Those items are in appendix B and include some activities from biology, chemistry, physics, and earth science.

The student sample includes 106 students in 7 different classes with 5 different teachers. The courses included level-one biology, chemistry, earth science, and physics, and upper level chemistry and physics. Four of the seven courses were introductory level. Three courses were advanced or IB courses (primarily juniors and seniors). The teacher sample included all ten science teachers in the science department.

RESULTS AND ANALYSIS

The results of each instrument were categorized using the same numbering system as the previous section. Each section contains the analysis method used and accompanying charts.

1. Technology Scheduling calendar

The outlook scheduling calendar was extracted and placed into an Excel™ spreadsheet. Each instance of scheduling for a technology item was treated as a single use, regardless of how many hours that the teacher was using the equipment. This method was used since teachers scheduled technology materials by course, and not by day or by hour. The data was stripped of teacher identifiable marks and then aggregated by month and plotted using a histogram (figure 2). The histogram shows a definitive difference between fall and winter-spring technology use.

Table 1, shows the disaggregated data by teacher, and a fall (September through November) average and a spring (February through May) average use per month. Portage Northern High School uses semester long level one science courses, thus level-one teachers repeat content twice during a year. An average use per semester would show a trend. December, January, and June are not in the averages due to the holiday break, semester final exams, and the end of the school year. The data in table 1 were analyzed comparing fall vs. spring averages via paired t-test for each teacher average. The t-test ($t=3.52$, $p= 0.0065$, $df = 9$) showed significant increase in the number of uses per teacher between semesters.

	T1 – Biology / chemistry (9,10)	T2 – Biology / Earth (10,11,12)	T3 – Biology / Earth (10)	T4 – Chemistry (9,11,12)	T5 – Earth / Chemistry (9,10)	T6 – Chemistry / Physics (9,11,12)	T7 – Physics / Forensics (11,12)	T8 – Earth / Biology (10,11)	T9 – Physics (9,11)	T10 – Physics (9,11)	All teachers
September	0	1	1	10	0	7	5	0	0	2	**33**
October	5	7	1	4	0	11	0	0	0	10	**39**
November	1	6	1	3	1	6	7	0	0	19	**44**
December	3	1	0	0	1	0	0	1	0	12	**19**
January	7	6	1	4	0	0	1	0	0	15	**34**
February	7	15	10	14	1	16	5	10	4	12	**94**
March	14	6	11	4	1	16	4	7	5	29	**97**
April	5	9	1	2	1	8	0	7	7	18	**58**
May	9	10	0	3	0	1	3	10	29	22	**89**
June	1	0	0	0	0	0	0	0	0	6	**7**
Fall average	2.0	4.7	1.0	5.7	0.3	8.0	4.0	0	0	11.3	**38.7**
Spring average	8.8	10.0	5.5	5.8	0.8	10.3	3.0	8.5	11.3	20.3	**84.5**

Table 1. Teacher use of technology by month. Including averages for fall and spring.

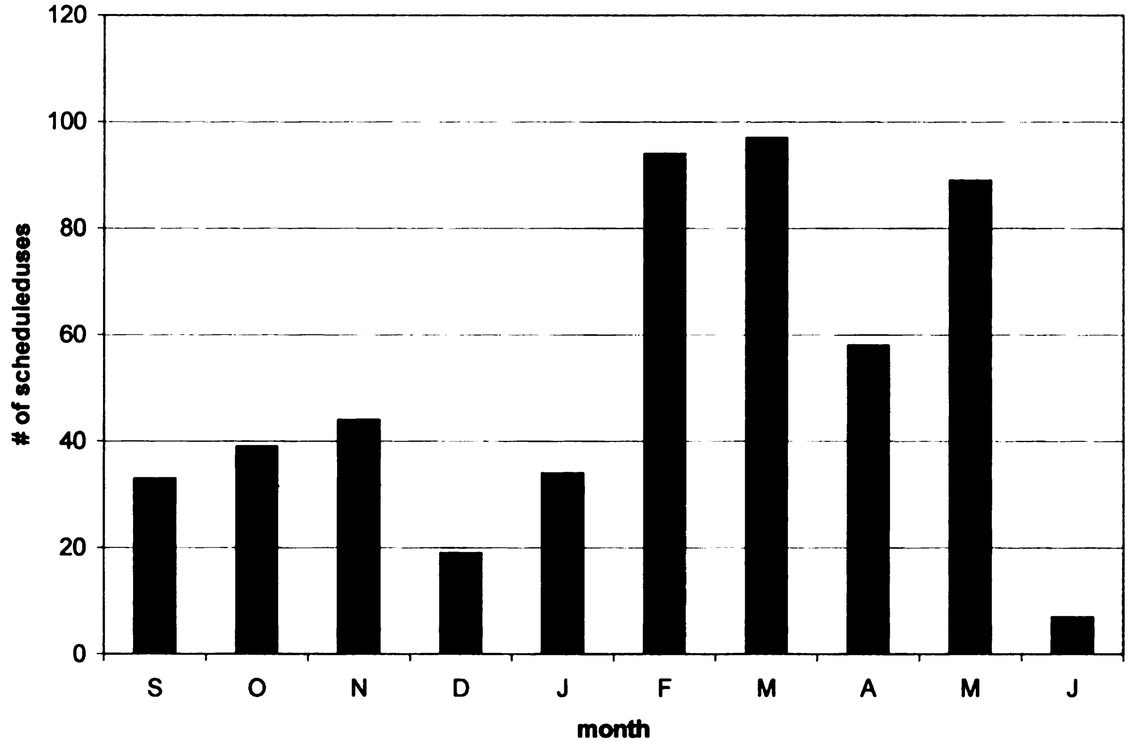

Figure 2. Number of scheduled technology items by month for the entire department.

The data were analyzed to look for a difference between tech-time teachers and non-tech-time teachers' use of technology (Figure 3). A t-test analysis was performed to determine if the trend in the use of technology is localized within the tech-time teacher or if his/her efforts affected the greater science department. The tech-time teacher showed little variance from the non-tech time teacher in his/her use of all technology components by month ($t = 0.182$, $p = 0.858$, $df=9$).

