June 2006

P.I.E.E Curriculum Integration

Gharam Han
Worcester Polytechnic Institute

Jonathan A. Kling
Worcester Polytechnic Institute

PIEE Curriculum Integration

An Interactive Qualifying Project Report

submitted to the Faculty

of the

WORCESTER POLYTECHNIC INSTITUTE

in partial fulfillment of the requirements for the

Degree of Bachelor of Science

by:

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Gharam Han

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Jonathan A. Kling

Date: June 01, 2006

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Professor John A. Orr, Major Advisor

1. piee
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Professor Richard F. Vaz, Co-Advisor

Abstract

The NSF-supported Partnerships Implementing Engineering Education (PIEE) program has generated over 150 lessons for grades K through 6 since 2003. Our project was aimed at collecting, editing, and promoting the implementation of these lessons in schools throughout the Worcester Public School System, the state of Massachusetts, and the nation. The lessons were organized, named and presented in a web format that helps teachers choose the lesson that is most appropriate for the needs of their individual class of students.

Acknowledgements

The Partnerships Implementing Engineering Education program would not have been possible without the funding we have received from the National Science Foundation. Equally important are John Orr, Jill Rulfs, Richard F. Vaz, George Pins, and Eileen Dagostino. We would also like to thank the fellows, who have worked closely with the students of the public schools and WPI, as well as the project advisors and coordinators to facilitate the project's progress. We would especially like to thank the Worcester Public School administrators who have made the project a success, including the principals, Dr. Patricia McCullough, Mr. Gerrald Hippert, and Ruthann R. Melancon. Along with the rest, we thank all of the other IQP students working in groups for their assigned grades; their work forms the backbone of the project. And certainly we acknowledge and thank all of the teachers from the grade K-6 classrooms who are participating in the project.

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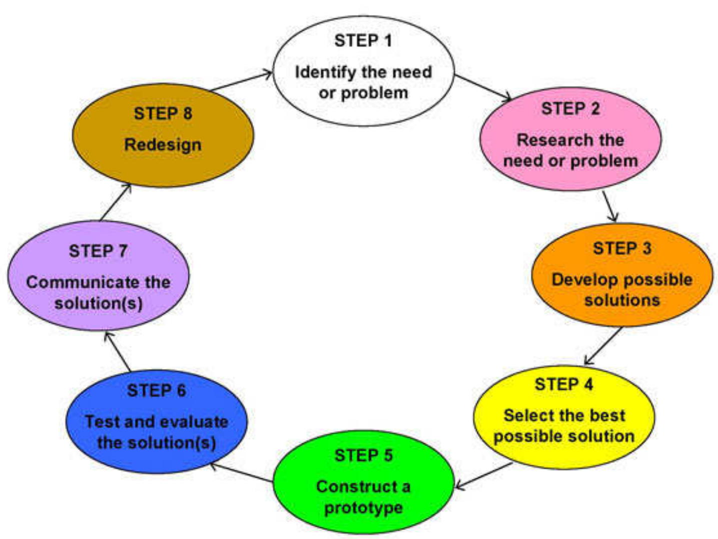
1. Introduction

1.1. Introduction

In a day and age when technology is integrated into our daily lives it is easy to take for granted the process needed to transform a product from concept to reality. Every television, radio, newspaper, or magazine product advertisement is the result of engineering in some way shape or form. Engineering is the method by which ideas and concepts are made into products. We currently live in an age of technology and engineering; where each and every day requires more insight about how to sustain our way of life. It does not matter if a technology is a pharmaceutical drug, a house, a toothpick, or a computer; one thing they have in common is that they fill a need. Necessity is the mother of all invention, and engineers are the ones to alleviate necessity with new technologies Thus, it is of the utmost importance that future generations are capable of expanding upon our current technologies.

The PIEE Program (Partnerships Implementing Engineering Education) at WPI was established in 2003 in order to implement engineering/technology topics in elementary school grades kindergarten through six in Worcester Public Schools. The PIEE project was founded with the hopes, that by introducing children to engineering at and early age, that they will be better suited to solve the problems of the future. Children will be familiarized with the engineering design process through a variety of lessons and activities. The engineering design process is not limited to only the formation of a product; it is an organized process of problem solving, based on the foundations of proper scientific method (Figure 1).

Figure 1: Engineering Design Process (Taken from PIEE brochure). [1]



Understanding the engineering design process provides guidance as to how to approach any scientific problem. It begins with the identification of a need or a problem, proceeds with the formation of possible solutions, development of a prototype, testing the prototype, and then improving upon the original design. It is easy to see the similarities between the scientific method and the engineering design process. Both seek to solve a problem through careful experimentation and constant redesign. To strive in the scientific field individuals must be able to approach a problem in an organized fashion, which reflects proper scientific method. Therefore the notion is that if children are introduced to engineering and technology topics at an early age, they will be more likely to apply them once higher education is reached. Early exposure to the engineering design process it the best way to ensure that tomorrow's engineers are prepared to tackle the problems and needs of the future.

