Laboratory Activities for Secondary Science Education in Rural Thailand

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Abstract

Thailand's National Education Act of 1999 set out many reforms, some specifically aimed at promoting active teaching methods. However, in many rural areas these reforms have not yet been adopted. The Office of Her Royal Highness Princess Maha Chakri Sirindhorn's Projects aims to spread active teaching methods to schools throughout rural Thailand. Through partnership with the teachers of the Baan Na Yao School we tailored, implemented, and evaluated science laboratory activities. Implementation of these activities increased student interest in science and encouraged teachers to embrace active teaching methods. The developed laboratory manuals can be used throughout Thailand to promote active teaching methods.

Acknowledgments

The Science Laboratory Activities for Secondary Education in Rural Thailand team would like to express its appreciation to the Office of Her Royal Highness Princess Maha Chakri Sirindhorn's Projects for sponsoring this project and allowing us to join the effort to spread active teaching methods throughout Thailand. We are grateful for the guidance we received from the Office's project coordinators Mr. Aphisit Pungporn and Dr. Nantaporn Virawathana. We also want to express our gratitude to the project liaisons, Panarat Seeharah, Napa Voravaramggul, and Siripastr Jayanta, for their guidance and advice. We would also like to thank the Thailand Border Patrol Police for sponsoring this project as well. We thank Richard Vaz and Chrysanthe Demetry, the site managers for organizing this project with the Office of Her Royal Highness Princess Maha Chakri Sirindhorn's Projects and the Border Patrol Police.

We would like to thank, Sumpan Patumthanaruk, the director of the Baan Na Yao School without whom this project would not have been possible. The project team also wants to thank all of the Baan Na Yao School teachers and students for their warm hospitality. We are especially grateful for the cooperation of the school's science teachers who took the time to use our designed laboratory activities in their classrooms. In addition, we greatly appreciate the welcoming people of the Na Yao village, who helped make Na Yao our home during our four week stay. In particular we appreciate the generosity of Fon, Keng, and Kroo Kaew who spent so much time ensuring our stay was comfortable and enjoyable. We will always remember the people we met and experiences we had while at Na Yao.

We want to extend our thanks to our advisors: Thomas Robertson and Brigitte Servatius of Worcester Polytechnic Institute (WPI), and Supawan Tantayanon of Chulalongkorn University. Their guidance and support aided us through the entire process of this project. We are also grateful to Dominic Golding of WPI for directing our preliminary research and project organization before the project team's collaboration in Thailand. Finally we would like to thank Chulalongkorn University and Worcester Polytechnic Institute for providing us with the opportunity to take part in the Science Laboratory Activities for Secondary Education in Rural Thailand project and cross-cultural experience.

Executive Summary

Before the opening of the Baan Na Yao School the youth of the Na Yao area did not have the opportunity of education beyond the primary levels and typically followed in the footsteps of their parents. One student expressed his aspirations for his future and stated that he wants to "continue studying to bring knowledge to the developing country [Thailand]." The Baan Na Yao School is equipped with extensive educational facilities and dedicated teachers that give students the chance to follow their dreams, but also recognizes a current need for engaging classroom activities that will increase the students' interest in science and improve problem solving skills.

The Thai government passed the National Education Act of 1999 specifically to improve teaching in all subject areas including the subjects of science and technology. The fulfillment of the goals of Thailand's National Education Act of 1999 is impeded by the country's tradition of rote teaching methods. The implementation of the act has been particularly difficult in rural areas of the country. The Office of H.R.H. Princess Maha Chakri Sirindhorn's Projects is dedicated to aiding rural areas in shifting teaching styles toward active teaching methods. Through this focus on education the Princess hopes to improve the students' overall academic success and long-term livelihood. As part of these efforts, The Office of Her Royal Highness Princess Maha Chakri Sirindhorn's Projects sponsored this project team to work with the Baan Na Yao School.

Project Goal

The goal of this project was to design several cost-effective science laboratory activities that tie into Thailand's national curriculum and are engaging, educational, cost effective, interactive, sustainable, relevant to, and appropriate for secondary level teachers and students in the Baan Na Yao School. The final facet of the goal was to disseminate information about these activities to schools throughout Thailand by conducting an open science fair and creating laboratory manuals for distribution.

Methods

The project team aimed to achieve the above goal through the following four objectives.

- **Select** prospective science laboratory activities by researching existing activities which fit the criteria presented in the project goal;
- **Tailor** the selected laboratory activities using information and feedback gathered from the teachers input on the activities' relevance to the Baan Na Yao students, school and curriculum;
- **Evaluate** the success of each activity by conducting the activities in the classroom, utilizing pre and post opinion surveys and tests, and analyzing classroom observations;
- **Disseminate** knowledge of laboratory activities through an open science fair and laboratory manuals. The laboratory manuals were submitted to the Office of H.R.H. Maha Chakri Sirindhorn's Projects and were then made available for use by schools in Thailand.

Science Laboratory Activities Developed for the Baan Na Yao School

The following activities were designed considering the criteria presented in the project goal and objectives.

- **"Seasons Modeling"-** An astronomy activity for Matthayom 6 (12^{th} grade) based on the concepts of seasonal changes and the rotation and orbit of the earth.
- **"Gravity is a Hammer"-** A physics activity for Matthayom 5 (11^{th} grade) based on the concepts of work, friction, and potential and kinetic energy.
- **"What's in My Food?"-** A chemistry activity for Matthayom 4 (10^{th} grade) based on the concepts of carbohydrates, proteins, and lipids.
- **"Precipitation Reaction"-** A chemistry activity for Matthayom 4 (10^{th} grade) based on the concept of double replacement reactions.
- **"Colors of the Sun"-** A biology activity for Matthayom 5 (11^{th} grade) based on the concepts of photosynthesis and light waves.

Findings and Analysis

To analyze the success of the developed laboratory activities we gathered information relevant to the three activities--"Seasons Modeling", "Gravity is a Hammer", and "What's in My Food?" using student and teacher opinion surveys, pre and post tests, classroom observations, and conversations with the teachers and students of the Baan Na Yao School. The other activities were not analyzed because there were not conducted in the classrooms due to time constraints.

We found that:

- **Teachers embraced active teaching methods**: The teachers understood the advantages of active teaching methods and plan to use the activities in the future as well for other topics they teach.
- **Hands-on activities engaged the students**: The students were excited to do hands-on activities and enjoyed group work and participating in the classroom.
- **Difficulty level/ relevancy to the curriculum limited the effects of the designed activities**: The activities fit the national curriculum but the relevant topics had already been covered in the respective classrooms at the Baan Na Yao School.
- **Students lacked confidence with open ended-questions**: Many students skipped questions or copied other students' answers on the post tests when questions required in-depth analytical problem solving. This was in part due to the students' discomfort with this level of problem solving.
- **Student interest in science increased as a result of participating in the designed activities**: The percent of students whose favorite subject was science significantly increased after participation in the laboratory activities.

Conclusions and Recommendations

Our main conclusions and recommendations are as follows.

For future education research teams

Conclusion: Open communication between members of the project team and the teachers of the Baan Na Yao School was inhibited during the initial phases of the tailoring process.

We recommend that future rural science education groups actively seek out opportunities to form relationships with the teachers in a social setting.

Conclusion: Flexible laboratory activities are easily tailored to target schools.	**We recommend** that the design of any laboratory activity be flexible.
Conclusion: Easy preparation was particularly important to the activities' sustainability.	**We recommend** that future project teams design laboratory activities to have preparation which is short and simple.
Conclusion: The use of locally available materials was particularly important to the activities' sustainability.	**We recommend** that all materials used in laboratory activities be locally available and inexpensive.
Conclusion: Students were more confident and comfortable with multiple choice questions than open ended and analytical questions.	**We recommend** that future student evaluations include a variety of question formats.

For the Office of Her Royal Highness Princess Maha Chakri Sirindhorn's Projects

Conclusion: The developed laboratory activities fulfilled the project goals and thus are educationally valuable.	**We recommend** that the Office of H.R.H. Maha Chakri Sirindhorn's Projects make the laboratory manuals available to all schools who want to use these activities.

Concluding Remarks

Findings collected from the conduction of the activities at the Baan Na Yao School were used for the final tailoring process of each experiment. The five developed activities included in our manual for dissemination are "Seasons Modeling", "Gravity is a Hammer", "What's in My Food?", "Colors of the Sun", and "Precipitation Reactions". We hope that the developed laboratory manual will be used by other schools throughout Thailand to help integrate active teaching methods into classrooms. We would like to thank the Office of H.R.H. Princess Maha Chakri Sirindhorn's Projects as well as Chulalongkorn University and Worcester Polytechnic Institute for allowing us the opportunity to work together on this project.

Authorship

The project team divided the writing of the major sections of the report among the project team members. For the editing process the group worked together to make changes to each written section. For some sections certain members took leading roles in the editing process as reflected below.

Abstract

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Importance of Education in Thailand

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Importance of Science Education

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Thai Education System

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Introduction

The founding of the Baan Na Yao School, by the Office of Her Royal Highness Princess Maha Chakri Sirindhorn's Projects as a free secondary school, presents an educational opportunity for the youth of the Na Yao village. Though this village is located approximately 100 kilometers east of Bangkok (as seen in Figure 6) it still takes at least 4 hours to drive the 160 kilometer route from this city to this remote area of hardworking agricultural small town families. Before the opening of the Baan Na Yao School, the youth of this area did not have the opportunity of education beyond the primary levels. In a village where children typically followed in the footsteps of their parents, the Baan Na Yao School gives its students the ability to follow their own dreams. One student expressed his aspirations for his future and stated that he wants to "continue studying to bring knowledge to the developing country [Thailand]." The Baan Na Yao School is equipped with extensive educational facilities and dedicated teachers but also recognizes a current need for engaging classroom activities that will increase the students' interest in science and problem solving skills.

A strong educational system is essential in any society for the "quality of education a child gets directly relates to opportunities that will open up for him later in life" (Garrovillas, 2005). In turn, most countries recognize that a well-educated citizenry is essential for national economic growth and stability (Todaro, 1997). Increasingly, the ability to compete in world markets is tied to the level of scientific and technical literacy within a country (Garrovillas, 2005). Thailand is lagging in this regard but recognizes the need for reform. This is evident through the poor result of the Program for International Student Assessment (PISA) which, in 2006, was taken by more than 400,000 students from 57 different countries. The cut off for a top PISA score of level 6 is 707.9 score points. In 2006, Thai students scored an average of 421 points, which puts Thailand in level 2, lower than the world wide average by 79 score points. Thai students' performance was in the bottom 25%. A table explaining the scoring system of the PISA is included in B1: PISA Scoring Rubric. These below average scores indicate a need for a stronger science education system (*OECD programme for international student assessment (PISA).*2009).

The Thai government passed the National Education Act of 1999 specifically to improve teaching in all subject areas including the subjects of science and technology. As two researchers argue, "Although the school science curriculum features scientific learning, Thai

science education, research, articles, national tests, and teaching emphasizes scientific achievement with little concern about science as a way of knowing (Yuenyong & Narjaikaew, 2008)." Active teaching methods have not been firmly established in all aspects of the Thai education system, especially rural Thailand.

The fulfillment of the goals of Thailand's National Education Act of 1999 is impeded by the country's tradition of rote teaching methods. The implementation of the act has been particularly difficult in rural areas of the country due to the discomfort and unwillingness of the teachers as a result of their image of themselves as dispensers of knowledge instead of facilitators of conceptual learning (Yuenyong & Narjaikaew, 2008). The Office of H.R.H. Princess Maha Chakri Sirindhorn's Projects is dedicated to aiding rural areas in shifting teaching styles toward active teaching methods. The Office has set up schools throughout rural Thailand including the Baan Na Yao School. In addition it promotes active learning, particularly in science, by sending education researchers and volunteers to aid the schools. Through this focus on education the Princess hopes to improve the students' overall academic success and long-term livelihood.