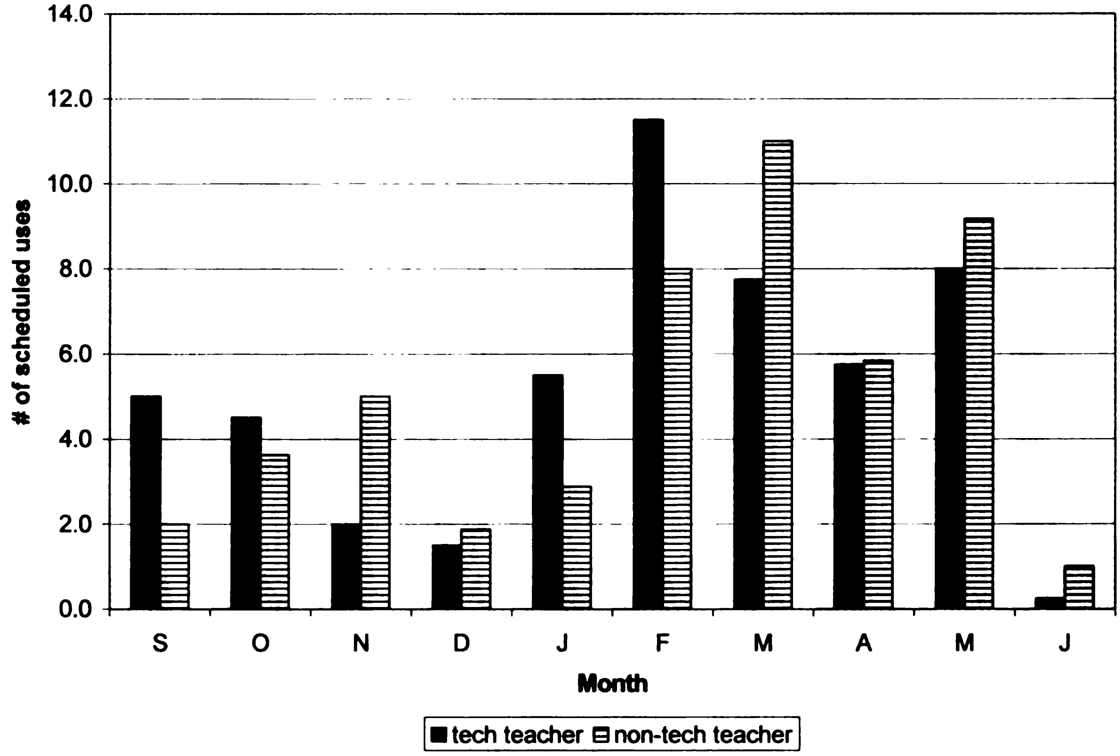

Figure 3. Aggregated use data by tech-time teacher and non-tech-time teacher.

2. Teacher Usage Instrument

Teacher use of technology and non-technology data were collected weekly on Friday of the current week or the Monday after the week using a paper form. The data were encoded by category and number of use on a Likert scale. Average occurrences per week were aggregated from the reported values. Figure 4 illustrates the data organized by category. The same aggregated data were analyzed via an ANOVA method to look for variance between the mean value in each category. The sample failed to show variance according to the ANOVA test ($p = 0.621$). Teachers appear to use the technology equipment consistently within the five week period of measurement.

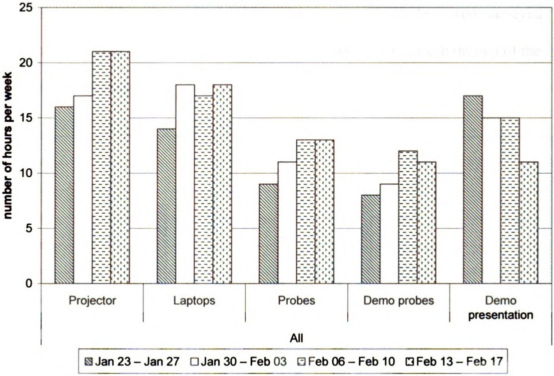

Figure 4. Teacher use of main technology items per week.

3. Student Use and Perception Survey Instrument.

The student use component was designed to illustrate what items of technology were being used in the classrooms. Figure 5 denotes the types of items used and the percentage of students who claimed to use that item in class. The first three categories are common Microsoft™ products, "LoggerPro" and "LabPro" are Vernier technology, "camera" is a digital camera, "microscope" is a digital microscope, "Turnitin" is Turnitin.com, an online anti-plagiarism service and report submission system, "calc" is a calculator, "bio" through "forensics" are content specific software for those curricular areas. The students were surveyed approximately five weeks into the fall 2005 semester and again at the end of the fall 2005 semester.

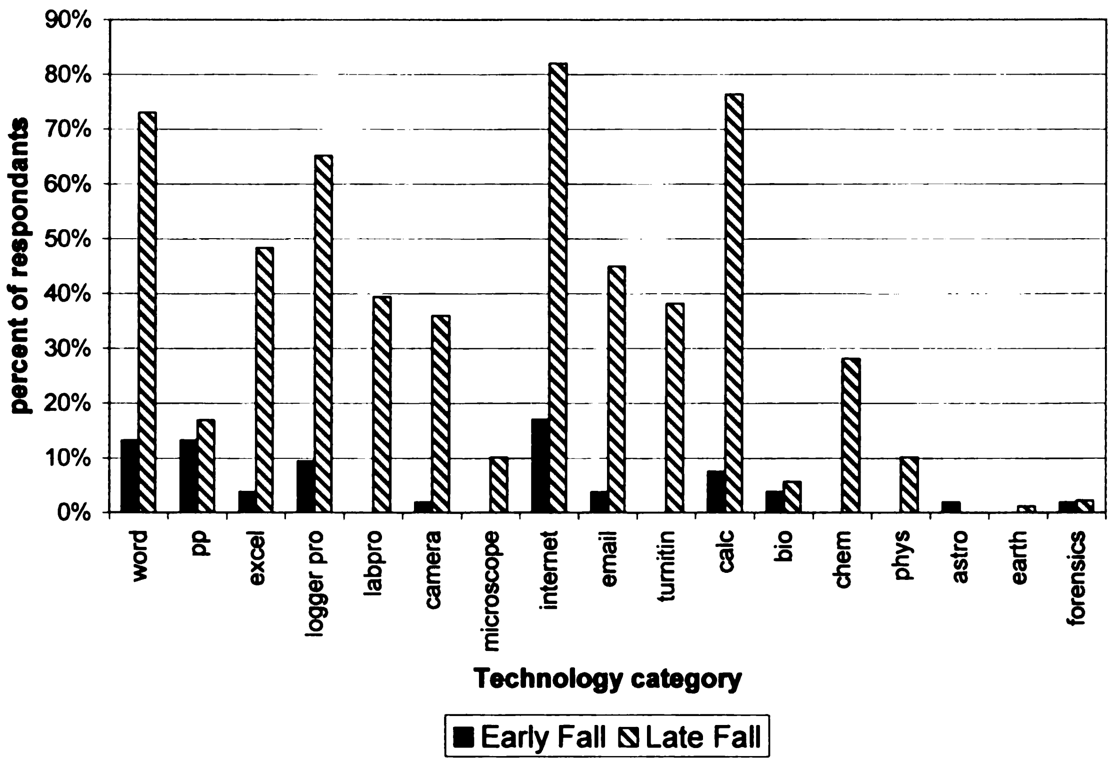

Figure 5. Percentage of student respondents who claimed to use that technology item in their classroom.

The percent use values were analyzed by t-test for differences in a single semester (unpaired, heteroskedastic). The students appear to have used a significant more amount of classroom technology later in the semester rather than in the early stages (t = 3.38, p = 0.004, df=105).

The students were also asked to respond to five Likert scale statements related to the use of technology. Table 2 shows the statements and the paired t-test results for each statement as well as average responses. None of the statements had a significant change over the course of the semester according to a t-test. Blank values were ignored from the descriptive statistics in this case. All the values in this table appear to be extremely high. Students appear to not have changed their perceptions of technology throughout the semester, or the questions being asked of them were inadequate to analyze any changes.

Table 2. Mean values for the student perceptions of technology in their classrooms.

	Mean values & standard dev. In semester			
Likert Scale Statement	**EARLY**	***Std. dev***	**LATE**	**std. dev.**
I am comfortable using the laptops in class.	4.64	0.8	1.140	0.5
I am comfortable using probes in the lab.	4	1	0.822	0.8
Technology in the classroom improves my education.	4.26	0.9	1.791	0.8
I am excited when I see the laptops are being used in class.	3.92	1.2	0.000	0.9
My teacher knows how to use technology well.	4.46	0.8	1.153	0.8

4. Dialog and Examples of Developed Materials

Teacher dialog happened over the course of the semester using email and face to face communication. These communications were relatively inert and were mostly of a informative manner rather than about technical issues or creative solutions to technology problems. They centered on the scheduling of technology, and maintenance of the equipment. Exemplars of these activities are assembled in Appendix B. They include some activities developed for biology, chemistry, and earth science. The bulk of the lab investigations developed by the tech-time teacher were generally re-writes from lab investigations that were currently being done without the use of technology.