The PIEE program here at WPI began with the proposal for Funding, directed to the NSF, which was written primarily by Judith Miller. The proposal outlines the goals of the project, as well as the steps that would be taken throughout the three-year plan of attack for creating this curriculum. Also, it gives some insight into the MSTECF, which we will discuss later in the paper.

The goals of the PIEE project as a whole, as stated in the NSF proposal are:

1. To develop partnerships among graduate and undergraduate fellows, public school teachers and students, and WPI and WPI-affiliated faculty.

2. To implement the Massachusetts Science and Technology/Engineering Curriculum Framework (MSTECF) in the K-6 curriculum, by using the partnerships to develop specific teaching strategies. These strategies will use engineering design process and data collection analysis to teach math, science, writing and engineering.

3. To assess and disseminate:
   a. The outreach process we develop for recruiting fellows;
   b. Student learning outcomes of the K-6 engineering design curriculum;
   c. Teacher preparation that results from this project.

The National Science Foundation has goals that closely match the aims that this project sets out to meet. For instance, from the NSF's Website, the following was taken:

"The National Science Foundation (NSF) is an independent federal agency created by Congress in 1950 "to promote the progress of science; to advance the national health, prosperity, and welfare; to secure the national defense…" With an annual budget of about $5.5 billion, we are the funding source for approximately 20 percent of all federally supported basic research conducted by America's colleges and universities. In many fields such as mathematics, computer science and the social sciences, NSF is the major source of federal backing.

We fulfill our mission chiefly by issuing limited-term grants -- currently about 10,000 new awards per year, with an average duration of three years -- to fund specific research proposals that have been judged the most promising by a rigorous and objective merit-review system. Most of these awards go to individuals or small groups of investigators. Others provide funding for research centers, instruments and facilities that allow scientists, engineers and students to work at the outermost frontiers of knowledge. NSF's goal is to support the people, ideas and tools that together make discovery possible. That's why we say NSF is "where discoveries begin.""

Certainly the PIEE program is not the first of its kind. There have been several programs like it in the past, but not very many that address the K-6 levels of education. At Merrimack Valley High School in Penacook, NH, a program was adopted called: Project Lead the Way. This program was like the PIEE program in that its goals involved pre-college engineering education. The program was designed to give high school students a more involved and in-depth introduction to several of the major fields of engineering, and to do so in a way that it would be very enticing and engaging, thus promoting more students to become involved in engineering at the post-high school level.

The PIEE project is the only project funded by the National Science Foundation that focuses solely on grades K-6. There are 3 Worcester Public Schools (WPS) that are currently involved in the program: Elm Park Community School on West Street, Midland Street School, and Flagg Street School. At Elm Park, grades 3, 4, 5, and six are participating. At Midland, all the grades are involved, and at Flagg Street, we have students from grades 2 and 3. These elementary schools provide the perfect environment to test the implementation of engineering and technology topics in grades K-6. Worcester is the second largest city in Massachusetts and is home to an extremely diverse group of citizens. This diversity is reflected in the WPS, especially within the elementary grade levels. Students are homogeneously divided into classes with no separation between suspected intellectual ability, ethnicity, or primary language. In fact, for many student English is not the primary language spoken at home (PIEE, Project Proposal).

While the WPS may provide a suitable test group for our project it presents certain problems that cannot be solved by the PIEE group alone. A close relationship has been established between the PIEE Project members and the teachers of the WPS. Although the main goal of the PIEE project is aimed towards the children, teachers are an integral part of implementing engineering and technology topics in grades K-6. It is reasonable to believe that many elementary school teachers may not have a background in, or not feel comfortable with, engineering and technology topics. Therefore it is important to accommodate the teachers as best as possible. This means providing key information to the teachers so they can effectively teach the subject material with out any prior background information on the subject matter. In order to successfully integrate engineering and technology topics in to grades K-6 it is going to take the co-operation of many groups of people as will be seen in later in the paper.

2. Project Background

2.1 Prior Progress

The PIEE program has been operational for two years prior to the 2005-2006 WPI school year. During this time individual grade groups have been creating lesson plans to be tested and evaluated within actual classrooms. Students worked closely with teachers, in order to "tailor" lesson plans to meet the specific goals set forth by both the state of Massachusetts and the Worcester Public School system. The Following table shows the breakdown of how the project was intended to unfold.

Table 1: Table of previous accomplishments by PIEE Project.

Year	Teams	Target Grades	Target Schools	Team Goal
One	Initiation	4-6	Elm Park and Midland	Develop 4-6 Curriculum
Two	Initiation	2-3	Year One Schools	Develop 2-3 Curriculum
	Adoption	4-6	Additional Schools	Adopt Curriculum from Year 1
Three	Initiation	K-1	Year One Schools	Develop K-1 Curriculum
	Adoption	2-3	Additional Schools	Adopt Curriculum from Year 2
	Sustainability Curriculum Int. Team	K-6	All Schools	Provide Lessons in Format available to all WPS teachers
Post Funding	Sustainability	K-6	All Schools	Expand outside the WPS.