The project team acted as a representative of this Office so the goals we designed aligned with those of H.R.H Princess Maha Chakri Sirindhorn's. The specific goals of this project were to design science laboratory activities for the Baan Na Yao School that were:

- Educational
- Cost-effective
- Engaging and Interactive
- Relevant to the national curriculum and Baan Na Yao students' lives
- Embraced by the Baan Na Yao teachers

The project team also disseminated knowledge of the laboratory activities through an open science fair and laboratory manuals for distribution by the Office of H.R.H. Maha Chakri Sirindhorn's Project. The project team stayed at the Baan Na Yao School for one month working closely with the administrators, teachers, and students to implement active teaching methods and evaluate their effects.

The project team hopes to increase the teachers' confidence in using active teaching methods, improve student interest in and understanding of science concepts, and ensure a likelihood of sustained use of the developed laboratory activities.

Background

Research shows that education is a foundation of a successful society. As economist Eduardo P. Garrvillas explains a "government's ability to provide quality education for its people is crucial not only to its survival but also to its ability to compete in the global market and be a meaningful partner in world affairs" (Garrovillas, 2005). Thailand has recognized a need to reform its education system from traditional rote memorization in order to keep up with world globalization. The basis of this change is focused on instilling students with innovation and problem solving skills to prepare them for the rigors of the outside world. A key to this reform is improved teacher education which will provide teachers with the necessary tools to implement active teaching methods in their classrooms. Though the Ministry of Education has executed reform efforts, the effects have not yet reached many rural areas of the country. The Baan Na Yao School, founded and sponsored by the Office of H.R.H. Princess Maha Chakri Sirindhorn's Projects, is an example of the reform efforts.

Importance of Education in Thailand

Thailand has placed great emphasis on the education of its population for many years. In 1868 King Rama V initiated an educational reform which included the introduction of Western-style formal education. This voluntary integration of western style techniques, considering that Thailand has never been colonized, shows Thailand's emphasis on the importance of education and their openness to implementing ideas originating from outside their borders. On the topic of this reform King Chulalongkorn proclaimed that once the Thai people "have acquired a literate education, goodness, beauty and prosperity will be with them to the end of their days (Wyatt, 1969)." His ideas were revolutionary for the time, and are now the foundation on which the modern Thai education system is built (Wyatt, 1969). By the 1930's Thailand's formal education system was firmly established.

Today, increasing globalization is rapidly changing Thailand's educational needs. These needs focus on "world-wide information technology, knowledge based societies, democracy and human rights, advanced technology, trade liberalization, new economic order, environmental preservation, and cultural diversification and sovereignty" (Cheng, Chow, & Tsui, 2001). Educational reform is needed in order to prepare the Thai citizens for world changes that will affect their lives (Cheng et al., 2001). The National Education Act of 1999 marks the beginning of Thailand's recent educational reform movement, and illustrates the country's willingness to change and adapt to the ever changing global demands of today.

If a country does not properly educate its people, it will not be able to effectively compete in a global economy (Friedman, 2000). Friedman argues that lower levels of education in a country limit a larger percentage of the population to manual labor. Less profitable sectors such as agriculture and other manual labor occupations, contain few opportunities for advancement, and are vulnerable to the vagaries of the weather and markets. This limitation is clear from the rates of poverty by occupation shown in Figure 1 and Figure 2. At the time the study was conducted poverty in Thailand was defined as an income that is less than 922 baht per person per month (National Economic and Social Development Board, 2002). Figure 1 shows that in Thailand occupational farming has the highest rate of poverty while the more skilled professions have the lowest rates. Data from the National Economic and Social Development Board (NESDB) shows that household poverty declines as the educational attainment of the head of household increases (Figure 2).

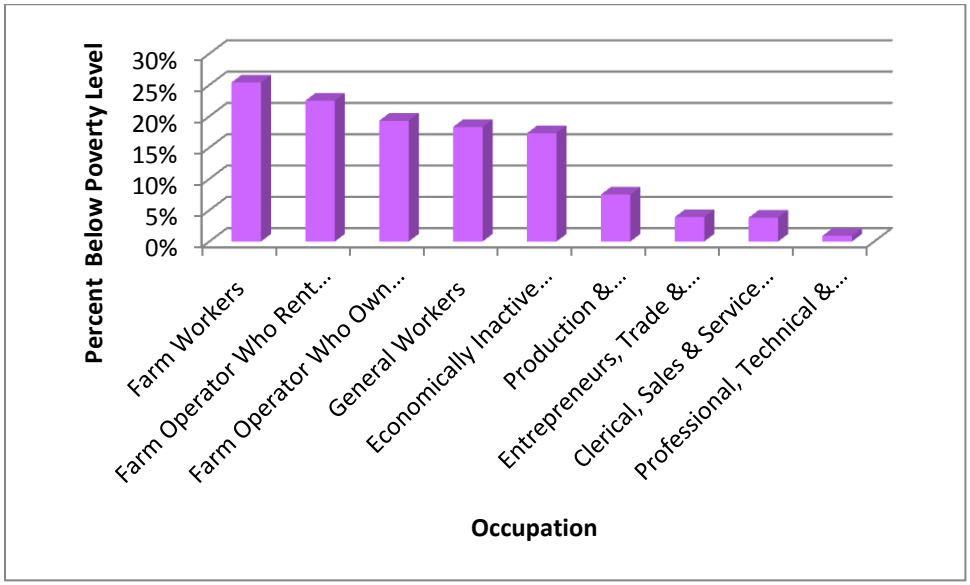

Figure 1: The relationship between poverty and occupation (National Economic and Social Development Board, 2002)

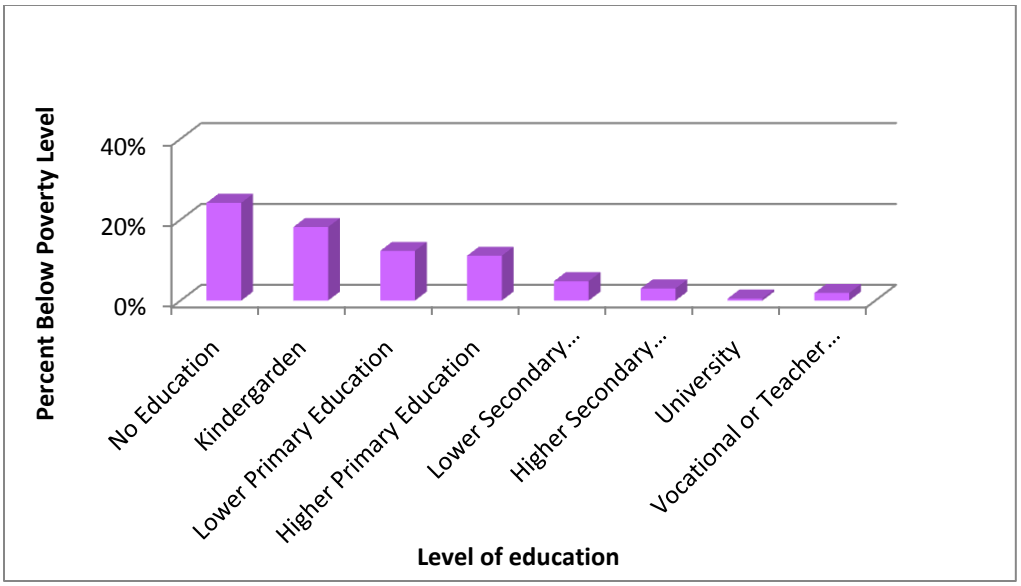

Figure 2: The relationship between poverty and level of education (National Economic and Social Development Board, 2002)

Success Through Science Literacy

Research shows that one component of a sufficient education is a thorough understanding of science concepts and their applications. Thomas and Durant claim that "ignorance of elementary science cuts off the individual from understanding many of the tools and services used every day" (Thomas & Durant, 1987). A general science education is required for people to gain an adequate understanding of scientific concepts, science literacy, and gives them the ability to compete in the global market (DeBoer, 2006).

Carlos L. de La Rosa, a professional environmentalist, highlights this global need for science literacy in order to properly manage natural resources. "Science literacy at the citizen's level in developing countries is essential for the development of sustainability and for the protection and conservation of irreplaceable global resources" (de la Rosa, Carlos L., 2000). An example of this need for science literacy in rural Thailand is described in Joseph Cornell's article on slash and burn farming. In order to increase the amount of crops produced in a given year, farmers use the slash and burn method, which allows for short term gains. If used for multiple years without providing time for the land to recover, this method will leave the land significantly damaged. Science literacy is required for the Thai farmers to adapt their current farming methods so that they do not risk further damage to their land and livelihood (Cornell, 2007).

In 2008 the Institute for the Promotion of Teaching Science and Technology (IPST) in Thailand stated that if people are scientifically literate the quality of their lives will be improved

and Thai society will benefit (The Institute for the Promotion of Teaching Science and Technology, n.d.). This is supported by Jenkins's 1990 article in *School Science Review*, which claims that people who are scientifically literate have a larger range of jobs available to them, and are better equipped to understand scientific information allowing them to have a better life (Jenkins, 1990). Laugksch defines science literacy as "the knowledge you need to understand public issues" which results from an effective science education (Laugksch, 2000). A strong education system is the tool which will instill science literacy in its students.

Thai Education System

The current Thai education system (in 2010) has roots in the set of reforms set out by the 1999 National Education Act. The act provides for twelve years of education, free of tuition, for all Thai children. The first nine of these years are compulsory and the final three years are optional. Figure 3 outlines the structure of the Thai education system.

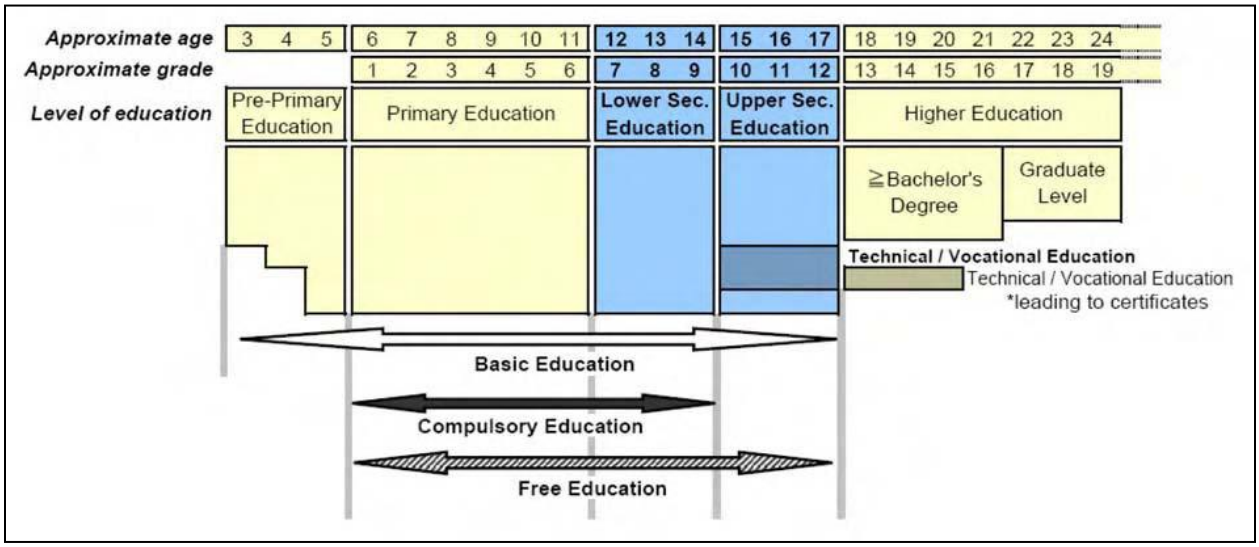

Figure 3 Levels of education in Thailand (United Nations Educational Scientific and Cultural Organization, 2008)

Thailand's National Curriculum consists of eight core subjects. The core subjects are Thai language, mathematics, science, social studies, religion and culture, health and physical education, art, career and technology, and foreign languages. Thinking skills, self learning strategies and moral development are included as part of the teaching and learning system. "Schools are required to promote learning reform by changing the teaching-learning method

from a teacher-centered approach to a learner-centered approach" (Office of the National Education Commision of Thailand, n.d.).