A balanced approach to teaching and learning was important, and some technology based lab investigations underwent major revisions resulting in less use of technology after their first trial in the fall semester. One lab that changed was the Gas Law Mini Lab. The lab is used in a freshman chemistry course. The initial idea was to use the LabPro and software to create detailed graphs of the relationships between gas variables (Pressure, Temperature, and Volume). The amount of time invested in having the student set-up, collect, and graph relevant data all while learning the gas law concepts was too intense. The lab was simplified to teach the students LabPro setup and then just the relationships between the variables. The lab itself was more appropriate to the level of students and the position within the semester. Technology was still used, but the appropriateness was adjusted to allow for effective student learning.

Another interesting investigation of note is a half-life lab. Originally, the Half-Life lab was designed using m&m ™ candies. These candies are sufficient to conduct a decay half life lab, but their only flaw is that a single random shake of the m&m's ™ leads to a

50% decay in the sample. This flaw can be observed in the Old Half-Life Lab in Appendix B. The lab could be upgraded so that the students would use the laptops to generate generic half life data using some randomization functions. The complexity of the data, as well as the absence of a concrete understanding of what it means for a particle to "decay", led us away from the laptops to a decidedly low-tech solution. The students use six sided blocks with colored faces to randomize particle decay. This physical manipulative did a much better job at the basic level of describing half-life. Using different colored faces, the half-life can be manipulated so that it takes six, three or one cycle to occur. The data is then plotted as a class using LoggerPro software. This mixed approach was then followed with the decidedly high tech version which employed a radioactive particle with a half-life of approximately 2.3 minutes and a Geiger counter connected to the software. While the students were analyzing the manipulative block data, the Geiger counter was collecting and plotting the real half life data. This mixed approach was common within the tech-time teachers. There was a collective understanding of the importance of the concepts as well as the technology's ability to help provide that understanding.

The teachers seem to appreciate the tech-time teachers. Non-tech-time teachers offered verbal "thank-yous", as well as written thank you notes to the tech-time teachers. I was often in other teachers' classrooms when the laptops were being used, and my interactions with both the teacher and students led to fewer problems. Student questions could be quickly responded to with the 12 to 1 ratio when two teachers are in the room. When I was piloting the Gas Law Mini Lab setup using the Laptops, gas pressure gauges, and the LabPro devices, a tech-time teacher assisted me. The presence of another teacher to troubleshoot the students and the software created a more successful lab and provided better feedback about changes that needed to be made to the lab. Without that teacher's help, the stress level associated with the investigation would have been greater. During one tech-time hour, I was working with another teacher using beral type pipets for the heat of fusion lab (See appendix B). The other teacher noted that if we can measure energy changes in water, that we could use sand in the beral pipet tips and for a Heat Emission & Absorption of Sand vs. Water lab in earth science. This lab is still being developed. The second lab was a direct result of the first lab's successful use of the probes and technology. Without the tech-time teachers interacting and observing the usage of technology outside of his/her content area, this connection would not have been made.

A recent email with a tech-time teacher from the second semester highlighted her activities. (D. Poulsen, personal communication) She developed eight full units of PowerPoint presentations for Astronomy & Earth Science. She developed seven internet activities for astronomy class, and produced three labs using probes for the earth science / environmental course, including a foul water and stream monitoring probe labs using the Vernier equipment. The tech-time position afforded her the resource of time to develop all of these activities. The tech-time teacher, when given appropriate dynamic time to work on important activities that solved a particular question or problem they faced, was able to find a solution that worked well.

The tech time position allowed me more time to discover uses of technology. During the semester when I was not the tech-time teacher, I wanted to develop an investigation using the colorimeter in a rate law lab for my upper level students. The lack of time prohibited me from adequately developing the lab for my students. That lab will have to be developed next year, when there is more time to complete the proper development and use of the technology.

CONCLUSION

Overall, the analysis of this professional development model answers the first question raised at the beginning of the thesis. The data analyses in figure 2 indicates a clear increase in the use of technology in the teacher classrooms through the school year. The tech-time teacher, through the SETSI program, appears to have been given the appropriate amount of time to affect a change in his/her own use of technology. The tech-time teacher created new activities and updated many other activities that had a positive outcome on student learning. It is important to note that the use of technology wasn't significantly different between the tech-time teacher and the non-tech-time teacher. (Figure 3) This reinforces the shared approach to the development and use of technology in the classroom. It also might reinforce a false hypothesis. The increase in the use might be due to the fact that the technology is present in the school, and that its presence is the reason for the increase in use. It would logically follow that the tech-time teacher should be using the technology the most, and thus should show a larger increase in usage compared to the non-tech time teacher. A control group (a group of students and teachers not exposed to the SETSI program) could better demonstrate result, but a control was not a feasible option within this study. The increase is clearly marked along the semester time line and the clarity in the change in use is clearly evident. (Figure 2) The intensity and interest of the science department in the inclusion of technology in the classroom is another factor that could be affecting the increase in technology use in the school. Seven of the ten teachers in the sample set showed a positive change in technology use. Two teachers showed insignificant increases in use (T4, T5 in Table 1), while one teacher showed a decrease in use (T7 in Table 1). The remaining seven teachers had significant increases in use over the school year. If the teachers in the study were significantly self-motivated, then this motivation could be the cause of the increase in use rather than the tech-time position.

The five week survey of use within the January through February time period is unremarkable in showing any trends. This time period was chosen since it was the beginning of the second semester, and thus, trends in self use would be automatically evident. There is no significant change in the technology use between those time periods as self-reported by the teachers in the study. This could be interpreted as a success for the SETSI program. The teacher use did not change within those five weeks, so it could be said that there was a consistency of use within the first five weeks of the second semester. Teachers appear to be using the technology in a balanced fashion in their classroom. The technology is not localized to a single lab activity and then re-shelved until the next time a technology based lab appears in the curriculum. The only issue undermining this conclusion is as expressed earlier – the change could simply be the result of the presence of technology and a motivated teacher rather than the direct result of the SETSI model.

The student use of technology increased during the course of a single semester. The students were initially measured approximately five weeks into the school year and again, near the end of the first semester. The most common uses were the internet and

Microsoft Word™. The least common uses were with the content specific software. In the chemistry field, the only software used is an organic modeling program, which isn't used until the advanced courses. There could be a factor of time associated with the discovery and use of appropriate content software. Finding software to use in the classroom is a time consuming task. A tech-time teacher cites evaluating 25 different CD-ROM packages for astronomy curriculum and only two were worthy of further investigation. She called the stack "huge" and was surprised to end up with 2. (D. Poulsen, personal communication). The evidence for increased use of different components of technology reinforces the claim that the SETSI program increased technology in the classroom. Students most likely had more access to technology in the classroom towards the end of the semester. Their use of the technology was not analyzed to see if they were using it for tech-time developed activities or for more traditional assignments.

The Likert scale evaluation of student perceptions was remarkable only in the consistency of the "strongly agree" values that appeared in the study. (Figure 6 and Table 3) Students rated their comfort with the probes as a strongly agree or a "no-experience". I would anecdotally disagree with their analysis. According to my observations, many students in my upper level classes were frustrated during the initial use of the probes. Their perception of their abilities with the probe technology appears to be inflated. The comfort level using the probes as an education tool should increase throughout the semester, but Table 2 values show no significant change. This reinforces the fact that perhaps the instrument used to measure the perceptions was flawed and the proper questions were not asked throughout the semester.