As can be seen in Table 1 the main goal changes each year depending on the previous year's accomplishments. The first year is normally devoted to the creation of lessons to be evaluated in the classroom. During the second year PIEE members evaluate the effectiveness of the lessons within the WPS. For example, during the first year lessons were only created for grades four, five, and six. Lessons were created in accordance to Technology and Engineering standards set forth by the Worcester and Massachusetts Public School Systems. In the Second year, the lessons created for grades four, five and six were brought into the classroom for implementation and evaluation. PIEE fellows and IQP students worked closely with the teachers from both Elm Park and Midland Elementary School to watch the lessons in action. Lessons were evaluated and revised as the year progressed. In addition the second year gave rise to the creation of lessons for grades two and three. In the third year, which is this current year, the development of lessons had just begun for grades K and 1, and the progressive development of the grade 2-6 lesson collection has been continued throughout the year.

2.2 MSTECF and WPS Benchmarks

The guidelines that are being used to write the lessons are partially defined by the MSTECF (Massachusetts Science and Technology/Engineering Curriculum Framework) published in May 2001, as well as another important document that sets forth goals for the new curriculum: The Worcester Public Schools benchmarks. Both the Massachusetts Frameworks and the WPS benchmarks reflect the concept that engineering/technology skills should be considered an integral part of the science curriculum, rather than independently. The MSTECF is broken down into different grade spans, and establishes technology and engineering topics that must be addressed within that span. The Worcester Public School system has developed its own set of Benchmarks, which detail the grade and some actual lesson objectives. During this experimental phase, universal organization and cataloging of lessons across all grade levels was not necessary. Instead, the organizational scheme of lesson material for a specific grade was the job of the members of the group creating lessons for that grade. Due to the intimate working relationship between the WPS and WPI students, this type of individual grade based organization has been working well thus far in creating lessons and evaluating them.

2.3 Current Project Status and Team Goal

However now that the PIEE project is in its third and final year of NSF funding, it is important to look beyond our area and not just within the WPS, to focus on statewide integration of technology and engineering topics with the regular science curriculum. This need for widespread applicability is what our team is trying to fulfill. It is the Curriculum Integration team's ultimate goal to devise a method that facilitates a teacher's access to the finalized lesson material regardless of their affiliation with WPS; and to ensure that all of the lessons that have been created: fit the benchmarks and frameworks, are available for all teachers to use, and are an integral part of the normal K-6 Science curriculum.

To do this, a completely universal level of organization is needed. It is no longer sufficient to organize material within a specific grade with out any integration among the other grades. If the PIEE project is to reach teachers who have not directly been involved with the project; then it is imperative that the material be presented in a professional manner that allows teachers from any of the K-6 Massachusetts classrooms to access and use the lessons, in a way that benefits their students and themselves. The task of organization and providing perpetual availability of lesson material across all seven of the grade levels is a substantial task and is the main product of our efforts.

As the Curriculum integration team, we are the last step in launching the "final product", which is the culmination of three years of progress towards a complete Engineering/Technology Curriculum for grades K-6. Once this year is over, there will be no more continuing creation of lessons, or preparing of binders, or designing of websites, so it is our job to ensure that all of these preparatory steps are made in order to make all of the work that has been done worthwhile to both WPI and the public schools of the state of Massachusetts.

2.4 Implementation/Presentation Methods

If the PIEE project's goal is to implement engineering and technology topics into classrooms across Massachusetts then it is necessary to make the material accessible to as many teachers as possible. While paper copies of lesson plans are an invaluable classroom resource, they are not suitable for distribution to new teachers. Despite the fact that all lesson plans meet WPS benchmarks and MA Frameworks, not all lessons are appropriate for all classrooms. There exists the possibility that a specific lesson plan, created by those working on the PIEE project, does not fit within the progression of material that the teacher has planned to teach. Some teachers simply may not have time for all of the lessons. In fact, many of the IQP students working in the classrooms have found that teachers sometimes do not have time to do an Engineering lesson with their normal science workload. Not every teacher will want to use every lesson from a full grade set. Teachers need a way to preview and select technology and engineering lesson plans that they think will compliment the lessons that are already a part of the regular science curriculum.

The proposed solution to this problem is to create an Internet site that will contain all of the created and finalized lesson plans. In addition to the collection of grade-unit organized lessons, we want to provide a chart or overall outline that can show the application of the lessons to the Benchmarks and the MSTECF. The Internet is a good medium to distribute lesson material to vast numbers of teachers without sending hard copies containing every lesson plan created. However, the question still remains as to whether or not an Internet site is the most practical method of retrieving lessons for teachers. Justification of a web-based medium to distribute created material to teachers depends on teachers' ability, and his or her willingness to access provided information. In order to gain a better perspective of the practicality of a website to distribute lesson plans to teachers, research on the use of technology in classrooms was conducted.