The current Thai classroom is shifting from rote memorization to a student centered learning environment. The Ministry of Education hopes to make this shift very rapidly as they state:

> Learning by rote will next year be eliminated from all primary and secondary schools and be replaced with student centered learning. . . Any teachers found failing to change their teaching style would be listed and provided with videotapes showing new teaching techniques. If they still failed to improve, they would be sent for intensive training. (Ministry of Education Thailand, 2006)

On student-centered learning, Professor Stiggins states:

> is based on the contention that student achievement and academic self-concept are determined, by and large, on the basis of students' perceptions of their own success in classrooms. It presents a philosophy that places students at the center of the classroom equation. The single most important value any teacher must bring to the classroom assessment process is a strong sense of caring about student wellbeing in school. (Stiggins, 2000)

Unfortunately this change has not been implemented in many schools due to the unwillingness of some teachers to change their teaching style and student discomfort with a new 'foreign' system which pushes their comfort zones. Many Thai teachers understand the importance of this shift in teaching methods but have yet to embrace the necessary changes in their personal teaching styles. This resistance is a result of the teachers' image of themselves as dispensers of knowledge instead of facilitators of conceptual learning (Yuenyong & Narjaikaew, 2008).

Teacher Education

According to Fullan an education researcher, teacher education is particularly important where educational reforms have been introduced (Fullan, 1998). In the classroom teachers can teach in whatever manner they believe best. If a teacher does not understand or agree with the proposed educational reform, he or she will not implement it. If teachers are determined to resist, it is very difficult, for authorities to close the gap between policy goals and policy implementation (Dove, 1986). Teachers must be able to see the importance of a particular style of teaching and so must be educated on the proposed reform. Understanding this, Linda Darling-Hammond, explains that developing the ability to see beyond one's own perspective, to put

oneself in the shoes of the learner and to understand the meaning of that experience in terms of learning, is perhaps the most important role of universities in the preparation of teachers (Darling-Hammond, 2000).

Important facets of teacher education are an understanding of the subject-matter to be taught as well as an understanding of teaching methods and the student learning process. Without significant subject-matter knowledge it is impossible to adequately teach a particular subject (Musikil, 2007). One of the great misconceptions about teaching is the presumption that anyone can teach what he or she knows to anyone else. In particular, people who have never studied teaching or learning often find it difficult to convey material that they themselves learned effortlessly and almost subconsciously (Darling-Hammond, 2000). Knowledge, including the knowledge of learning, teaching methods, and curriculum is termed pedagogical knowledge. Linda Darling-Hammond believes that pedagogical knowledge is more frequently found to influence teaching performance and often exerts an even stronger effect than subject-matter knowledge (Darling-Hammond, 2000). The major components of pedagogical content knowledge are mapped out in Figure 4.

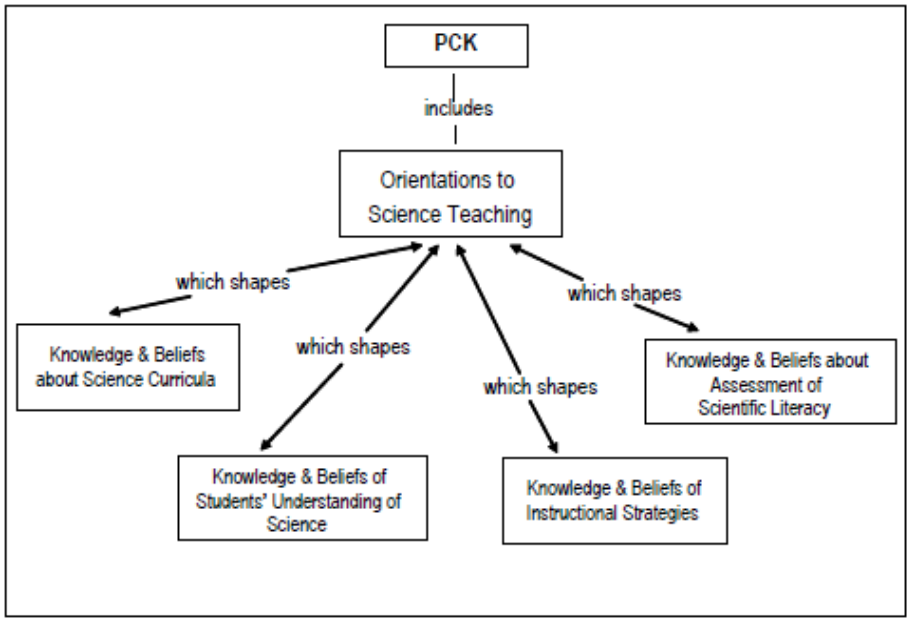

Figure 4: Pedagogical Content Knowledge (PCK) (Musikil, 2007)

Effective methods of educating teachers concentrate on the teacher as a questioner as well as a knower. T.K. Russel, author of "Teachers who Teach Teachers", has found that an effective teacher must also be a learner and that in order for teachers to learn, they must be

willing to question their teaching methods. Teachers must ask questions, generate hypotheses, gather and analyze data, and draw conclusions. When teachers are also learners, they can respond to the varying circumstances of their work and learn to work more effectively (Russell, 1995). The American Educational Research Association has found that "student teachers who themselves experienced learning in an active way are more inclined to plan lessons that facilitate students' active knowledge construction (Korthagen & Kessels, 1999)."

Teacher preparation is a crucial aspect of any education design project or reform for teachers who are prepared are often more confident in their teaching. Well prepared teachers add to the value of educational activities. According to a survey of beginning teachers in 1998, teachers with extensive preparation believe that they have great influence on a student to succeed, while teachers with less preparation believe that students fail because they do not apply themselves and that they as teachers have little influence on a student's success (Darling-Hammond, Chung, & Frelow, 2002).

Thailand is now reforming its methods of teacher training through its National Education Reform Act of 1999. In 2005 there were over 614,000 teachers of basic education under the Ministry of Education. The National Institute for Development of Teachers and Education Personnel (NIDTEP) plans on spending 60 million baht between 2006 and 2010 to create a national network to develop over 600,000 new teachers and educational personnel. These educational aspirations require substantial training efforts of new teaching approaches, curriculum, standards and Information and Communications Technologies (ICT) proficiency (Ministry of Education Thailand, 2006). As seen in Figure 5, in Thailand 70% of all teachers in basic education have a bachelor degree and 13% hold a masters qualification while 10% do not have a degree. The qualifications of the remaining 7% are unknown. Comparatively, China has a higher percent of educated teachers with over 80% of teachers holding bachelor's degrees (Ministry of Education of the People's Republic of China, 2009). The United States requires all primary and secondary public school teachers to hold a bachelor's degree (U.S. Department of Education, 2006). Private school teachers in all countries are not accounted for.

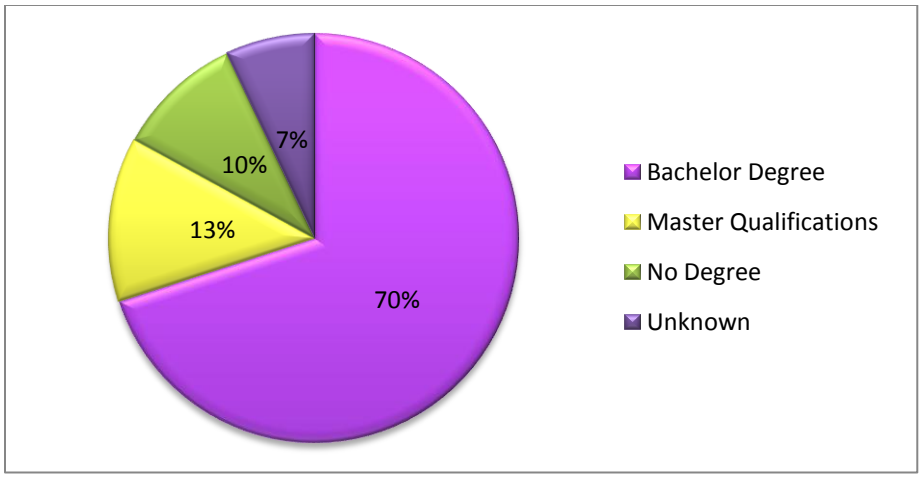

Figure 5: The Educational Background of Thai Teachers in Basic Education (Ministry of Education Thailand, 2006)

There are significant teacher shortages in key subject areas such as mathematics, biology, physics and chemistry in Thailand (Ministry of Education Thailand, 2006). The Thai Ministry of Education is addressing this professional development of the country's teachers. The ministry has developed three major goals, for 2004 through 2013 (Table 1):

1. To change the perceptions about a career in education;
2. To develop modern active teaching methods in teacher training institutions; and,
3. To develop teacher potential through ongoing professional development.

Table 1: Strategic focus and key themes for teacher and education personnel reform 2004-2013 (Ministry of Education Thailand, 2006)

Strategic focus and key themes for teacher and education personnel reform 2004-2013	
Change perceptions on a career in education (Executing agencies: Teachers' Council/ Office of Teacher Committee and Education Personnel) ◆ improving occupational standards for teachers. ◆ developing personnel management systems and career paths. ◆ create and develop new salary schemes, allowances, and benefits for teachers. **Produce new trend teachers in teacher training institutions** (Executing agency: Commission on Higher Education) ◆ urgently develop curriculum for new trend teachers. ◆ urgently develop teacher training institutes. ◆ develop instructors in education faculties.	**Develop teacher's potential through ongoing professional development** (Executing agencies: NIDTEP with the Office of Teacher Committee and Education Personnel) ◆ create leadership for change programmes. ◆ develop the potential of teachers and education personnel ◆ set up alliances and develop networks. ◆ support continuing education. ◆ create new management systems. ◆ drive the development strategy.

The first goal, to change perceptions about a career in education, will be implemented by the Teachers' Council and the Office of Teacher Committee and Education Personnel. The Ministry of Education gave them the task to improve occupational standards for teachers, develop personnel management systems and career paths, and create new salary schemes and benefits for teachers. The Executing Agency Commission on Higher Education is responsible for meeting the second goal, to develop modern active teaching methods in teacher training institutions. The Commission will be developing a curriculum for teachers, developing training institutes, and developing instructors in education faculties. The third goal, to develop teacher's potential through ongoing professional development, will be promoted by the National Institute for Development of Teachers, Faculty Staffs, and Educational Personnel (NIDTEP) and the Teacher Committee and Education Personnel. NIDTEP is creating leadership for change programs, develop the potential of teachers and education personnel, set up alliances and develop networks, support continuing education, create new management systems and drive this development strategy (Ministry of Education Thailand, 2006). Thailand is actively improving teacher educations so that a shift can be made from rote memorization to active learning which will improve the education Thai people. For additional information on Thailand's efforts to improve teacher education see Appendix B.