Overall, the snapshot nature of the perceptions reinforces the idea that, at Portage Northern, students are using some technology prior to high school and arriving at the high school with established convictions about the statements being evaluated in the study.

The SETSI program results appear to support the concept that when given the time for a teacher to develop his/her own skills and create advantageous resources for students, that there is a significant increase in the use of technology in the high school science classroom. Teachers were pleased with the results of the program and felt like good products (activities, labs, etc) were being developed. The student perception change was not decidedly supported by the study and there may be more factors necessary to investigate the perception of the changes in teaching and learning from the use of technology in the classroom.

FURTHER ANALYSIS

The SETSI program could be evaluated further to provide a better picture beyond this initial study. Portage Public Schools is collecting district wide assessment data to look for improvements in science education. This may show a connection to the SETSI program, but causality would be hard to establish due to the complexity and variety of factors involved in student education. A study that focused on one particular aspect of technology in the classroom might be a better indicator of the effectiveness of a SETSI program. I would suggest an investigation specifically surround the use of data collection probes and the results of student knowledge of concepts. This would give a more definitive correlation to technology and the students' learning.

Student perceptions should be evaluated more aggressively in the future. The minimal five statement Likert scale is not enough to definitively evaluate student perceptions of technology. A study surrounding these perceptions could stand alone and would be useful to investigate how students respond to technology use increase in their learning environments.

The use of electronic probes for measuring lab data is an area where further research could be done. An investigation into the root of the problems with the probes could look at conceptual problems with the science content or operational problems with the probes themselves. The student improvement in learning and application of science concepts could be better analyzed within the context of a more focused study surrounding the use of the probes.

FUTURE OF THE SETSI PROGRAM

All the teachers felt the SETSI program and tech-time teachers were essential to the use of technology in the science classroom. The tech-time teacher was utilized and had a greater service role in the science department. The SETSI program has received funding for a second year (2006-2007). Portage Public Schools will continue to collect student performance data to make a more comprehensive picture of the district science curriculum available, including aspects of technology and its use.

The SETSI program is also undergoing changes as well. The collaborative effort between the science teachers in both high school buildings will be stressed next year. There was some duplication of efforts by the tech-time teachers at each school that could have been alleviated with better communication. Within Portage Northern, the science program is centering all courses on a collective environmental connection. Whenever possible, new activities are being developed that connect students to the local (Southwest Michigan) ecosystems. Tech-time teachers will most likely have new areas to focus technology integration as a result of this connected theme.

The SETSI model is also being investigated as a model for other departments within PPS. It is also being investigated for use outside of a technology application. When a department begins a new curriculum cycle, the inclusion of technology is occurring and the SETSI model will be evaluated as a possible route of effective professional development within their department.

Certain teachers have a greater affinity to technology and thus find themselves being utilized regardless of their status as a tech-time teacher or not. Certain teachers do not want to be tech-time teachers. All of the teachers in the science department were enthusiastic about the program. With this attitude, it seems logical that some teachers will continue to champion technology and always be the teachers to include new uses in their classroom. It is important for the SETSI program to pair these teachers with teachers who have less skills and desire to use technology. This would continue to reinforce a consistent curriculum within all the science courses offered in Portage Public High Schools.

APPENDIX A – SURVEY INSTRUMENTS

Appendix A-I Teacher Usage Instrument

Name:					
For each of these questions circle how many hours that equipment was used. Consider a section of a class as a single hour. (e.g. – I teach three hours of Chem I, and I used the projector in that class for 1 hour this week, and I also used it in my IB Chem I for two hours, therefore I would record 3 hours) (II,III)					
This week...	**Hours of use**				
...I used the projector in my classroom	0	1-3	4-7	8-11	12 or more
...my students used the laptops	0	1-2	3-4	5-6	7 or more
...my students used the probeware in the lab	0	1-2	3-4	5-6	7 or more
... I used the probeware in the classroom to present a topic or demo	0	1-2	3-4	5-6	7 or more
... I presented a demo	0	1-3	4-6	7-9	10 or more
Definitions:					
Probeware :	Any device that uses electronics in a lab setting to collect data (took a digital photo is included, as well as, digital microscope, Vernier, etc.)				
Demo:	Use of any equipment other than whiteboard or projection equipment to illustrate a science concept. Student involvement should be minimal in a demo. Non electronic equipment is included.				

Appendix A-II – Student Perceptions and Use Instrument

Name :

For the items below, answer each question to the best of your ability.

Technology use and impact (III)

Below is a list of technology items that you may have used in your class.	*Check the items that you have used in this class.*	*For the items that you have checked, rank the top four items that have had the greatest impact on your grade. (1 is the most impact...4 is the least impact.)*
Microsoft Word®		
Microsoft PowerPoint®		
Microsoft Excel®		
Vernier LoggerPro® (graphing software)		
Vernier LabPro® (data collection probes)		
Digital Camera		
Digital Microscope		
Internet		
Email		
Turnitin.com		
Lon-Capa (Online homework system)		
Calculator		
Biology specific software		
Chemistry specific software		
Physics specific software		
Astronomy specific software		
Earth science specific software		
Forensic science specific software		

Below are a set of statements, please check a box that indicated how much you agree or disagree with the statement. Check "I have no experience..." when you have not used that item in your class. (II,III)	***Str on gly dis ag ree***	***Disagree***	***Neutral***	***Agree***	***Strongly Agree***	***I have no experience with this item.***
I am comfortable using the laptops in class.						
I am comfortable using probes in the lab.						
Technology in the classroom improves my education.						
I am excited when I see the laptops are being used in class.						
My teacher knows how to use technology well.						

APPENDIX B – SETSI TEACHER DEVELOPED MATERIALS AND ACTIVITIES

Gas Law Mini Labs

Abstract:

In this lab investigation you will explore the relationship between physical properties of gases. Historically the physical properties of gases intrigued scientists. This lab consists of various stations with different properties to investigate about gases and the relationship of their properties.

Materials:Each station has its own materials:

Station 1: Crush! Teacher demonstration station: Hotplate, soda can, tongs, and water.
Station 2: Marshmallow Person: mini-marshmallow, marker, large syringe (60ml) with Luer lock cap.
Station 3: Push that syringe: 60mL syringe, gas sensor, LabPro, laptop.
Station 4: Cartesian diver: Cartesian diver apparatus
Station 5: Hot and cold syringes: A syringe with Luer lock, hot plate, hot water, cold water.
Station 6: fixed volume sample – 125mL Erlenmeyer flask, gas pressure sensor, temperature sensor, lab pro, laptop.

Special Safety Concerns:

- Watch the hot water! Don't get burned

Procedure:

Proceed to each station and conduct the steps listed below, be sure to record observations and answer questions before going to another station. For each station, there are variables that are being controlled, and variables that respond to those changes. You need to identify the variable that is being controlled and the variable that is responding.

Station 1: Watch the instructor do the demonstration and record your observations in the data section.

Station 2:

1. Take one mini-marshmallow and using the marker provided draw a face on the marshmallow.
2. Remove the plunger from a syringe.
3. Insert the marshmallow person into the syringe.
4. Replace the plunger, set it at the maximum value.
5. Place the Luer Lock on the syringe.
6. Decrease the volume of the syringe while holding your thumb on the Luer Lock.
7. Record what happens to marshmallow person.
8. Open the syringe Luer Lock.
9. Set the plunger to the minimum level without crushing marshmallow person.
10. Close the syringe Luer Lock.
11. Increase the volume of the syringe to the maximum.