2.5 Justification (National Statistics)

The National Center for Education Statistics (NCES) is a governmental organization that oversees the collection and analysis of data pertaining to education in the United States (U.S.) and other countries. The collected data ranges in topic from enrollment trends to violence protection. These educational statistics are a valuable resource and are often referred to by many organizations and governmental departments. [2]

Since 1994, the NCES has been conducting surveys pertaining to internet accessibility in elementary schools across the nation. The organization reports that approximately ninety-nine percent of all teachers reported having at least one computer available for use in their school. In 1994 only thirty percent of all elementary schools reported to have computers with Internet access. In addition ninety-two percent of all elementary school teachers reported having at least one computer within their classroom. Moreover, teachers with Internet access in their classrooms were more likely to use computers to instruct children, conduct preparatory work, and participate in communicative tasks than teachers who did not have a computer located in their classroom. [3]

Such strong data has had a powerful influence on deciding if a website is a practical means for distributing lesson material. The aforementioned data are general statistics from across the country; the NCES also provides statistics that more accurately resemble the conditions of the Worcester Public Schools. In 2002, one hundred percent of all public schools in city locales were connected to the Internet. Also, individual classroom connectivity was found to be around ninety percent in these city schools. In past years, "percent minority enrollment" has been a factor in the statistics regarding Internet access in public schools. In 1994 only twenty-seven of schools, with 50% or higher minority enrollment were connected to the internet, whereas in 2003, NCES reports that ninety-nine to one hundred percent of all public schools are connected to the internet, regardless of minority enrollment. In relation, 95% of public school classrooms, in schools with a 21-49% minority enrollment, had an Internet connection in 2003. [3]

2.6 Rationale

The data presented by the NCES indicates that the majority of public school teachers have access to the Internet on a daily basis. Thus, an Internet website is a practical medium for distributing engineering/technology based lesson plans. Using a website is also very practical for other reasons as well. Through the use of a website, lesson plans could be updated instantaneously, assuring that the most recent lesson material can be accessed as soon as it is available. Another advantage in developing a website to disperse lesson plans is that they can be viewed by individuals other than teachers. School administrators, curriculum development committees, and other organizations can view the created lesson plans and perhaps inspire additions or revisions for the advancement of technology and engineering in elementary schools.

With the justification of making a website confirmed certain steps could be made towards completion of the goals set by the curriculum integration team. Since teachers will be the primary users of the created lessons it is important to keep their desires in mind. As previously mentioned, the curriculum integration team's goal to make the created lessons as accessible to teacher all over Massachusetts regardless of there involvement in the PIEE program or not. This means more than just making a website to dispense lesson material. Lesson information such as, lesson length and lesson description are also valuable to the teacher and must be readily available prior to downloading the lesson. Keeping this in mind we must investigate what is needed to make a good website, in order to present this information in a professional and organized manner.

2.7 Information Architecture (IA)

IA is a difficult concept to explain, and has four major definitions that are commonly used to describe the aspects that it encompasses. The guidelines set forth by the following definitions are relevant to assembling the final collection of lessons in PDF and Word Format in a usable web setting

1. Combination of organization, labelling, and navigational schemes within an information system.
2. Structural design of an information space to facilitate task completion and intuitive access to content.
3. The art and science of structuring and classifying websites and intranets to help people find and manage information
4. An emerging discipline and community of practice focused on bringing principles of design and architecture to the digital landscape.

The first second and third definitions relate most directly to this project's proposed "static website", which will contain hundreds of lessons grouped into units and grades. The fact that no one, single, succinct definition can describe IA is part of what makes creating a good website so difficult. In different applications, information architecture can take on different meanings and involve different problems, but every situation involves structure, organization and labelling.

With any information architecture, inherent troubles arise simply from trying to convey an author's ideas into words, and then from words into a usable form within the tangled digital World Wide Web. To help clarify the idea of IA, it is best to first define the term information. Information is nothing that can be called *exact*. Information is different than data, such as numbers and formulas that may be used to calculate figures. Information is also different from knowledge, which is the loose change that floats around inside all of our heads. Bits and pieces of random information, mostly based on life experiences, make up our knowledge base. Information is somewhere floating in the middle of these two extremes. Sometimes our information can be very clear and straightforward and other times it can seem that it has no logical classification. A person who works with IA strives to find the ways to classify this type of information. "Information" on the World Wide Web could be a website, a document, a picture, a program, a chart or any of slurry of other content objects. Within the category of "information" is contained the idea of "metadata", which are bits of information that represent specific content objects like people, processes or groups.

What does an Information Architect do with all this information?

With large amounts of documents or other content, a structure into which all these items are built is required. The structure needs to contain a construction or arrangement of organization, and the categories set forth by the organizational system need to have meaningful labels.

1. "Structuring" loosely, means deciding how to break up chunks of information into various-sized bites (e.g. encyclopedia, entry, paragraph, sentence, word).
2. "Organizing," means that the components of a structure are grouped into meaningful, clear, definite categories.
3. "Labelling" consists of making names for the categories created in the organization process, as well as creating names for a series of navigational links that will be used to move from one group to another and also within individual groups.