Active Teaching Methods

The goal of designing laboratory activities for use in rural Thailand is to transition the education method from traditional rote memorization to hands-on and interactive learning. Two presenters at the Annual Meeting of the National Association for Research in Science Teaching (New Orleans, LA, April 28-May 1, 2000) point out that "science education reforms…emphasize conceptual knowledge as an important part of science learning, further stressing that conceptual knowledge must be applied in computational problem-solving (Wolfer & Lederman, 2000)." Professor Murakami, former head of the University of Tokyo's Research Center for Advanced Science and Technology, compares his Japanese raised students to those raised oversees. According to Murakami the differences between the two were strikingly obvious as the students raised outside of Japan were generally more active in discussion and would raise questions to challenge the professor. He observed that those students taught with rote memorization in Japan "[did] not develop the ability to identify problems and respond to them appropriately (Normile,

1996).” Had this study been conducted in Thailand instead of Japan a similar conclusion would be expected due to a common tradition of rote memorization in both educational systems.

The key features of most modern active teaching methods include creativity, communication, critical thinking/analytical skills, teamwork, and inquiry. This approach requires students to work together as teams to solve and analyze problems instead of the teacher simply explaining the solution as in the rote memorization teaching method. The National Research Council's report, *Taking Science to School: Learning and Teaching Science in Grades K-8* summarizes the past 20 years of educational reform efforts with the claim that “Students who are proficient in science: 1. know, use, and interpret scientific explanations of the natural world; 2. generate and evaluate scientific evidence and explanations; 3. understand the nature and development of scientific knowledge; and 4. participate productively in scientific practices and discourse (Winokur, Worth, & Heller-Winokur, 2009).” Active teaching strategies will instill these skills in students (Winokur et al., 2009).

The K-W-L method is one example of an active teaching method. K-W-L was successfully implemented in college physics courses at a university in Virginia, United States. It is broken down into three clear phases. The first, K, is finding out what students already Know about the topic. Next is W to find out what the students Want to know. The L step is conducted after the activity is completed to find out what the students have Learned from the experiment (Wrinkle & Manivannan, 2009). The outline of this method can be easily adapted for use in the Baan Na Yao School. One apparent issue will come with the W step (what the students want to know) because of the need to adhere to the national curriculum. This can be controlled by having the students make predictions of an activity preselected by the teacher so that their discussion can be guided towards the topic selected by the teacher. The adapted K-W-L method will still require the students to think about the subject matter critically before realizing the answer through experimentation.

A thorough analysis of the K-W-L method was conducted with college students in an introductory level course on the subject of vectors. Two groups were created, a K-W-L group and a control. Each group was given the same instructions. The control group simply read the assignment and conducted the activity and follow up questions individually. The K-W-L group had a **discussion**, **predicted results**, and **worked in teams** to conduct the laboratory activity and

discussed the results. A test was then developed to assess the students' understanding of vector addition. The K-W-L group test scores were equal or higher than the scores of the control group; the K-W-L group also performed especially well on the more challenging problems. These results show that the K-W-L group gained a fuller **understanding of the subject matter** than the traditional control group through the integration of **creativity**, **communication**, **teamwork** and **inquiry** (Wrinkle & Manivannan, 2009).

A similar teaching method to the K-W-L is the science, technology and society approach (STS). The STS method "emphasizes the relationship between science, technology and society – based on a Thai Context (Yuenyong & Narjaikaew, 2008)." The technique, developed and implemented in Thailand, has been shown to develop the students' understanding of **target concepts**, while also developing their **critical thinking skills** (Yuenyong & Narjaikaew, 2008). Active teaching methods such as K-W-L and STS involve engaging students on multiple levels from provoking critical thought to performing **hands-on** activities. **The themes of creativity, communication, critical thinking, analytical skills, teamwork and inquiry permeate across active teaching methods.**

Baan Na Yao School and the Na Yao Village

The Office of H.R.H. Princess Maha Chakri Sirindhorn's Projects has selected the Baan Na Yao School to receive aid in the development of science laboratory activities. The school is located in the Na Yao Village which is within the Chachoengsao province in the amphoe (district) Sanam Chai Khet. Though this village is located approximately 100 kilometers east of Bangkok it still takes at least 4 hours to drive the 160 kilometer route from the city to this remote area of hardworking agricultural small town families as seen in Figure 6. It is a rural village with a population of approximately 6,000 inhabitants. The village economy is based mainly on agrarian pursuits.

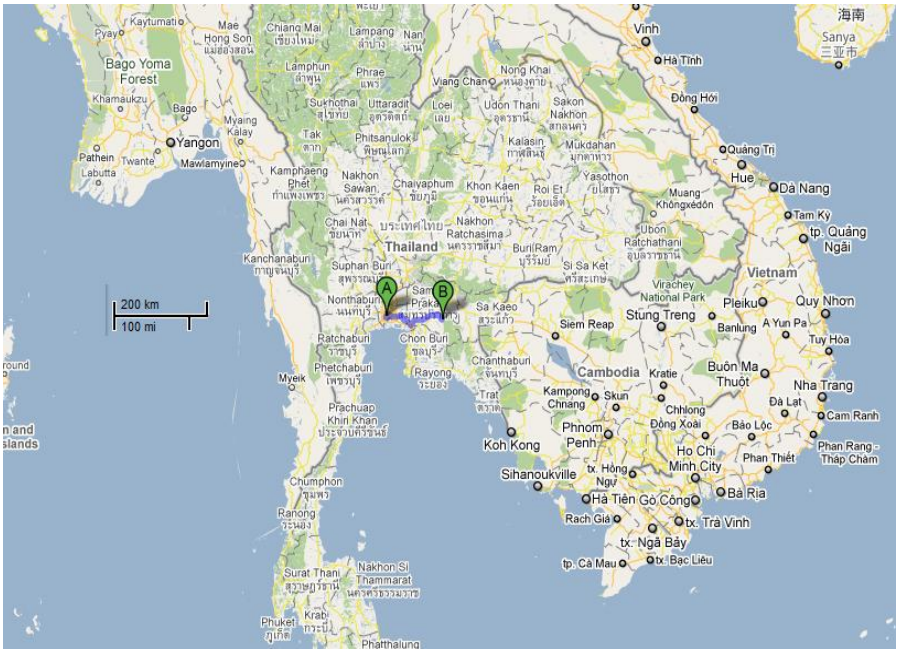

Figure 6 Map of Thailand (Bangkok is at A Na Yao is at B) (Google, 2010)

The Baan Na Yao School is a secondary school with approximately 500 students. The school grounds cover a thirty acre forested area which includes a seven acre rice farm, fish ponds, herbal gardens, an auto shop, a chicken farm, agricultural equipment, a school store, and multiple science laboratories. The students help out in each of these facilities. Within the forest various stations are set up where the students learn concepts in the subjects of biology and chemistry. The fish ponds are used to teach life cycles and economics. Locally used farm equipment (located on the school grounds) including a lever arm device that is used to raise the nets that catch the fish, a machine used to grow sprouts which incorporates gearing and pulleys, and two machines which are used to grind sugar cane using torque and gears are all used to teach physics. The herbal gardens are used to teach farming skills which many of the students will need outside of school as well as biology concepts. In the auto shop the students are taught how to assemble and disassemble cars which is a useful tool when working with tractors and other mechanical farm equipment. This equipment must be maintained by the operator and these skills a particularly important in rural areas where replacement equipment is hard to come by. The student-run school store is used as a tool to teach the students both economics and responsibility. The school also has basic science laboratories for physics, biology, chemistry and astronomy. The facilities and environment of the Baan Na Yao School have great potential but are not being used to their fullest capacity.

All of the students in the Baan Na Yao School live in the Na Yao village. The majority of the students work on family farms or in family stores and without this school would have no opportunity explore alternative career paths or continue onto higher education. Observations of the students revealed that they are motivated and interested in learning. They seem eager to participate in classroom activities demonstrated by their attentive focus and eagerness to seek out knowledge. They demonstrate a great respect for their teachers which is based upon the respect for the knowledge the teachers possess. Further proof of this motivation is shown by the 70% of graduates that go onto university education, according to information from the director of the school. More information about the school can be found in Appendix A.

The Baan Na Yao School is different from many schools in Thailand in because it divides its students into three tracks. The students are allowed to pick which track they will follow at Matthayom 4 and continue on that track through Matthayom 6. All of the tracks cover agriculture, general science topics, language arts, mathematics, physical education, social studies and cultural studies. Track 3 is typically chosen by male student and focuses on mechanical and technical design. Track 2 is typically chosen by female students and focuses on cosmetology and culinary arts. Track 1 is chosen by students who want to focus more deeply on science and mathematics. Throughout this report the classes are referred by grade and track in the form Matthayom number then track number. An example is 5-1.

Baan Na Yao Curriculum

The Baan Na Yao curricula which activities were designed for were chemistry, astronomy, and physics. Background information on these subjects at the Baan Na Yao School was supplied by the Office of H.R.H. Princess Maha Chakri Sirindhorn's Projects with the original proposal for this project. The information briefly describes the current activities used to study these subjects before the introduction of the new activities.

Astronomy

The current astronomy curriculum at the Baan Na Yao School for Matthayom 6 focused on geologic time, and the universe. One of the activities which was designed for the Baan Na Yao School focuses on seasonal changes, the Earth, space and general astronomy. The school's current laboratory activities for geological time and the universe were: fossils (making fossils with play-dough, plaster, plants and animals); excavation (school ground, examples of rocks and

minerals); geologic mapping (rock layer in school ground); solar system models, structure/composition of earth and other planets.

Physics

The current physics curriculum at the Baan Na Yao School for Matthayom 5 focused on kinetic energy, gravitational potential energy, and mechanical energy. One of the activities which was designed for the Baan Na Yao School falls under the category of energy. The school's current laboratory activities for energy used the materials: kinetic energy (uses a wooden car, wooden rail, pulley, ticker timer, and strip of paper); gravitational potential (wooden car, rail, spring scale and ruler); and mechanical (sand bags, spring scale, rail and ticker).

Chemistry

The current chemistry curriculum at the Baan Na Yao School for Matthayom 4 focused on biomolecules, the human digestive system, and food preservation. One of the activities which was designed for the Baan Na Yao School falls under the biomolecules category. One of the current chemistry activities conducted before the introduction of the new activities was the upkeep of an outdoor water purification system using Water Hyacinth.

Methodology

The goal of this project was to design several cost-effective science laboratory activities that tie into Thailand's national curriculum and are engaging, educational, interactive, sustainable, relevant to, and appropriate for secondary level teachers and students in the Baan Na Yao School. This small rural school was founded by the Office of H.R.H. Princess Maha Chakri Sirindhorn's Projects as a free high school in 2004. Laboratory manuals describing the activities in detail which were created for distribution by the Office of H.R.H. Maha Chakri Sirindhorn's Projects. In order to achieve this goal, we developed the following objectives:

1. **Select** prospective science laboratory activities by researching existing activities which fit the criteria presented in the project goal;
2. **Tailor** the selected laboratory activities using information and feedback gathered from the teachers input on the activities' relevance to the Baan Na Yao students, school and curriculum;
3. **Evaluate** the success of each activity by conducting the activities in the classroom, utilizing pre and post opinion surveys and tests, and analyzing classroom observations;
4. **Disseminate** knowledge of laboratory activities through an open science fair and laboratory manuals. The laboratory manuals will be submitted to the Office of H.R.H. Maha Chakri Sirindhorn's Projects and were then made available for use by schools in Thailand.

Selection of Prospective Science Laboratory Activities

The project team researched and selected a variety of laboratory activities for discussion by representatives from the Office of Her Royal Highness Princess Maha Chakri Sirindhorn's Projects and the Baan Na Yao School. This gave the Office of H.R.H. Princess Maha Chakri Sirindhorn's Projects an option to choose the activities that would be implemented in the Baan Na Yao School. The research for the selected activities focused mainly on varied teaching methods to allow us to assess the effectiveness of the designed activities. Major conclusions from this research are summarized in B3: Subject Matter Research. This selection process also included the brainstorming and selection of proven-effective activities to use as bases for the proposed activities. The Chulalongkorn members of the team conducted a primary interview of

one of the teachers of the Baan Na Yao School, Ajarn Wimol Suwannasom. From this interview, we were able to gather basic recommendations and comments. This interview is summarized in Appendix A. The key points in her suggestions for the laboratory activities were to make them simple, challenging, and interesting for the students but to also keep cost and availability of materials in mind.