12. Record what happens to marshmallow person.
13. Open the Luer Lock, remove the plunger, and throw away marshmallow person. DO NOT EAT HIM/HER!

Station 3:

1. Remover the syringe from the gas pressure sensor by turning it the same way as you would a screw.
2. Make a table in the data section with **pressure** as one column and **volume** as the other.
3. Set the syringe at 8 mL and reattach the syringe to the pressure sensor.
4. While one of operates the laptop, the other will operate the syringe.
5. Click collect on the laptop. (to start the collection)
6. Click **keep** and input the volume (in mL) from the syringe.
7. Increase the volume of the syringe by 2 mL and click **keep.** Enter the volume.
8. Continue this process until you are at 20 mL.
9. Go back down to 10 mL and collect that data again.
10. Click **STOP.**
11. From the computer monitor, record all your data, and sketch the graph from the laptop.
12. Reset the laptop by opening the file ***G:\huberchem\HchemI\pushsyringe.cmbl***
13. Record all observations and data.

Station 4:

1. Pick up a bottle.
2. Squeeze the bottle.
3. Watch what is occurring in and to the dropper. Record your observations.

Station 5:

1. Remove the Luer lock and set the syringe at 20 mL, replace the Luer lock.
2. Place the syringe in the hot water bath for 30 seconds. Watch for change, it can be subtle. Make observations.
3. Quickly transfer syringe to the ice water bath. Watch for change, it can be subtle. Make observations.
4. Record observations about the syringe in the data section.

Station 6:

1. The laptop should have logger pro opened to the file ***g:\huberchem\HChemI\presstemp.cmbl***
2. Observe the meters on the laptop screen. Make a table of temperature and pressure.
3. Ensure that the flask is sealed and that the probes are connected properly.
4. Ensure that the flask and thermometer are recording room temperature and pressure and record those values.
5. Immerse the flask and thermometer in the cold water sample. Watch the pressure and temperature change. Record what happened to both the temperature and pressure.

6. Transfer the flask and thermometer to the hot water sample. Watch the pressure and temperature change. Record what happened to both the temperature and pressure. DO NOT LEAVE THE FLASK IN THE HOT WATER SAMPLE FOR TOO LONG, the stopper will pop off.
7. Remove the flask and thermometer and set back to the table top.

Data:

On the rest of this page make your own table to record data about this lab. Ensure that it is legible and complete.

Chemistry **Gas Law Mini Labs**

Conclusion questions:

Station 1:

1. What happened in the can?
2. Where was the pressure that crushed the can?
3. Speculate how this might have happened.

Station 2:

4. What two gas law variables are involved in this station?
5. What variable(s) are you controlling (the independent variable)?
6. What is the relationship between the two variables that you are changing?

Station 3:

7. What are the two variables that you are changing in this part of the experiment?
8. What does the graph show about the relationship between volume and pressure?
9. Sketch a complete graph for the system.
10. Is the relationship inverse or direct?

Station 4:

11. What two variables are being changed in this experiment?

12. As you are squeezing the bottle what are you doing to the contents of the dropper? What property of the dropper is being changed when this happens. Remember that this is a **gas** law lab!!!

13. How does the Cartesian diver work?

Station 5:

14. What variables are being changed in this experiment?

15. If you did this experiment with a balloon, how would the volume of a balloon change as the temperature of the balloon changes?

Station 6:

16. What two variables are being investigated in this experiment?

17. What variable is not being changed in the experiment?

18. Write a sentence or two indicating the relationship between temperature and pressure using your observations from this station.

Chemistry

OLD Half Life Lab

Abstract:

Radioactive materials are constantly losing small particles from the nucleus in a process known as radioactive decay. Each atom of a particular radio-isotope has a certain chance of decaying in a given amount of time. In this activity we will simulate this randomness by rolling dice, where each die represents a radioactive atom. Despite the randomness, the probability of decay occurring is the same for each atom of a particular isotope, which allows us to look at consistent patterns, such a half-life. Half-life is the amount of time it takes half of a radioactive isotope to decay. This time remains the same no matter how much of the isotope remains.

Materials:

m&m™ sample
Shoe box with a line in the middle
Graph paper

Special Safety Concerns:

None.

Procedure:

1. Count the total number of m&m's you are starting with. This is the number of "total undecayed m&m's" after zero time
2. Place the m&m's in the shoebox and put on the lid. Shake the box for 10 seconds, this is the half-life time. Remove and set aside any of the m&m's that have an "m" side up if they are on one side of the line. These m&m's are considered "decayed". Record the number of m&m's removed in the column "m&m's Decayed ". Count how many m&m's are left – this is the "Total Undecayed m&m's" for the first roll.
3. Shake the box again, counting and removing any m&m's with "m" up. Keep track of how many m&m's are "decayed" and "undecayed"
4. Continue shaking the box and removing m&m's until there are no m&m's.
5. Repeat this entire procedure again before eating any decayed m&m's.
6. Graph "Time(s)" v. "Total Undecayed Dice."

Data:

	Trial #1		**Trial #2**	
Time (s)	**M&m's decayed**	**M&m's undecayed**	**M&m's decayed**	**M&m's undecayed**
0	0		0	

OLD Half Life Lab

Results:

Attach your graph of "Time" v. "Total Undecayed m&m's" Be sure to include a best fit curve.

Pick a particular number of "Undecayed m&m's" and see how much time it took until that total was half that number. For instance, determine how many turns it took to go from 40 m&m's to 20.
What number did you pick? How much time did it take for there to be half as many?

Now pick a different number and determine how many turns it took to get to half that many m&m's?
What number did you pick this time? How many turns did it take in this case?

Repeat this with a few other numbers. Take the average of all of these numbers. This is the half-life for the system.

Conclusion questions:

Which was more consistent, the amount of time it took to remove half the m&m's remaining, or the number of m&m's removed each turn?

Do you think you would have similar results if you started with 1000 m&m's? Why or why not?

Do you think you would have similar results if you started with 2 m&m's? Why or why not?

Half Life Lab

Abstract:

Radioactive materials are constantly losing small particles from the nucleus in a process known as radioactive decay. Each atom of a particular radio-isotope has a certain chance of decaying in a given amount of time. In this activity we will simulate this randomness by rolling dice, where each die represents a radioactive atom. Despite the randomness, the probability of decay occurring is the same for each atom of a particular isotope, which allows us to look at consistent patterns, such a half-life. Half-life is the amount of time it takes half of a radioactive isotope to decay. This time remains the same no matter how much of the isotope remains.

Materials:

2 blocks with a single side colored (2 per person)
1 person per class with record the data on the board
1 person per class will record data on a laptop

Special Safety Concerns:

None.

Procedure:

1. We are investigating how long it takes for half of the sample to "decay". This is defined as half life. "Decay" for this lab, is when the block lands colored side up.
2. When the instructor says "roll", you roll both of your blocks. If they land colored side up, they have decayed. Bring your decayed blocks to the front table to be counted.
3. The recorder will record the data on the board.
4. Steps 2 through 4 will repeat until all blocks have decayed.
5. This entire lab will be repeated a second time.
6. When you are done with your blocks, begin recording all the data from the board.

Data Analysis (only for student with laptop)

7. Obtain a laptop and open Logger Pro. Open the file, *g:\huberchem\HchemI\halflife.cmbl*
8. Enter the trial data into Logger Pro. (No connecting of the dots)
9. Ensure that the title and axes are correct.
10. Change the page setup to landscape.
11. Print your graph (Instructor will tell you how many sheets)

Data Analysis (for all students)

12. Draw in a curve of best fit for all the data.

Data:

	Trial #1		Trial #2	
Cycle	**Blocks decayed**	**Blocks undecay ed**	**Blocks decayed**	**Blocks undecay ed**
0	0		0	

Half Life Lab

Results:

Attach your graph of "Half-life of blocks" Be sure to include the best fit curve.