Once a structure has been built, organized, and logically labelled, it needs to accommodate managerial tasks, as well as user-based findability tasks.

For the overall success of a website, with regard to its usability, users must be able to easily find and use the content. Sometimes this can be done by "searching" and sometimes by "browsing". Searching means that the user already knows just what they are looking for, and they enter keywords, or some other form of data that is representative of the piece of information that they are trying to find. The website is then queried for matching items, and the possible choices are returned to the user. Browsing refers to the act of opening a set of content and viewing many items at once, in a fashion determined by the web designer. The user does not specifically enter what he or she wants to see, but more casually "browses" all of the options and chooses the one that they want.

Also important to the success of the site are the people behind the scenes who make sure that information is properly maintained. The website to be designed by this project will be virtually static and unchanging with regard to its content; thus, information maintenance will be minimal. Once built, organized, and optimized for findability, our site will not require much content management.

Art and creativity separate ordinary websites from extraordinary ones. The navigational and organizational systems of a website and architecture cannot simply be calculated from a given set of inputs or desired needs/requirements. To achieve high productivity, usability, and efficiency, a website must start with a solid, creative, and well-designed structure. To do this, the creators of the IA use the skills that come from experience, intuition, and creativity. No one system is always right or always wrong and creating the perfect IA for a given application is an ever-changing art form.

Not all aspects of website creation and construction are the responsibility of the information architect. The following fields are not part of IA:

1. Graphic Design
2. Software Development
3. Usability Engineering

A graphic designer typically works closely with an Information Architect by presenting visual limitations to the IA regarding naming of links and other areas that affect the visual aspects of the site. For instance, if the IA decides that the names for the links will be "natural healing remedies", "natural herbal medicines", and "non-natural methods of rehabilitation", the length of the names may pose a problem for the graphic designer who has designed the buttons and actual shapes of the buttons that will contain the link names. If the graphic designer determines that these names are too long, then a compromise will have to be made, to either change the labelling scheme of the organization of the structure, or to change the visual appearance of the website to accommodate longer names in the link buttons. These examples illustrate the types of difficulties when working with IA. The look and feel of the website, meaning the fonts, colors, sizes of buttons, pictures on pages, and other visual effects, are not handled by an IA team. [6]

These issues would be even more important if we ourselves were going to be doing the designing of the site and handling its construction. However, the website development team here at WPI is taking care of forming the website to host our content and manage the data. So in our case, the information about the structuring and organizing of the site is purely background information to think about when planning how the site may be set up.

3. Methodology

3.1 Organization

Organization was the driving force behind the Curriculum Integration (CI) team's actions throughout duration of their work. In order to present a professional final product, organization of lesson material was of the utmost importance. In addition, organization of the lesson material often inspired new idea that could be applied at later stages. The first order of business, for the Curriculum Integration team, was to universally organize lesson materials across all grade levels. As the only team with access to all the lesson plans for every grade level, the CI Team was able to universally organize all the lesson materials.

The organization of the lesson materials was not an easy task for several reasons. One problem was due to the fact that not all the grades had been creating lessons from the beginning of the PIEE project. As a result all of the grades were at different stages of development. Grades four though six had been in development for three years, providing enough time to create lessons, evaluate them in the classrooms, revise evaluated lessons, and begin creating more lessons. In contrast grades two and three had only had two year of prior progress. While the 2005-2006 school year was the first and only year for grades K and one. Thus it is understandable that each grade may be at a different stage of development whether it be, lesson creation or lesson evaluation. The task, then, is to formulate a plan that will effectively facilitate the co-progression of material formulation and organization, while still maintaining lesson congruence across all grade levels.

To address this need, weekly meetings were arranged between the CI team and all of the PIEE fellows. These weekly meetings provided a basis on which to start the organizational process. Meetings with the fellows were invaluable in making the final steps towards project completion. For many of the fellows this allowed them to gain perspective on the progression in comparison to the other grades. In addition it allowed the fellows to give each other advice on problems they were having. As for the CI team it provided regular updates on the progress the grades had been making. The weekly meetings also provided a chance to report their progress to the fellows, and inform them how it may be impacting their work. Throughout the year many of the CI team major advancements were the fruit of meeting brain storms.

After the third meeting each of the PIEE fellows provided a lesson inventory sheet with lesson names, lesson summaries, unit letter, in addition to benchmark and framework information. The reasons behind this are two fold. First, it was necessary to take an inventory of all the lessons that had been finished and those that were yet to be finalized. Second, it allowed the CI team to devise a method of organization that could be applied to all the grade levels. Finished lesson plans were given lesson codes that provided the lesson's suggested grade level, unit letter, lesson number, and lesson name (Figure 2). Since lessons were mainly created with the use of Microsoft Word, the lesson codes were used to name lesson files in order to quickly identify key lesson information without actually opening the file. The universal naming system was an invaluable source of information in future organizational processes.