The project team decided on six activities, two from each subject, to be presented to the Office of H.R.H. Princess Maha Chakri Sirindhorn's Projects. The activities selected were:

Astronomy: Solar System

1. "Seasons Modeling"(Frede, 2008)
2. "What Kind of Shadow Can You Make?"(Denney, 2005)

Physics: Energy

1. "Gravity is a Hammer"(Hutton, 2009)
2. "Gravitational and Kinetic Ball"(Adams, Blyth, Halliday, Horner, & Wheaton, 2008)

Chemistry: Biomolecules

1. "Soil Testing"(U.S. Environmental Protection Agency, 2007)
2. "What's in my food?" (Ramapo High School, 2009)

These activities were adapted from existing researched activities which fit the key features of active teaching.

An official meeting was held at the Office of H.R.H. Princess Maha Chakri Sirindhorn's Project's with representatives of the Office and Baan Na Yao School as well as the entire project team to discuss the details of the project. At this meeting three of the six proposed activities were chosen for proposal at the Baan Na Yao School: "Seasons Modeling," "Gravity is a Hammer," and "What's in My Food?" A brief description of each developed activity is included in the section below titled Description of Developed Laboratory Activities. After discussing the goals of the project team and the team's project timeline the sponsor provided a budget for the project team to use to complete the project objectives. The timeline and budget are included in Appendix C and Appendix D respectively.

Tailoring of the Proposed Activities

The project team began developing relationships with the Baan Na Yao teachers and administrators on arrival at the school. As suggested by Professor Chrysanthe Demetry, an expert in the field of education, we ensured that the teachers understood that we were not there to evaluate or judge them but to aid them in creating new innovative activities for them to conduct with their students (interview notes can be seen in A3: Professor Chrysanthe Demetry) (Demetry, 2009). We developed trusting relationships with the teachers in order to gain meaningful input from them to design the laboratory activities. The teachers knew the students in their classrooms and they were one of the best tools to understand which approaches may or may not have worked well for these activities. The team continued to connect with the teachers through meetings, classroom observations, and social interactions outside of the classroom. These connections allowed us to gain insight on how classes were conducted at the Baan Na Yao School and helped us tailor the activities better to the needs of the school.

Language and cultural barriers inhibited the fostering of relationships between the teachers of the Baan Na Yao School and the WPI members of the project team. To overcome this language barrier, the WPI members of the team made efforts to learn Thai and strove to be somewhat competent in the language. The Chulalongkorn members of the team aided in verbal and written communication between the WPI team members and Na Yao people. To overcome the cultural barrier, WPI members of the project team observed the Thai customs and culture so that we would not accidentally offend any member of the Na Yao community. The entire project team participated in cross-cultural exchanges such as dance, cooking, and sports throughout our time at the Baan Na Yao School. These interactions helped build understanding and positive relationships between the Na Yao people and the project team.

The support of teachers is important in changing classroom activities or structure as described in the Teacher Education background section. The project team set up a focus group at the convenience of the science teachers to discuss each proposed activity and to make adjustments as necessary. The focus group included teachers of the classes for which the laboratory activities were developed, the members of the project team, and the Baan Na Yao School biology teacher. The team had developed three activities for proposal to the teachers. These include “Seasons Modeling”, “Gravity is a Hammer”, and “What’s in My Food?”. The biology teacher was included because she wanted an activity designed for her class as well. A

background, materials list, procedure, and pre and post tests were presented to the teachers at the meeting. The manuals are included in as a supplement to this report. At the start of the focus group we conveyed the team's purposes for bringing interactive science laboratory activities to the Baan Na Yao School.

This focus group created an accepting and open atmosphere so that the teachers felt comfortable enough to thoughtfully answer and discuss questions posed by the project team. Because the teachers were not comfortable with discussing in English, the Chulalongkorn members of the team acted as facilitators of the discussion. The facilitators encouraged different opinions and ideas on a set of questions. In order to successfully do this; the questions were concise, clear, open-ended, and non-threatening. In particular we addressed the following topics through a list of developed questions as seen in Appendix E:

- Current classroom and laboratory activity structure
- Students' engagement in the classroom
- Views about hands-on activities
- Laboratory Activities' connection to the Baan Na Yao curriculum, grade level, and to the students' daily lives
- Supplies and equipment available for laboratory activities
- Preference of the developed activities
- Addition of a biology laboratory activity which the biology teacher requested.

The facilitator strove for the most complete discussion by asking answer promoting questions such as: "can you talk more about that?", "can you help me understand what you mean?", and "can you give an example?".

The information from the focus group was transcribed and analyzed. The major themes and details discussed in the focus group were noted and organized in a Microsoft Excel Spread Sheet for easy analysis. These results are included in Table 2: Focus Group Results. The project team interpreted each answer and considered how it would affect the project.

Table 2: Focus Group Results

Questions	Teacher Responses				Interpretation and effects			
	Physics	Astronomy	Chemistry	Biology	Physics	Astronomy	Chemistry	Biology
How long have you been teaching or living at the Baan Na Yao School?	teaching and living at Na Yao for 9 months	Teaching and living at Na Yao 4yrs 5 months	Teaching and living at Na Yao for 6 months	Teaching and living at Na Yao for 2 months	Teachers typically do not remain at the school for a long period of time but there does not seem to be a reason why. The astronomy teacher has been here the longest and will be knowledgeable and influential within the school			
What do you enjoy most about teacher?	They want to pass on their knowledge in their respective fields to the students so that the students can apply it to their daily lives. They enjoy working with the students and aim to instill good morals to help the students grow up to be good people.				It is helpful that they have a positive atitude towards teaching. This aligns well with the goals we set forth for the project and will make implementation of the activities easier.			
How do you run your classroom?	They teach according to the schedule that they are given. Students take at least one period of science a day.				This means that the schedule is important to them and we have to align our work to fit that schedule.			
How often do you have a lab class?	They only conduct laboratory activities 2 or 3 times a semester.				The teachers seemed eager to add more activities so that they could preform them more often. They know that the students like doing these kind of activities so it excites them that the students will have more activities that they will enjoy.			
How engaged are the students in the classroom?	The students like to do laboratory activities but the teachers do not have many laboratory activity for the students to do.				This again reemphasisses the previous point that the teachers are excited about the group being here and developing new activities for the students to perform.			
What type of activities seem to engage the students the most?	They like doing hands on outdoor activities and enjoy challenges. They want to learn more about the microscope. They seem very interested in science and have already been asking about science topics.				The students are motivated to learn about their world and the enviornment around them. They are very intrested in science. Most of the students seem ambitious and want to continue on to universities.			
How do you feel about hands on activities in the classroom?	The teachers see it as an opportunity for the students to have a chance to do more laboratory activities. They feel that the laboratory activities are very useful.				Same conclusions drawn above.			
What kind of activity are you looking for?	Physics-The proposed activity is fine. Make sure to vary the weight and height.				Each activity will be adapted according to the teachers requirements.			
	Astronomy-The activity that we proposed is good because the students have not learned how to do modeling. This would help with that skill							
	Chemistry-the activity we proposed because the students like reactions that are changing colors and it fits into the lesson plan that they are studying right now.							
	Biology-It would be nice if we could come up with an activity involving microscopes and photosynthesis.							

In order to tailor the activities to be relevant to the students' daily lives the project team needed to gather information from them as well. We asked about information that pertained to the culture and industry of the village and extracurricular activities the students were interested in. In order to obtain this information we interacted with the students inside and outside of school through classroom observation, casual interactions, basketball, cooking classes, and trips with the teachers and students. The gathered information was used in the further design and tailoring of the proposed activities. Table 3 shows the specific information gathered which was relevant to the design of each activity listed side by side with the corresponding tailoring.

Table 3: Gathered Information Relevant to Designed Activities and Corresponding Tailoring

Astronomy	
"Seasons Modeling"	
Gathered Information	*How the activity was tailored*
Classrooms are extremely bright	The model was altered to include a box around the earth to block out stray light
Small plastic soccer balls can be used to represent the earth	A partnership was made with the art teacher to prepare materials
Physics	
"Gravity is a Hammer"	
Gathered Information	*How the activity was tailored*
Wood is not cost effective for this activity in the Na Yao area	Oasis foam is an affordable and locally available alternative
Standard weights for laboratory use are not available	Recycled empty water bottles are readily available and serve as adjustable weights for the activity.
Chemistry	
"What's in My Food" & "Precipitation Reactions"	
Gathered Information	*How the activity was tailored*
Students eat eggs, rice, candy, peanuts, oranges, green vegetables, and carrots regularly	These foods were incorporated into the activity
The school did not have needed chemicals in stock	The chemicals were ordered by the project team
Chemistry supplies are limited and rarely used	The team examined and cleaned all of the equipment and materials which would be used in the experiment
Biology	
"Colors of Sunlight"	
Gathered Information	*How the activity was tailored*
Biology teacher requested an activity on photosynthesis	A new activity was developed to examine the effect of filtered sunlight on plant growth
Available microscopes are limited and broken	Activity was developed on observations not requiring a microscope

A crucial step in the design of these activities was to verify that they work properly. A study conducted by a team of WPI students working in a London project center investigated the problems associated with designing laboratory activities. One common issue that they found was that "there were significant problems with each activity's materials and instructions" (Hegarty et al., 2009; Hegarty, Hitchcock, Lafleche, & Warner, 2009). It was important that our activities were reviewed and tested to avoid problems with materials and clarity of instruction before they were passed on to the teachers to conduct in their classrooms. The team tested each laboratory activity exercise with the exact setup and materials which were used by the students to verify that the experiment works properly.

Meetings were set up at the convenience of each teacher to demonstrate and explain the tailored science laboratory activities. The project team supplied a background of "Need to Know" information on each activity before demonstrating the laboratory procedures. The teachers were encouraged to conduct each step of the activity so that they understood the process and possible outcomes of the experiments. It was important that the teachers be comfortable with teaching the activities so that they are more likely to continue using them after the project team had left the site.

Throughout the instruction of the science laboratory activities the project team kept in mind the following criteria for further tailoring:

- Laboratory activities' connection to the Baan Na Yao curriculum, grade level, and to the students' daily lives
- Clarity of laboratory procedures
- Clarity and degree of difficulty of worksheets
- Suggestions on improving the experiments

During the meeting with the chemistry teacher, she requested that the project team develop a second more difficult chemistry activity for her advanced students. The project team took her suggestions and developed an additional chemistry activity entitled "Precipitation Reactions." This laboratory activity is included in the attached laboratory manuals.

In addition to encouraging the teachers to collaborate and run through the activities themselves, if possible, we suggested that the teachers taught the activities to a small number of

students while we were present to assist if necessary. This gave the teachers more confidence when conducting the laboratory activities with an entire classroom and allowed the project team an opportunity to make observations during the instruction of the laboratory activities which aided in the development of the final manuals.

The activities were altered from the generic versions initially researched in order to fit into the curriculum of the Baan Na Yao School while being as simple, engaging, and informative as possible. These alterations included the use of locally available materials and the adjustment of activities so that they related to the students' lives. Teacher and student concerns or additional input voiced at any stage of the project was used to continuously tailor the designed laboratory activities.