For the following questions, you may consult your Line of best fit.

1. Pick a particular number of "undecayed blocks" and see how many "cycles" it took until that total was half that number. For instance, determine how many cycles it took to go from 40 blocks to 20 blocks.
   What number did you pick? How much time did it take for there to be half as many?

2. Now pick a different number and determine how many cycles it took to get to half that many blocks.
   What number did you pick this time? How many turns did it take in this case?

3. Repeat this with a few other numbers. Take the average of all of these numbers. This is the half-life for the system.

Conclusion questions:

Which was more consistent, the amount of time it took to remove half the blocks remaining, or the number of blocks removed each turn?

Do you think you would have similar results if you started with 1000 blocks? Why or why not?

Do you think you would have similar results if you started with 2 blocks? Why or why not?

If a chemical has a half life of 50.0 years, how much of a 600g sample would remain after 200 years?

Energy of Fusion Lab

Abstract:

When heat is transferred generally the temperature of the two objects exchanging thermal energy changes as well. When a substance is near a phase changing temperature, the energy that was changing the temperature needs to be used to change the phase. In this lab, the LabPro devices will be used to measure the temperature of a water sample as it is cooled in a salt-ice mixture that is below the freezing point of water.

Materials:

Laptop	Sand
LabPro	Ice
Two temperature probes	Rock Salt
Styrofoam™ cup	Tap Water
Adapted Beral pipet (cut 0.765cm from bulb)	250 mL Beaker

Special Safety Concerns:

The ice-salt slurry can reach temperatures of -20°C, this can cause frostbite in minutes. Avoid prolonged contact with this temperature.

Procedure:

1. Turn on laptop and log in. Connect LabPro and two temperature probes. Open the file g:/huberchem/HchemI/phasechangeenergy.cmbl
2. Fill the coffee cup half full with crushed ice.
3. Add a scoop of salt.
4. Stir the mixture with a temperature probe. Observe the temperature of the mixture on the screen.
5. While this is being stirred, complete steps 6 - 8
6. Fill the pipet with water almost to the top.
7. Add a pinch of sand to the water in the pipet. (This prevents super-cooling of the water by providing a place for the water to freeze.)
8. Install the probe into the pipet carefully. The temperature probe should be in the center of the pipet.
9. When the ice-salt mixture is at or below -10°C, click collect data in LoggerPro.
10. Immerse the water pipet into the mixture. Our goal is to freeze the water in the pipet and watch the change in temperature.
11. Stir both probes in the ice-salt slurry. Make observations on the pipet water, at regular intervals but do not remove it from the slurry for more than a second, as the temperature readings will be in error.

12. Continue stirring until the two probes are within 1 degree of each other in temperature.
13. Remove the probes from the ice-salt slurry and place them in a 205 mL beaker full of room temperature tap water.
14. Continue until the probes are within 5 degrees of temperature difference.
15. Click stop in LoggerPro.
16. Print two copies of your graph.

Cleanup

17. Remove pipet from probe.
18. Drain all water and ice-salt slurry down the drain with an excess of water.
19. Clean station completely from any liquid spills.
20. Replace station exactly as it was found.

Data:

Observations on pipet water:

Results:

Attach the graph of the cooling to this lab.

Chemistry

Energy of Fusion Lab

Conclusion questions:

(The word "water" refers to the water in the pipet bulb.)

1. Briefly describe the shape of the graph of the water as it was frozen and then thawed.

2. Why do you think that the temperature of the water only went down to zero degrees and then stopped for a while before reaching thermal equilibrium with the ice-salt slurry?

3. When you heated the water in the room temperature water beaker, did the system stop for a while at zero degrees again?

4. Is there still energy being transferred (heat) when the water stops changing temperature at zero degrees? Why do you think that?

5. What is that transferred energy causing to happen in the system?

6. Draw what you think a graph would look like for water undergoing the change from a liquid to a gas (boiling) by a heat source that is 300°C.

Enzyme Action

Introduction:

A catalyst speed up a chemical reaction by lowering the activation energy required to get the reaction started.

Enzymes are biological catalysts that carry out the thousands of chemical reactions that occur in living cells. They are generally large proteins made up of several hundred amino acids. Some enzymes consist of a protein apoenzyme and a small cofactor, which might be a metal ion or a coenzyme, often a vitamin derivative.

In an enzyme-catalyzed reaction, the substance to be acted upon, or substrate, binds to the active site, or business end, of the enzyme. The enzyme and substrate are held together in an enzyme-substrate complex by hydrophobic interactions, hydrogen bonds, and ionic bonds.

The enzyme then converts the substrate to the reaction products in a process that often requires several chemical steps, and may involve covalent bonds. Finally, the products are released into solution and the enzyme is ready to form another enzyme-substrate complex. As is true of any catalyst, the enzyme is not used up as it carries out the reaction but is recycled over and over. One enzyme molecule can carry out thousands of reaction cycles every minute.

Each enzyme is specific for a certain reaction because its amino acid sequence is unique and causes it to have a unique three-dimensional structure. The active site also has a specific shape so that only one or a few of the thousands of compounds present in the cell can interact with it. If there is a cofactor on the enzyme, it will form part of the active site. Any substance that blocks or changes the shape of the active site will interfere with the activity and efficiency of the enzyme. If changes in the three-dimensional structure of the enzyme are large enough, the enzyme can no longer act at all, and is said to be denatured.

There are several factors that are especially important in determining the enzyme's shape, and these are closely regulated both in the living organism and in laboratory experiments to give the optimum, or most efficient, enzyme activity:

1. **Salt concentration**. If the salt concentration is very low or zero, the charged amino acid side chains of the enzyme molecules will stick together. The enzyme will denature and from an inactive precipitate. If, on the other hand, the salt concentration is very high, normal interaction of charged groups will be blocked, new interactions will occur, and again the enzyme will precipitate. An intermediated salt concentration such as that of blood (0.9%) or cytoplasm is the optimum for most enzymes.
2. **pH**. The pH scale, which is logarithmic, measures the acidity or H^+ concentration in a solution. The scale runs from 0-14 with 0 being highest in acidity and 14 lowest. When the pH is in the range of 0-7, a solution is said to be acidic: if the pH is around 7, the solution is neutral; and if the pH is in the range of 7-14, the solution is basic. Amino acid side chains contain either carboxyl groups (COOH) or amino groups (NH_2) that readily gain or lose H^+ ions. As the pH is lowered, an enzyme will tend to gain H^+ ions, and eventually enough side chains will be affected so that the enzyme's shape is disrupted. Likewise, as the pH is raised, the enzyme will lose H+ ions and eventually lose its active shape. Many enzymes have an optimum in the neutral pH range and are denatured at either extremely high or low pH. Some enzymes, such as those which act in the human stomach where the pH is very low, will have an appropriately low pH optimum. A buffer is a compound that acts like a sponge to pick up any extra H^+ or OH^- ions so that the pH changes very little. The buffer molecules (B) must be in two forms to do this:

   $B + H^+ \longrightarrow BH^+$

   $B^+ + OH^- \longrightarrow B + H_2O$

   Different buffers are designed to keep the pH of the solution surrounding the enzyme at various pH levels.