The most important information to a teacher, when choosing a lesson, is what educational standards are addressed within that lesson. During the creation of lesson plans the PIEE team worked closely with the WPS in the classroom. For this reason lessons were often modeled with benchmark standard in mind. Thus it became important to document which benchmark standard had been fulfilled. After the lessons were inventoried the CI team began to catalog all the lessons according to what benchmark standard they hit (Table 2). The charts contained the benchmark code (established by the WPS), benchmark description, and Lesson that meet that particular benchmark. While the PIEE project is mainly interested in the technology and engineering standards, all the WPS benchmarks were addressed and cataloged. This facilitated the integration of T/E topics within the pre-existing science curriculum. Benchmark catalogs also were used to ensure that all of the benchmarks set forth by the WPS had been met within a certain grade level. The fellows found these charts useful in that they helped monitor the progression of the lesson creation.

Figure 2: Lesson code format and examples.

Grade-Unit Letter-Lesson #-Lesson Name

Ex:

3-B-1-Treehouse (Grade 3 - Unit B - Lesson 1 - Tree house)
6-B-2-Volcano (Grade 6 – Unit B – Lesson 2 – Volcano)

Unfulfilled benchmarks could be identified and lessons could be created to meet the standard.

Table2: Excerpt from grade 1 benchmark catalogue.

Grade 1 Benchmark Catalogue

Benchmark Code	Benchmark Description	Lessons that Hit Benchmarks
01.SC.TE.01	Identify and describe the characteristics of natural materials and human made materials.	1-D-I-TheFivePilgrims 1-D-II-WackyShoes 1-D-IV-Mr.Fox'sBox
01.SC.TE.02	Identify and explain some possible uses of natural materials and human materials.	1-D-I-TheFivePilgrims 1-D-II-WackyShoes 1-D-IV-Mr.Fox'sBox

Although the benchmarks were a good outline for lesson creation they cannot be applied outside of the WPS. In order for the PIEE lesson to be applied outside of the WPS the Massachusetts framework standards must be fulfilled. The framework standards were established by the Massachussetts Department of Education and highlight certain topics that must be addressed within a given grade set. Lesson plans that meet the framework standards can be applied throughout the state of Massachusetts, which is in the interest of the PIEE project as whole. Framework catalogs were created, documenting which standards had been met and which lessons had met them. (Table 3)

Table 3: Excerpt from grade 1 Framework Catalogue.

Technology/Engineering Framework Catalogue for Grade 1		
Framework Code	**Framework Description**	**Lessons That Hit Framework**
K-2.TE.1.1	Identify and describe characteristics of natural materials.	1-D-1-TheFivePilgrims 1-D-2-WackyShoes 1-D-4-Mr.Fox'sBox
K-2.TE.1.2	Identify and explain some possible uses for natural materials and human made materials.	1-D-1-TheFivePilgrims 1-D-2-WackyShoes 1-D-4-Mr.Fox'sBox

The formulation of a framework catalog was an essential part of the organizational process and was the jumping off point for the framework checklists. While the framework catalogs were extremely helpful in identifying standards that have been met and those yet to be met, they are not organized to in the best fashion to facilitate lesson selection by the teacher. The framework catalogs organize lessons according to each individual framework standard. The framework checklists on the other hand list all of the lessons and provide information on the lesson that maybe important to the teacher. (Table 4) This means that a teacher can choose a lesson based on lesson description, lesson length, and how many framework standards it meets. This was not possible with the catalogs because the frameworks were listed individually. Since the framework checklists seemed to be the most informative document, from a teacher's viewpoint, it was decided that this would be the main method for lesson browsing by the teacher.

Table 4: Excerpt from grade 2 framework Checklist.

Grade 2 Framework Checklist									
Lesson Name	**Lesson Description**	**# of Sessions**	**Session Lengths**	**3-5.TE.**					**Additional Frameworks**
				1.1	**1.2**	**1.3**	**2.1**	**2.2**	
2-A-1-Terrarium	During this unit, the students will experience living, nonliving, and once living things through the design, building, and observing of a terrarium.	3	1. 45 minutes 2. 60 minutes 3. 30 minutes	x	x	x			K-2.ES.1 K-2.ES.3 K-2.ES.4 K-2.LS.1 K-2.LS.2 K-2.LS.3 K-2.LS.4 K-2.LS.7 K-2.LS.8
2-A-2-Birdhouse	This lesson introduces children to the idea of "structure." It provides them with the opportunity to design and construct both a shelter for their terrarium, and a birdhouse or feeder.	5	1. 20 minutes 2. 20 minutes 3. 20 minutes 4. 40 minutes 5. 20 minutes	x	x	x			

3.2 Fellows Meetings

One of the most important on-going methods that we employed to organize and compile all of the lessons and appropriate documents was the holding of weekly meetings with the graduate fellows who were advising the grade teams. Katie Bush, Karen Kosinski, Megan Holmes, Steve Toddes, Leena Razzaq, and Jen Gray were all very helpful in keeping us up to speed on the important issues with the lessons they were working on. At our meetings we discussed things like benchmarks and frameworks that had very few lessons available that addressed the learning standards which they implied. By doing this, we were able to help ourselves to create a more comprehensive list, help the grade teams to create a much more developed set of lessons, and to ultimately help the students who will be learning from the lessons.