Evaluation of the Success of Each Lesson Through Implementation of the Laboratory Activities

A general outline for each activity is listed below:

1. Pre-opinion survey
2. Background of "Need to Know" information
3. Pre test
4. Procedure
5. Post test discussion
6. Post test
7. Post-opinion survey

The first step in implementing and evaluating the laboratory activities was to conduct a preliminary survey to evaluate the students' opinions and attitudes towards science. The survey included four Likert scale questions for the pre-opinion survey and five Likert scale questions for the post-opinion survey as well as two multiple choice questions in each and a few additional short answer questions. The scale includes five different options for the students to choose from including: strongly disagree, disagree, neutral, agree, and strongly agree (Mogey, 1999). This survey is included in Appendix E.

We have taken into consideration the findings of previous WPI education projects in Thailand which found that students often copied their peers when asked to articulate their thoughts (Amendolare, Briskey, LaGoy, Largesse, & Orme-Johnson, 2008; Whitten-Kassner, Patrick, Okumura, & Colangelo, 2009). The project team encouraged the teachers at the Baan

Na Yao School to have the students express their own thoughts and ideas while taking our surveys.

Before the students performed the laboratory activity the teacher provided background information on the subject matter. This included a lecture by the teacher and a discussion in which the students were encouraged to asked questions.

After the background discussion a worksheet was distributed to the students to serve as a preliminary evaluation. This 'pre test' tested the students' knowledge on the subject matter. The pre test contained a few short answer questions, true or false, or multiple choice questions most of which were easily answerable, a few which were harder to answer, and one question that the students should not have been able to answer. The one temporarily unanswerable question as suggested by Professor William Clark, of Worcester Polytechnic Institute, was used as a way to keep the students actively thinking throughout the experiment. This question would be answerable upon completion of the activity (Clark, 2009). This suggestion was obtained through an interview with Professor Clark, the notes of which can be seen in Appendix A.

After completion of the pre test the teacher distributed and explained the laboratory procedure to the students to allow them the opportunity to ask any clarifying questions. The Baan Na Yao teachers conducted the laboratory activities independently from the project team. The Thai members of the team were available for assistance when needed. The laboratory activities were conducted in this manner so that in the future teachers would be able to conduct them on their own. "Clinical research can be influenced by many factors that are capable of invalidating results, and one of these factors is known as the Hawthorne effect: the mere awareness of being under observation can alter the way in which a person behaves (De Amici, Klersy, Ramajoli, Brustia, & Politi, 2000)." Through discussion with the three previous IQP teams that had similar projects to this, we learned that direct assistance from the team members in the classroom affected the students' interactions and performance. It was also noted that the teachers tended to use the project team as assistant teachers. This was avoided by the initial clarification that the project team was there to teach the teachers, not the students. The Chulalongkorn students observed how the Baan Na Yao students were progressing, their interactions with each other, and their interactions with the teachers. The problems the teachers and students encountered and problems with the laboratory procedures were noted for consideration in the final lab manuals.

After the laboratory activity was completed the teacher distributed the post test and then the post-opinion survey (included in Appendix E) to the students. We compared the science opinion surveys to determine if the students' opinions on science had changed. The post test handout posed the previously unanswerable question. Having completed the laboratory activity, the students should have been able to answer this question. In addition to this other questions were asked to determine the students understanding of the concepts of the laboratory activity. These questions required problem solving using these concepts. The pre and post test questions are included in each laboratory activity in the developed manuals.

The Chulalongkorn members of the project team met with each of the teachers to discuss the outcome of the laboratory activities. The topics of this discussion included the students' increased knowledge from the activities and student engagement and group dynamics. The project team gave the teachers a Likert scale and short answer question survey to assess their opinions and feedback on the laboratory activities. This survey is included in Appendix E and the results from these surveys are included in Appendix F. The meetings with and surveys of the teachers helped the team determine the success of the activities. The success of the activities was defined as both an increase in student knowledge and engagement and a high level of teacher confidence in teaching the designed activities using active teaching methods. The data collected from these observations was also used to evaluate the feasibility of the activities' sustainment in future years as well as the ability to have the activity spread to other schools.

Dissemination of the Knowledge of the Laboratory Activities

Dissemination of the designed laboratory activities and active teaching methods will allow not only the Baan Na Yao School to reap the benefits of the project but will allow other schools in Thailand to benefit as well. Dissemination of the project occurred through the following means: the teachers of the Baan Na Yao School, an open science fair, and laboratory manuals.

Teachers are the most important part in making this project sustainable as well as the greatest tool in dissemination of the information about the laboratory activities we have developed. The team observed that the teachers of the Baan Na Yao School enjoyed teaching and understood the laboratory activities that the team had put together. The activities will be used again if they are viewed and reviewed positively. Teachers from other schools are more

likely to use activities in their classrooms when the suggested activities come from a fellow teacher who is also a knowledgeable and respected figure in the education field.

The project team organized the open science fair in coordination with the teachers and students of the Baan Na Yao School. The fair served as a means to introduce the community to what the project team had done in the school as well as showcase the school to the community. It was also an opportunity for the teachers and students to demonstrate what they had learned from our activities. The fair also helped to demonstrate the merits of the laboratory activities to students and teachers of the Prathom school that attended the fair. The objective of this fair is best summarized in Sumpan Patumthanaruk's, the School Director's, words as he explained that he "wants other schools to know this school is doing these activities so that they can use them in their curriculum."

The fair was set up in such a way that was both informative and interactive. The project team, teachers, and students set up the five developed laboratory activities as well as miniature demonstrations that reinforce the lessons learned in the laboratory activities and reinforce how they work. This advanced the goal of dissemination because it facilitated teacher-teacher interactions where the focus of these interactions was on the laboratories presented and the experience the Baan Na Yao teachers had using these experiments in their classrooms.

Teacher and Student manuals were developed by the project team and are included as a supplement to this report. The teacher's manual contains all of the content which is included in the student manual as well as answer keys to pre and post test activities and specific teacher instructions. For each activity there is brief background describing the basic scientific concepts behind each activity and a detailed materials list laying out all the equipment and materials needed for each experiment. A detailed procedure section is included as well. Pictures are also included as visual aids to accompany each section of the manual where appropriate. The team translated the manuals with an online translator and the Chulalongkorn members of the team fixed translation errors. The manuals were presented to The Office of H.R.H. Maha Chakri Sirindhorn's Projects in order to be made available to schools throughout Thailand.

Description of Developed Laboratory Activities

The activities developed through this project are included as a supplement to this report in teacher and student manuals. The specific activities selected for design for the Baan Na Yao School were:

- **"Seasons Modeling"-** An astronomy activity for Matthayom 6 (12^{th} grade)
- **"Gravity is a Hammer"-** A physics activity for Matthayom 5 (11^{th} grade)
- **"What's in My Food?"-** A chemistry activity for Matthayom 4 (10^{th} grade)
- **"Precipitation Reaction"-** A chemistry activity for Matthayom 4 (10^{th} grade)
- **"Colors of the Sun"-** A biology activity for Matthayom 5 (11^{th} Grade)

The **"Seasons Modeling"** laboratory activity was designed to aid students in understanding what causes seasons, in their village and around the world. In small groups, students test four hypotheses on what cause seasons. A model was designed to represent the Earth and sun which the students use to discuss each hypothesis. Through these discussions the students are able to determine the accepted hypothesis. This activity promotes group work, hypothesizing, visualization, and analytical problem solving skills.

The **"Gravity is a Hammer"** laboratory activity was designed to explore the concepts of work, friction, and potential and kinetic energy. Manual labor is common in these students' daily lives, this laboratory activity aids in understanding how to optimize work done. This activity allows students to test the work done on a nail by dropping different weights from different heights. Students work in small groups to test a specific weight and drop height and then compare their findings with the other groups. This activity promotes group work, critical thinking, and analytical problem solving skills.

The **"What's in My Food?"** laboratory activity was designed to aid students in understanding the nutrients present in their daily diets. Students learned about simple and complex carbohydrates, proteins, and lipids. In groups they test a list of commonly eaten foods for each of these nutrients. By understanding how the body uses each nutrient and what foods contain each nutrient, the students will be able to better choose what they eat on a daily basis. This activity promotes group work, critical thinking, and laboratory skills using equipment and chemicals.

The "**Precipitation Reaction"** laboratory activity was designed to explore the concept of double replacement reactions. Through this laboratory activity students individually perform precipitation reactions and analyze the results. This laboratory activity was specifically recommended by the chemistry teacher as an activity for her advanced class. This activity promotes group work, critical thinking, analytical problem solving skills, and laboratory skills using equipment and chemicals. This particular activity was not conducted in a classroom while the project team was at the Na Yao village because of time constraints.

The "**Colors of the Sun**" laboratory activity was designed to explore the concepts of light waves and photosynthesis. The biology teacher noted photosynthesis as a specific topic of interest to her students and in a largely agricultural community photosynthesis is particularly relevant. This laboratory activity takes several weeks but allows students to observe the effects of sunlight on bean plant growth. The students plant four pots of bean seeds and place one pot in the sunlight, one in the dark, one in the sunlight covered with green tissue paper, and one pot in the sunlight covered with red tissue paper. Over the three weeks the students take care of these plants, note observations on appearance, and measure growth. After the three weeks the students analyze their observations and data to understand the effects of sunlight on plant growth. This activity was designed to promote group work, observation, and critical thinking skills. This particular activity was not conducted in a classroom while the project team was at the Na Yao village because of time constraints.

Findings and Analysis

This portion of our report presents the findings and analysis of our work done at the Baan Na Yao School. This section evaluates the successes and short comings of the project. The detailed findings from the pre and post opinion surveys and tests can be seen in Appendix F.

Overall Findings on Laboratory Activities

The overall findings described below apply to the "Seasons Modeling", "Gravity is a Hammer", and "What's in My Food?" laboratory activities and show the major successes of and problems encountered during this project.

Teachers embraced the laboratory activities and active teaching methods. The teachers saw the benefits of performing the laboratory activities in the classroom which used active teaching methods. The teachers viewed the pre and post tests as useful because they could track the progress of their students by comparing the tests. It is clear that the teachers embraced these activities because they plan on using the activities and active teaching methods in years to come. The Likert Scale portion of the teacher post-opinion surveys showed that every teacher agrees that they would consider using these activities again next year. The physics teacher explained that "This method [active teaching and laboratory activities] can be applied to different topics and other subjects as well."

The students were engaged throughout each activity. The project team observed that the students worked well in groups which kept them focused on the tasks at hand. The students enjoyed discussion which caused them to be more attentive throughout the laboratory activity so that they would not miss any details thus allowing them to have a more intelligent discussion about the results.

Laboratory activities are effective when they are at the appropriate difficulty level for the students. Students are not interested in activities that involve concepts which are not analytically challenging. The chemistry teacher expressed this when she requested an additional, more advanced laboratory activity for her advanced students during the meeting to teach her the activity "What's in My Food?". On the other hand, when an activity is too difficult for students, the students are not able to connect the scientific concepts to the observations of the activity. For classes where this was an issue, the teachers decided not to use the activity altogether. This was the case in the designed physics activity. The teacher decided to use the activity with only his

track 1 class because he felt that the activity was too difficult for the students in tracks 2 or 3. The project team recognized that to ensure the sustainment of a laboratory activity it is necessary to align the activity with the abilities of the students.

Students commonly copy each others' work. The team noticed that students copied each other on pre and post tests because there were groupings of students having identical answers. This was especially apparent on the physics pre and post tests where most of the students had the exact same answers. One major reason the students copied each other was that they were not graded on the activities so there was less incentive to do the work on their own. Another reason the students copied one another is that they did not understand the question asked or did not know the answer. If they knew someone who had answered the question they could easily copy that student who would willingly share their answers. The copying affected many of our results and made it difficult to assess whether or not the students gained understanding of the concepts during the laboratory activities.