3. **Temperature.** All chemical reactions speed up as the temperature is raised. As the temperature increases, more of the reacting molecules have enough kinetic energy to undergo the reaction. Since enzymes are catalysts fro chemical reactions, enzyme reactions also tend to go faster with increasing temperature. However, if the temperature of an enzyme-catalyzed reaction is raised still further, a temperature optimum is reached: above this pint the kinetic energy of the enzyme and water molecules is so great that the structure of enzyme molecules starts to be disrupted. The positive effect of speeding up the reaction is now more than offset by the negative effect of denaturing more and more enzyme molecules. Many proteins are denatured by temperatures around 40-50°C, but some are still active at 70-80°C, and a few even withstand being boiled.
4. **Small regulator molecules.** Many molecules other than the substrate may interact with an enzyme to regulate or modulate its activity. If such a molecule increases the rate of the reaction it is an activator, and if it decreases the reaction rate it is an inhibitor. The cell can use these molecules to regulate how fast the enzyme acts. Any substance that tends to unfold the enzyme, such as an organic solvent or detergent, will act as an inhibitor. Some inhibitors act by reducing the -S-S- bridges that stabilize the enzyme's structure. Many inhibitors act by reacting with side chains in or near the active site to change or block it. Others may damage or remove the cofactor. Many well-known poisons such as potassium cyanide and curare are enzyme inhibitors that interfere with the active site of a critical enzyme.

Turnip Peroxidase

In this experiment, you will study the enzyme peroxidase from turnips. Peroxidases are widely distributed in plant and animal cells and catalyze the oxidation of organic compounds by hydrogen peroxide as follows:

$$H - R - O - H + H_2O_2 \xrightarrow{\text{peroxidase}} R = O + 2H_2O$$

Any cell using molecular oxygen in its metabolism will produce small amounts of H_2O_2 as a highly toxic byproduct. A peroxide has a very reactive ----O---O--- structure, so it is critical that it be quickly removed by enzymes such as peroxidase before it can damage the cell.

In order to follow the reaction as it proceeds, you will be using a special substrate, the reduced, colorless form of a substance called guaiacol. Guaiacol is an organic chemical produced by the guaiac tree of Central America, and it corresponds to H---R---O---H in the equation. In the reaction, guaiacol will donate hydrogens and thereby become oxidized. It has a brown color in its oxidized form; you will be able to measure the amount of oxidized guaiacol produced by determining the intensity of the color in the spectrophotometer.

$$\text{4 guaiacol} + \text{4 hydrogen peroxide} \xrightarrow{\text{peroxidase}} \text{tetraguaiacol} + \text{8 water}$$

In this reaction, hydrogen peroxide is reduced to water by giving up an atom of oxygen as guaiacol give up 8 of its hydrogens. The oxygen and hydrogen combine to form more water. The decomposition of H_2O_2 is thus a good example of an oxidation-reduction reaction.

Preparation of Turnip Extract

1) Weigh out 2 g of turnip (peeled)
2) Place it in a blender with 200 mL of distilled water
3) Blend it thoroughly at the high setting for about 1 min.

This suspension is the turnip extract and contains the enzyme peroxidase. The activity of the turnip extract will vary from day to day, depending of the size and age of the turnip and the extent of blending You should adjust the turnip suspension to be fore dilute or more concentrated so that you absorbance for the baseline is in the range 0.1-0.2.

Computer and Probe Set Up

1. Hook up the Logger Pro to the computers USB port
2. Hook in the Calorimeter into channel one of the Logger Pro
3. Make sure the Calorimeter is set to Green (470 nm)
4. Turn on the computer
5. Log in
6. Go to NHS applications
7. Go to "Logger Pro

Experiments

1. **Baseline**
    a. Obtain three test tubes. Label them 1, 2, and 3.
    b. Place the correct amounts of the following substances in the correct tubes.

	Guaiacol	Turnip Extract	.1% Hydrogen Peroxide	Distilled Water
Tube 1 (control)	.1 mL or 100 ul	1.0 mL		8.9 mL
Tube 2 (substrate)	.1 mL or 100 ul		.2 mL or 200 ul	4.7 mL
Tube 3 (enzyme)		1.0 mL		4.0 mL

    c. Fill a cuvette with the solution from tube #1. Kimi-wipe the outside of the cuvette. Place the cuvette inside of the Colorimeter and close the lid.
    d. Press "go" on the computer screen and let the computer read for 3 minutes. This is your "zero".
    e. Label this graph Baseline: Zero. Put your names on the graph and save to your U drive. ****Make sure your x and y data tables save to this screen.**
    f. Now pour tube 2 into tube three. Wait 20 seconds and then pour the liquid into a clean cuvette. You will have extra liquid left in the test tube. Place the cuvette into the colorimeter, close the lid.
    g. Press "go" on the computer screen and collect data for 3 minutes.
    h. Label this graph Baseline. Place your names on the graph and save to your U drive. ****Make sure your x and y data tables save to this screen.**
    i. You will compare the rest of your graphs to this baseline.
    j. Clean out the test tubes for the next experiment.

2. **Effect of Enzyme Concentration**
    a. Twice the Amount of Enzymes

i. Hypothesize what will happen when twice the amount of enzyme is added.
ii. Fill the test tubes with the following items:

iii. Fill a cuvette with the solution from tube #1. Kimi-wipe the outside of the cuvette. Place the cuvette inside of the Colorimeter and close the lid.
iv. Press"go" on the computer screen and let the computer read for 3 minutes. This is your "zero".
v. Label this graph Twice Enzyme: Zero. Put your names on the graph and save to your U drive. ****Make sure your x and y data tables save to this screen.**
vi. Now pour tube 2 into tube three. Wait 20 seconds and then pour the liquid into a clean cuvette. You will have extra liquid left in the test tube. Place the cuvette into the colorimeter, close the lid.
vii. Press "go" on the computer screen and collect data for 3 minutes.
viii. Label this graph Twice the Amount of Enzyme. Place your names on the graph and save to your U drive. ****Make sure your x and y data tables save to this screen.**

b. Half the Amount of Enzyme
   i. Hypothesize what will happen when half the amount of enzyme is added.
   ii. Fill the test tubes with the following items:

   iii. Fill a cuvette with the solution from tube #1. Kimi-wipe the outside of the cuvette. Place the cuvette inside of the Colorimeter and close the lid.
   iv. Press "go" on the computer screen and let the computer read for 3 minutes. This is your "zero".
   v. Label this graph Half Enzyme: Zero. Put your names on the graph and save to your U drive.
   vi. Now pour tube 2 into tube three. Wait 20 seconds and then pour the liquid into a clean cuvette. You will have extra liquid left in the test tube. Place the cuvette into the colorimeter, close the lid.
   vii. Press "go" on the computer screen and collect data for 3 minutes.

viii. Label this graph Half the Amount of Enzyme. Place your names on the graph and save to your U drive.

	Guaiacol	Turnip Extract	.1% Hydrogen Peroxide	Distilled Water
Tube 1 (control)	.1 mL or 100 ul	.5 mL or 500 ul		7.9 mL
Tube 2 (substrate)	.1 mL or 500 ul		.2 mL or 200 ul	4.7 mL
Tube 3 (enzyme)		.5 mL or 500 ul		4.0 mL

	Guaiacol	Turnip Extract	.1% Hydrogen Peroxide	Distilled Water
Tube 1 (control)	.1 mL or 100 ul	2.0 mL		7.9 mL
Tube 2 (substrate)	.1 mL or 100 ul		.2 mL or 200 ul	4.7 mL
Tube 3 (enzyme)		2.0 mL		4.0 mL

3. **Effect of Varying the Substrate Concentration**
    a. Design and carry out an experiment to determine whether varying the concentration of the substrate H_2O_2 affects the rate of reaction.