3.3 Determining File Format

Because most public school teachers are able to connect to the internet, the goal of this project is to make lesson plans as easily accessible as possible. Microsoft Word has been the preferred method of creating lesson plans for the PIEE project in past years. The versatility of Microsoft Word is invaluable when creating and/or modifying documents. Files can be auto-formatted to meet desired document layouts and outlines. Functional "Tables of Contents" can be created for easy navigation within a document. However, these advantages can become pitfalls if Microsoft Word is the only format made available to teachers. Microsoft Word's editing capabilities become a liability when posting documents on the web. The PIEE program wishes to maintain a certain level of professionalism in its lesson creations. The ability to edit PIEE created lesson plans may hinder the ability to maintain professional grade material. On the other hand, the ability of lesson plans to be altered may be a desired trait when trying to incorporate engineering/technology topics into other areas of a science curriculum. Another disadvantage of Microsoft Word files is the availability of the software. Microsoft Word is a rather expensive program to obtain if it is not already installed on a computer. It is not unfathomable that some teachers may not have the resources to obtain a copy of this expensive software. This project strives to offer lesson plans in a safe and secure file format that is functional across all operating systems, while maintaining a level of changeability for easy incorporation into science curriculum.

Adobe Acrobat Portable Document Files (PDF) was decided upon as the universal file format by which to present finalized lesson plans. PDF files are functional across all operating systems from Windows and Apple to UNIX and Red Hat. Files stored as Portable Document Files can also be set to deny any editorial processes. This is important in order to maintain original copies of lesson plans that cannot be edited except by the author, adding a level of security to the professionalism of created material. Another positive aspect of PDF files is the availability of the program that reads it, Adobe Acrobat. Adobe Acrobat can be downloaded, free of charge, from the Adobe website (http://www.adobe.com). This allows anyone with an Internet connection to download the software and read any PDF file. To maintain the ability to customize the created lesson plans, Microsoft Word versions will also be available for download at a later date, once the website has become well established. If a teacher decides to use a lesson plan and wishes to customize it for simple integration into a pre-existing science curriculum, then Microsoft Word can be used to modify the document.

3.4 Creation of the website

At this point, we had decided on the format of our content, and had generated some ideas about how we wanted the users of the site to be able to access the lessons. The next step was to decide what additional information was applicable and what other types of content would be useful to the teachers. We wanted the teachers to be able to quickly access everything that they would need to teach any given lesson that they chose. Not all the lessons stand alone ready to teach. Some of them require additional supplementary materials like worksheets and stories that would be read to the students. These would need to be available for downloading, but the question was: Where to include them. Our options were to either include them as part of the lesson itself, but some of them are used in more than one grade. We decided that it would be best to include all of these supplementary materials in a separate location, so that they could be accessed without finding the particular lesson that they complement. Also, in the case of worksheets, the teacher may need to print multiple copies of the document, so we did not want them to have to open the lesson and select only the text that they wanted and print it in that manner. The supplementary materials are available on a separate page that can be reached from the page that contains links to all of the individual grade checklists.

We began planning out the navigation of the website and consulting a representative at the web development office. Her guidance helped us to understand more about the requirements that we would have to meet in order to have all of our content available in a form that would be easy to use. Some of the navigation that we proposed was found to be less than perfect, so with the help of Nancy Adams, we were able to reform our plans for the order of the website and develop an easier and more fluid approach to finding the lessons and navigating the various pages of our site. Instead of having a preset order of pages that linked further into the depth of the content, we were able to set up a separate frame with links to various sections of the material available on the left side of the page. This would make it easier for the user to move from one section to another and then back again, without having to go back and forward in the browser.

In the case that the website became a non feasible option, we also produced a CD that contained all of the excel sheets with working links to each lesson. This CD acts somewhat like a website of its own. If the CD is inserted, and the main page file is opened, the link to the grade page, as well as all of the links to individual lessons are all working. These links were simply set up with the directory pointed toward another location on the same CD, and all of the information that will be on the website was also created on this one stand alone CD.

3.5 Styling

The spreadsheets that we created were originally designed with various colors and were presented in a grid like fashion. Since our site was to be included as a part of the existing WPI website, our format would have to look like the rest of the site. We created our spreadsheets in Microsoft Excel and used the in-program capability of saving as an html format. However, when we presented these to Nancy Adams at web development, she found that the coding produced by Excel's conversion tool was much more complicated than necessary, and would make it difficult to apply the necessary visual changes. Instead, we provided her with the original Excel sheets, so that she could use her expertise to create the html code in a manner that would allow her to easily apply the custom style sheet that would produce the visual styling required for most WPI web pages. The result was a much simpler code that was more readily customized and conserved more space.