The laboratory activities increased student interest in science. This is made clear by the results of the pre and post opinion surveys. There is a clear increase in the number of students that said that they had a greater interest in science. A graph of this increase can be seen below in Figure 7.

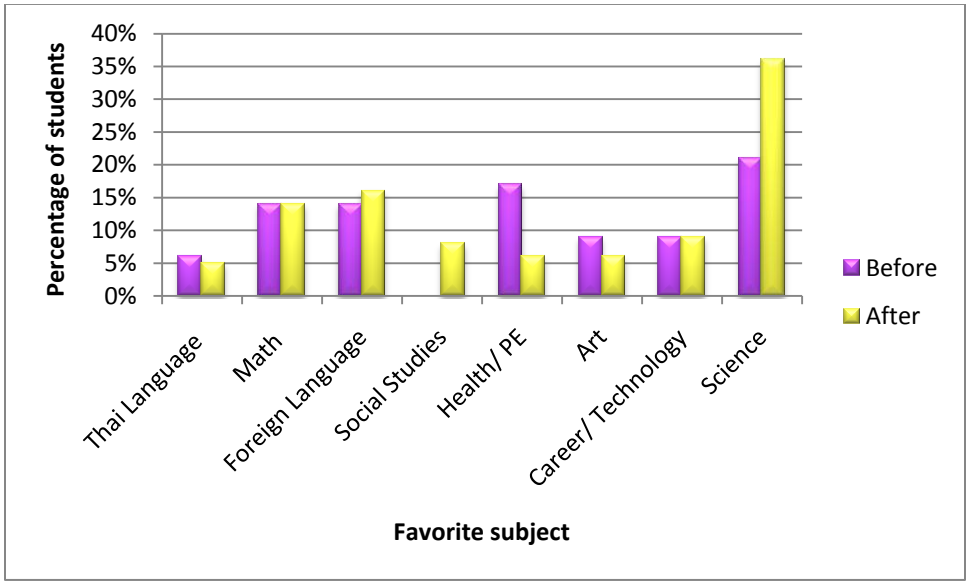

Figure 7: Pre and Post Opinion Survey, "What is your favorite subject?"

Assessment of the Needs of the Baan Na Yao School

The top priority upon arrival to the Na Yao village was to gather information on the teachers, students, and school that would be used in tailoring the laboratory activities. Our findings are as follows.

The Baan Na Yao teachers were not comfortable expressing their opinions on the presented laboratory activities. During the focus group all the teachers expressed that they liked the activities that were presented and made few comments, besides material changes, on how they could be altered to the needs of the school and students. The summarized analysis of the focus group results are shown in the Methodology section of this report in Table 2: Focus Group Results.

It was difficult to receive input or constructive criticism on the activities presented because we had not yet built trusting relationships with the teachers. Building trusting relationships was particularly important for these teachers because before they felt comfortable with us they expressed agreement whether or not they truly wanted to. This was a factor because of the non confrontational nature of Thai people. It took time for the project team to build the trust needed to receive the teachers honest input on the activities considering there relevancy to their classrooms and students. Input from teachers is crucial in tailoring activities for a particular school therefore partnering with teacher is essential. Thus, it was important for us to make every effort to connect with the teachers of the Baan Na Yao School.

Teachers have very little spare time. The project team observed that the teachers of the Baan Na Yao School teach from 7:30 in the morning until 4:30 in the afternoon. In addition to their full class schedule some teachers have families and other personal obligations which require their attention. The teachers also dedicate some of their spare time to extracurricular activities related to the school such as facilitating Scout Camp events, athletics, and performing arts. This leaves the teachers with very little time to devote to development of new educational activities.

Students are committed to the Baan Na Yao School. The project team observed the students' commitment to the school on a daily basis. Every morning on arrival to school, students picked up trash, swept classrooms, and lined up for the morning assembly. Freshman students cooked lunch for the school and many students helped with maintenance around the school. In addition, students voluntarily stayed after class to help around the school, caring for

the fish and chickens and working in the rice fields and herb garden. This commitment was not only shown for the school facilities but also for the teachers and director. Students greeted their teachers with the respectful wai and followed direction well. From this respect for the school and teachers, we were assured that the students would respect our project and our presence at the school.

Many students have a sincere interest in continuing education. Most of the students have a positive attitude towards learning and believe that it can help their future. This can be seen on the pre-opinion surveys where the students indicated what they wanted to do after leaving the Baan Na Yao School. The pie chart below (Figure 8) shows the results of those who wanted to continue studying versus those who did not want to continue studying.

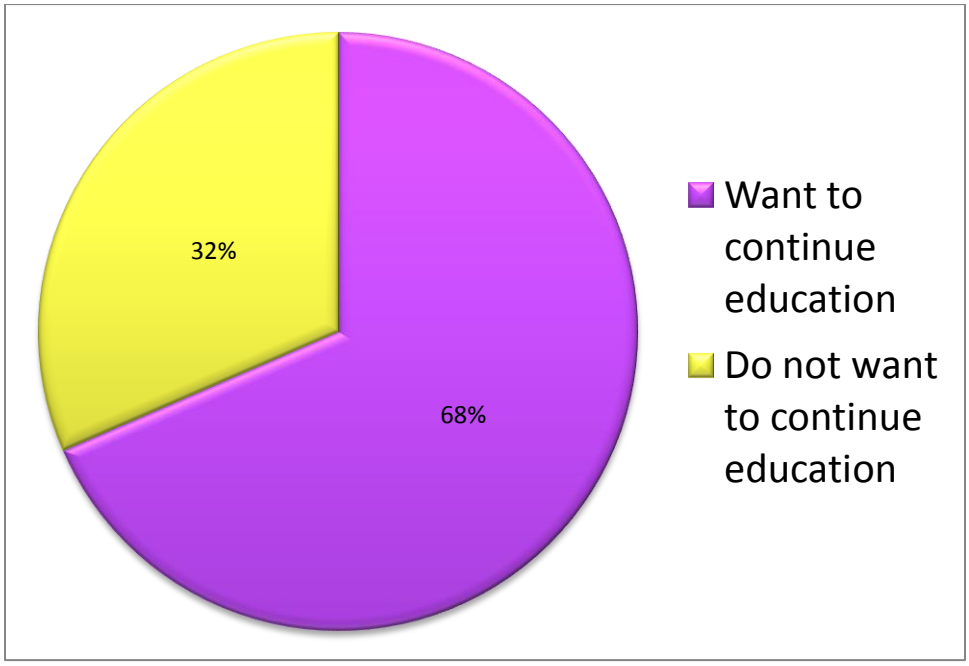

Figure 8: Opinion Survey Results- Students who want to continue education versus those who do not.

The students enjoy hands-on outdoor activities. The Baan Na Yao School teachers regularly use the school's extensive outdoor educational facilities as part of their class curriculum. All of the outdoor activities require student involvement as seen in the example in Figure 9. The participation in the outdoor activities was observed to be significantly higher than in the indoor lectures. Students verbally expressed their excitement for this chemistry activity involving water purification in one of the school ponds and for physics activities which utilize

the outdoor rice huskers and fish lever arm. The outdoor facilities are covered in posters of what the students have learned from the outdoor activities. The excitement and engagement during these activities illustrates the students' interest in education when taught through active teaching methods.

Figure 9: Photographs of the Outdoor Education Activities at the Baan Na Yao School

Current classroom activities are limited to teacher lectures. While observing classroom lectures we noticed that many students did not participate and some slept on their desks. Some students would not attend class at all when the teachers lectured. Some expressed that concepts were more difficult to understand when presented through lectures than when incorporated into activities. The lectures did not excite the students or stimulate their desire to learn science. By considering the student engagement in hands-on outdoor activities we concluded that hands-on indoor activities had the potential to increase student engagement in the classroom.

Evaluation of the success of laboratory activities

Observations, pre and post opinion surveys and tests, and teacher surveys and conversations were used to analyze the activities and their effects on the teachers and students. This analysis showed that the activities were overall a success because they increased student interest in science and were embraced by the teachers.

"Seasons Modeling"

The astronomy activity brought new media into the classroom and allowed students the opportunity to participate in a hands-on activity. This activity allowed the teacher to use active teaching methods and engaged the students in an interactive experiment which required critical thinking, group work, and discussion. The astronomy activity was the first experiment which

was conducted in the classroom and served as a building block for the activities to follow. Flaws in the design of the student procedure and pre and post tests were analyzed and considered in the tailoring of the physics, biology and chemistry activities.

Students showed an increased interest in science. In the Matthayom 6 track 1 astronomy class (6-1) an additional 48% of the eight students listed science as their favorite subject on the survey following the activity as compared to the initial survey. In the 6-2 class 21% of the sixteen students listed science as their favorite subject on the post-opinion survey as compared to 6% on the initial survey. These percentages are illustrated in the pie charts below in Figure 10 & Figure 11 respectively. This increase shows that the astronomy activity positively affected student interest in the subject of science.

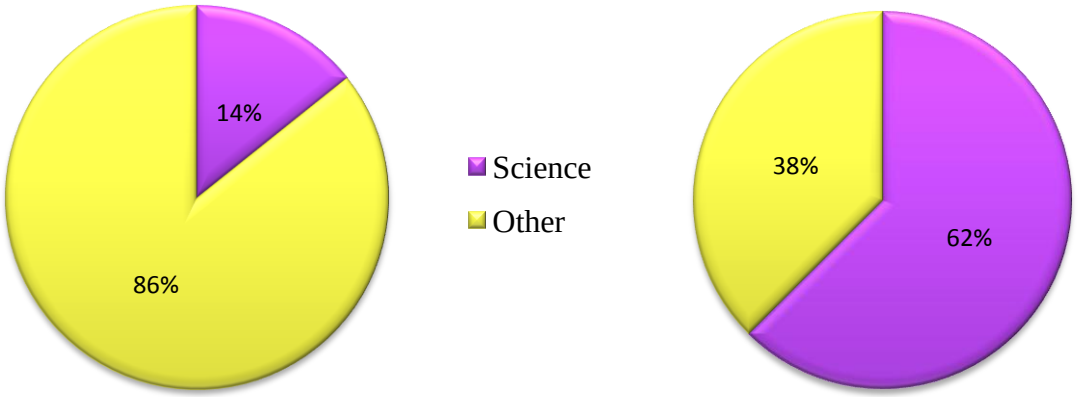

Figure 10: Astronomy class 1 Opinion survey results, *"What is your favorite subject?"* Before and After

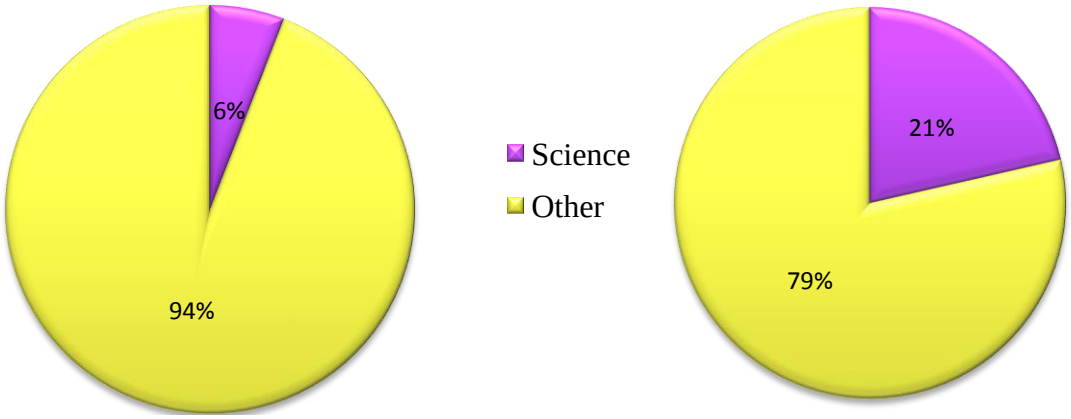

Figure 11: Astronomy class 2 Opinion survey results, *"What is your favorite subject?"* Before and After

Students enjoyed elements of active teaching. The key aspects of the active teaching methods included in the astronomy experiment were group work, discussion, hands-on interaction and critical thinking. Students pointed out many of these aspects when asked to list what they liked about the activities on the post-opinion surveys. They specifically noted "brainstorming and discussion" and "working in a group." This positive open-ended response shows that active teaching methods were successfully implemented because the students were able to identify these aspects without knowing that we specifically planned for these methods to be utilized.