4. **Effect of Temperature**
    a. Hypothesize what the reactions will do at the temperatures of 4°C, 25°C, and 60°C.
    b. For each reaction fill the test tubes with the following items:

	Guaiacol	Turnip Extract	.1% Hydrogen Peroxide	Distilled Water
Tube 2 (substrate)	.1 mL or 100 ul		.2 mL or 200 ul	4.7 mL
Tube 3 (enzyme)		1.0 mL		4.0 mL

    c. Place the tubes in the hot water bath or the cold water bath for 5 minutes to equilibrate for 5 minutes before mixing.

Modified from Carolyn Eberhard's General Biology Laboratory Manual. Pulbished by Saunders College Publishing, 1990.

Chemistry

Liquid Density Lab

Abstract:

Determining the density of a liquid is better performed when multiple measurements are taken for any given liquid. Density is the combined values of mass "over" density. This can easily be compared on a graph to slope (rise "over" run). Thus, if mass is plotted on the y-axis and volume is plotted on the x-axis, then the density of the sample is the slope of the line of best fit. This also helps to reduce errors in a single measurement and error from just simple averages. This investigation uses the Logger Pro graphing software to create a plot of the mass and volume measurements and determine the slope (density).

Materials:

Sample liquid
10 mL graduated cylinder
Plastic Beral Pipet
Mass Balance

Special Safety Concerns:

Some of the liquids being tested are flammable. Do not use near open flame.

Procedure:

1. Build a data table in your lab notebook of volume and mass.
2. Place a weighing boat on the mass balance and tare the balance.
3. Place the graduated cylinder on the balance and tare the balance.
4. Add approximately 1.0mL of the sample liquid to the graduated cylinder. Do not add exactly 1.0 mL, this is an incorrect use of the equipment and invalidates your data. Record the exact volume in the data table. Record the mass of the liquid in the data table as well.
5. Add another 1.0 mL sample of the liquid to the graduated cylinder (total volume of 2.0 mL) and record the exact volume and mass.
6. Repeat step 5 until eight data pairs have been collected.
7. Dump the liquid down the drain and rinse with an excess of water.
8. Dry the graduated cylinder with a small piece of paper towel rolled into a thin tube.

Data Analysis:

9. Log on to a laptop and open logger pro
10. Refer to the Logger Pro handout to determine how to format the data table and graph.

11. Refer to the Logger Pro handout to insert a Line of Best Fit into your data.
12. The slope of the line of best fit is the density of the liquid.
13. Print the graph of your data, one for you and one for your lab partner.

Liquid Density Lab

Data:

Results:

The density of sample liquid number____________________ is

______________________.

I confirm this to be true because…

Conclusion questions:

7. What is the precision (how many digits the device can measure to) of the graduated cylinder that you used?

8. Why do you think that it is important not to try and fill the graduated cylinder exactly 1.0 mL each time?

9. On a scale of 1 to 10 (where 10 is a perfect understanding of the graph and its concepts) how well do you feel you understand how the graph helps us determine density.

APPENDIX C – LIST OF AVAILABLE EQUIPMENT EMPLOYED BY TEACHERS AT PNHS

45 Laptop computers with wireless internet

32 Vernier LabPro devices

Multiple probes for use with Vernier system:

Temperature, pH, various Force sensors, heart rate, Geiger counter, UVA measurement, UVB measurement, Colorimeter (Spectrometer), Gas pressure, Oxygen partial pressure, CO_2 sensor, Dissolved oxygen sensor, Oxygen-Reduction potential, respiration rate, humidity, flow rate sensors, nitrate selective probe, ammonium selective probe, EKG sensor, hand strength, and high temperature thermocouples.

3 Bluetooth equipped printers.

3 Digital cameras

2 digital microscopes

3 USB equipped digital cameras for imaging (microscopes, desktops)

Vernier LoggerPro software for graphing

ACD Labs ChemSketch organic modeling software

Faces Forensic science software

Microsoft Office student package

Biology content software

Earth Science Software

Astronomy software

BIBLIOGRAPHY

Bardeen, M., Freeman, W., Lederman, L., Marshall, S., Thompson, B., & Young M. J. (1998). Three-Year High School Science Core Curriculum: A Framework.. Project ARISE: American Renaissance in Science Education Washington DC: U.S. Department of Education.

Davidson-Shivers, G. V., Salazar, J, & Hamilton, K. M. (2005). Design of Faculty Development Workshops: Attempting to Practice What We Preach. College Student Journal. 39, 528-540.

Du, J, Havard, B, Yu, C, & Adams, J (2004). The Impact of Technology Use on Low-Income and Minority Students' Academic Achievement: Educational Longitudinal Study of 2002. Journal of Educational Research & Policy Studies, 4, 21-38.

Franklin, C. A. (2005). Factors that Influence Elementary Teachers' Use of Computers. Annual Meeting of the American Education Research Association

Freedman, M. P. (1997). Relationships among laboratory instruction, attitude toward science and achievement in science knowledge. Journal of Research in Science Teaching 34, 343-357.

Gonzales, P. (2004). Highlights From the Trends in International Mathematics and Science Study: TIMSS 2003. Washington, D.C.: NCES.

Livingston, P. (2005). Laptop Program Update. Learning and Leading with Technology. 33, 21-22.

Livingston, P. (2004) Laptops Unleashed: A Middle School Experience. Learning and Leading with Technology. 31, 12-15.

Lord, T. R. (1997).A Comparison Between Traditional and Constructivist Teaching in College Biology. Innovative Higher Education. 21, 197-216.

Mao, S & Chang C. (1998). Impacts of an inquiry teaching method on Earth science students' learning outcomes and attitudes at the secondary school level. Proceedings of the National Science Council ROC (D) 8, 93-101.

McGregor, D., & Gunter, B. (2006). Invigorating Pedagogic Change. Suggestions from Findings of the Development of Secondary Science Teachers' Practice and Cognisance of the Learning Process. European Journal of Teacher Education. 29, 23-48.

NSTA Board of Directors, (2006). NSTA Position Statement: Professional Development in Science Education. Retrieved June 20, 2006, from NSTA Web site: http://www.nsta.org/positionstatement&psid=45

O'Connell, J. & Phye, G. (2005). Creating Strategies for Improved Teaching and Learning. Technology Horizons in Education Journal. 32, 26-29.

Oppenheimer, T. (2003). The flickering mind: the false promise of technology in the classroom and how learning can be saved. New York, NY: Random House

Ormrod, J. E. (2003). Educational psychology : developing learners. Upper Saddle River, NJ: Merrill.

Schoen, H. L., & Hirsch, C. R. (2003). Responding to calls for change in high school mathematics: Implications for collegiate mathematics. American Mathematical Monthly, 110, 109-123.

Sheppard K. & Robbins D. M. (2005) Chemistry, The Central Science? The History of the High School Science Sequence. 82, 561-566.

Snow-Renner, R. & Lauer P.A. (2005). Professional Development Analysis. McREL Insights. Denver, CO: McREL.

Standard & Poors, (2006). Portage Northern High School, Michigan Public School - Overview. Retrieved June 20, 2006, from SchoolMatters - A service of Standard & Poors Web site: http://www.schoolmatters.com/app/location/q/stid=23/llid=118/stllid=206/locid=6471/catid=-1/secid=-1/compid=-1/site=pes

Stevens, A. C., & Hartmann, C. E. (2004). A Successful Professional Development Project's Failure to Promote Online Discussion about Teaching Mathematics with Technology. Journal of Technology and Teacher Education. 12, 57-73.