Throughout the process of preparing our files for presentation on the website, it was important to provide web development with as much information as possible. We spent the time to explain the importance of the different sections of the content and give her a clear picture of the way in which the users may be using the site. Throughout this process, we were able to convey our ideas to her very well, and she was able to understand the importance of each part of our proposed site and she began to become familiarized with the charts and checklists that we provided her with. This was very important, since she was the one ultimately designing the site and creating the methods of navigation throughout the various areas of information. She also provided us with useful tips and guidelines that are commonly used in designing the site map and organizing the sections.

4. Results

Compilation of the lesson materials shed light on many aspects of the project that needed to be completed before lessons could be distributed. Fufillment of the benchmark and framework standards was monitored with the use of the benchmark and framework catalogs. Through the use of the catalogs any un-fulfilled technology/engineering standards were exposed, and lessons were created in order to fill these holes. The result was a comprehensive technology/engineering curriculum that fulfilled all benchmark and framework standards set by the WPS and Massachusetts Board of Education. In addition many non-technology/engineering standards were also met, in order to facilitate easy integration, of technology and engineering topic, in the regular science curriculum.

Over the course of the 2005-2006 school year the CI team has made many accomplishments toward dispensing lesson materials to teachers across all of Massachusetts. Lesson inventory sheets were created in order to keep track of created lessons, unevaluated lessons, and lessons to be finalized. Once finalized, lessons were collected and organized based on different criteria. Benchmark and Framework catalogs were created to ensure the all relevant benchmarks and frameworks were met for a given grade. Using these charts lessons were organized in a uniform and professional manner. All lesson names follow a uniform coding system that provides information on the lesson itself, such as grade level, unit letter, and lesson number.

To facilitate the teacher's need to effectively browse for lessons in a timely manner, framework checklists were created. Framework checklists allow teachers to choose a lesson, based on a desired level of included learning standards. Through the checklist: information such as lesson length, lesson descriptions, and met standards can be viewed before the lesson itself is even downloaded or viewed. An internet site is in development, as part of the existing PIEE page, in order to dispense all finalized lesson materials. Lessons will be found in the Resources section of the PIEE Project website. http://www.wpi.edu/Academics/PIEE

5. Recommendations

Since the 2005-2006 WPI school year was the last year the PIEE program was nationally funded, all work was finalized and completed. Despite the completion of the project, recommendations are still appropriate. While the website was designed to be self sustaining, it would still be worth while to have regular updates. There are several ways to approach this problem. The first option is to obtain addition funding to carry on the PIEE project. Continuation of funding would enable the creation of more lesson plans to be distributed to the teachers. If this is the course to be taken, the program could be run in the same fashion as it has in past years. In addition if the curriculum integration team is carried on into future year's organization could be conducted as the lessons are being made, rather than organizing the material towards the end of the funding period. Another option for future work is to pass the PIEE project on to another non-profit organization within the WPI community. Organization such as Tau Beta Pi or Engineers with out Borders could oversee the maintenance of the website and make updates as necessary.

Further aesthetic changes could be made to the website as well. One possible change is to add a comment board, where teacher may post questions on the lesson material. These suggestions can then be used to further tailor the site to the teachers needs. One problem that arises is that with an active posting method there needs to be and organization that will monitor the posts. At the current time this is not possible due the end of the PIEE project (as funded by the NSF), however could be possible if the project was handed off to another organization.

6. Conclusions

The project has officially ended, with regards to funding and creation of new lesson materials. It is our feeling that the project has been a success and all of the teams involved throughout the past 3 years have produced a great deal of material. The addition of the Curriculum Integration Team for this final year has helped to make the website a reality. Lessons will available online and can be downloaded, viewed, or printed through the WPI PIEE site at http://www.wpi.edu/Academics/PIEE.
The work done by our team, in conjunction with the cooperation of the individual grade teams and their respective fellow supervisors has strengthened the working partnerships between the students of WPI, the professors of WPI, the students of the WPS, and the teachers of the WPS.

7. Works Cited

1) P.I.E.E (2005). Partnerships Implementing Engineering Education Brochure. Worcester MA.
2) N.C.E.S (2005). About NCES. Washington D.C. **2005**.
3) E. D. Tab, B. P., Jennifer Jones, Bernard Greene (February 2005). Internet Access in U.S. Public Schools and Classrooms: 1994-2003. National Center for Education Statistics. Washington D.C, National Center for Education Statistics.
4) Various (2002). Worcester Public School Benchmark Standards. Worcester.
5) Various (May 2001). Massachusetts Science and Technology/Engineering Curriculum Framework. Massachusetts Science and Technology/Engineering Curriculum Framework, Massachusetts Department of Education.
6) Louis Rosenfeld and Peter Morville, Information Architecture for the World Wide Web, published 1998 by O'Reilly
7) Miller, J. (2002). K-6 Gets a Peice of the P.I.E.E.
8) P.I.E.E (2006). Partnerships Integration Engineering Educatoin. Worcester, Worcester Polytechnic Institute. **2006**.