The designed pre and post tests were difficult to compare. The teacher commented on the post-opinion survey that the questions were unclear. This confused the students and affected the test results. The pre and post tests had different difficulty levels as well which was clear in the comparison of the scores. The pre and post tests were also designed using different question formats. Because the test questions were not easily compared, it was difficult to gauge how much the students had learned. This limited the ability to measure the activity's success in educating the students on the concept of seasons. This finding aided the team in creating pre and post tests for the other activities by showing the importance of being able to compare the tests.

Students have a better understanding of astronomy concepts after conducting this laboratory activity. Though the pre and post tests were difficult to compare the results still

show an increase in student understanding. Table 4 summarizes the pre and post test scores for the 6-1 and 6-2 classes.

Table 4: Astronomy Class Pre and Post Tests

Class	Pre test	Post Test	**Percent Increase**
6-1	71%	69%	**-2%**
6-2	59%	70%	**11%**

The average score in the 6-1 class did not significantly change. Even though the score did not improve, the class gained increased knowledge of the astronomy concept because they performed equally on the more difficult test. The table shows that in the 6-2 class the average score increased by 11% despite the higher difficulty level of the post test. The scores on the pre and post tests show that the astronomy activity directly increased student understanding of the science concepts.

The tailored model added confusion to laboratory observations. Initially, the laboratory activity was intended to be run in a dark classroom using a light bulb to represent the sun. This would allow for the model earth to freely move around the light source without interference. The classrooms at the Baan Na Yao School were unable to meet the necessary level of darkness for the laboratory activity to be run as planned. To compensate, the activity was adapted to include a box around the model earth and directional flashlights to be used as a light source. The astronomy teacher pointed out on the post-opinion teacher survey that the model could not show how the earth orbits the sun. The inhibited model was unable to clearly represent the earth in every position around the model sun and forced more mental visualization to observation than intended. This finding may not occur in all rural schools, as some may have facilities which can block out sunlight more effectively.

The student procedure was confusing. In the 6-1 and 6-2 classes there were four and three students respectively who found the laboratory procedure to be unclear. Some described their difficulty as "confusion" or "trouble understanding the media." This confusion was also noted by the astronomy teacher. She felt that the light source was not bright enough to produce the desired effect, and the model was restricted because the student's had to hold the earth with

their hands to represent the tilt. These comments show that the model was difficult for the students to use and it should be better explained in the procedure.

Students enjoyed hands-on activities. The astronomy model gave the students a chance to physically manipulate a model instead of watching the teacher demonstrate. This was exciting for the students because they rarely have the opportunity to participate in hands-on classroom activities. On the post-opinion survey one student pointed out that she liked the activity because "I got to experiment by myself rather than study from the black board." Another student pointed out that everybody in the large class, of sixteen students, was involved in the activity. This shows that the model was embraced by the students, and that the majority of the class was engaged in the experiment. On the teacher post-opinion survey, the astronomy teacher agreed with the statements that her students were more engaged than normal and that they better understood the material as a result of this activity. These teacher and student opinions show that the astronomy experiment succeeded in engaging the students.

Evaluation of the Success of "Seasons Modeling"

The "Seasons Modeling" activity fulfilled all of the laboratory activity criteria set forth in the project goal. In particular, this activity was **hands-on** and **interactive** as each student was able to use the model and participate actively in discussion when hypothesizing. Through discussion with the astronomy teacher we found that she liked having a new media to use in the classroom. She also noted that the materials were **inexpensive** as most of the materials came from recycled sources.

Both the teacher and students found the wording of some questions on the pre and post test to be difficult. The students found parts of the instruction confusing especially pertaining to the modeling of each hypothesis. The teacher found some of the materials to be restricting. Also the pre and post tests were difficult to compare because of their dissimilarities. These problems were addressed for the final laboratory manuals. Some questions were removed, others were made more clear, and the pre and post tests were made more comparable. Careful instruction was added to the procedure on how each hypothesis should be modeled. It was noted that a box is not necessary if a room that is sufficiently dark can be used for the experiment.

The physics laboratory activity was embraced by both the teachers and students in the classroom. This success increases the likelihood of the activity's sustainment. The experiment engaged the students in a hands-on activity which required them to think critically and analyze their data. Our findings show that students had the most trouble with the analysis step of the experiment which shows their inexperience in solving abstract problems. This activity has aided the teacher in implementing active teaching methods into the classroom. More activities like this one can be integrated throughout the curriculum to help further build analytical problem solving skills.

Students showed increase interest in experiments. In the track 1 class (5-1) an additional 11% of the thirteen students listed experiments as their favorite subject in school after completing the laboratory activity as shown in Figure 12.

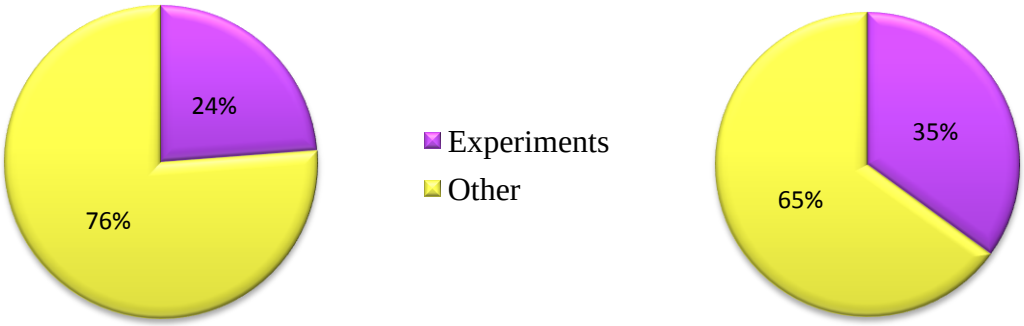

Figure 12: Physics class 5-1 Opinion survey results, "*What is your favorite type of activity in school?*" Before and After

The students pointed out specific reasons that they enjoyed the activities on the post-opinion surveys. Many students noted that they liked working in groups and the problem solving involved in the activity. This shows that those aspects of the activity worked effectively to engage the students in the experiment.

Students have a better understanding of physics concepts after conducting this laboratory activity. The physics teacher noted in the post-opinion survey that "this activity helped the students to understand the topic more than a lecture would have." The students reported the same feelings in their opinions surveys. Each of the 13 students who took the survey either agreed or strongly agreed that they have a better understanding of the physics

concepts as a result of the "Gravity is a Hammer" Activity. This finding is an indicator of the success of the activity because it shows the strong educational value fostered by the experiment.

The amount of work for each group in the class was uneven. There were mixed results in the post-opinion survey related to time; one student claimed that the experiment was too short while others complained that they did not have enough time to finish. This was a result of the varied drop heights and weights based off assigned variables which caused a discrepancy in the number of trials each group needed to conduct. The groups with more trials also needed to do more calculations which further slowed them down. This problem has been considered in the tailoring of the activity for the final laboratory manual.

Some students did not fully complete the post test. 12 post tests were turned in for the physics experiment. Only one question on the post test was answered incorrectly on any paper turned in. 5 of the 12 students left that question incomplete while the 7 students who were correct clearly copied each other. The question that caused a problem was one which required them to sketch and analyze a simple graph of the data collected in the experiment. From review of the tests it is clear that those 5 students simply drew an incoherent graph and wrote no explanation of its meaning. Through discussion with many students in all levels of the school, the team gathered that students would prefer to leave a question incomplete than to get the answer wrong. This shows that at least 5 of 12 students were uncomfortable with the amount of analysis required to interpret a graph. This is not necessarily a limitation of the physics activity but is more so an indicator that students are not comfortable with this type of analysis. The transition to problem solving from rote formula memorization may have been too abrupt for the students in this class so they made no attempt to answer the question.

The physics teacher embraces the importance of active teaching methods. Through the overall responses on the post-opinion survey it is clear that the teacher embraced the activity. He stated that "this method [active teaching and laboratory activities] can be applied to different topics and other subjects as well." This shows that he understands active teaching methods and hopes to integrate the methods into the rest of the physics curriculum. This positive result increases the likelihood of sustainment of active teaching methods.

Evaluation of the Success of "Gravity is a Hammer"

The "Gravity is a Hammer" activity fulfilled all of the laboratory activity criteria set forth in the project goal. The students particularly enjoyed the group work and problem solving

involved in the laboratory activity which kept the students **engaged** throughout the experiment. The physics teacher noted the activity's **educational** value by expressing that it increased student understanding more than lecturing alone would have. Through the post teacher opinion survey it was determined that this laboratory activity was clearly **embraced by the physics teacher** as he stated "I would like to use similar activities for other topics".

Students had trouble with one specific question and said several other questions had unclear wording. The teacher also noted that there should be an option to use varied materials. The project team addressed these issues by clarifying the wording of the open ended questions. A few open-ended questions were changed into multiple choice questions because this format worked better for those questions. In the teacher preparation section a note was added to suggest other possible materials that could be used effectively in this laboratory activity.

"What's in My Food?"

The students in the chemistry class have a clear increased understanding of the nutrients in their foods as a result of the chemistry laboratory activity. This experiment also supported their laboratory skills in using testing equipment properly which was otherwise unused. The conduction of the activity and responses from the teacher showed the flexibility of the activity depending on the desired difficulty level and time constraints.

The chemistry activity supports student laboratory skills. The chemistry teacher commented on the post-opinion survey that the activity built the students' laboratory skills, and this was made clear from classroom observation as well. In testing the chemistry activity prior to implementation in the classroom, the project team discovered that much of the laboratory equipment had clearly not been used or cleaned properly for an extended time. It was clear that the students did not have regular opportunities to practice laboratory techniques. During the laboratory activity, the students had opportunities to use various chemistry apparatus and handle chemical solutions.

Students have a better understanding of chemistry concepts after conducting this laboratory activity. In comparing the pre and post tests for the chemistry activity, only the questions which were included in both tests were considered in scoring. the overall scores of the questions on the post tests did not increase significantly because the pre test scores were already high. There was however, a significant gain on one specific question which showed improved student understanding of the nutrients in their foods. This specific question was "What is your

favorite food that has a lot of simple carbohydrates?" The open ended nature forced the students to think about what they know about carbohydrates and relate it to the foods they eat. In the 5-1 class, half of the students got this question wrong on the pre test but all fourteen students answered correctly on the post test. The results of that question are included in Table 5 below.

Table 5: Chemistry Class Pre and Post Test Question *"What is your favorite food that has a lot of simple carbohydrates?"*

Class	Percentage Correct		Percent Increase
	Pre Test	Post Test	
5-1	50	100	50
4-2	100	100	0

The percent change in overall score on the questions repeated from the pre to post tests are summarized in Table 6 below.

Table 6: Chemistry Pre and Post Test Score Comparison

Class	Pre test	Post Test	**Percent Increase**
5-1	95.0%	92.3%	**-2.7%**
4-2	93.0%	95.4%	**2.4%**

This chart shows a maintaining and slight increase in the already high test scores. This shows that the students did improve despite the already high scores of the pre tests.

The laboratory procedure was not clear to all students. This finding is similar to one found in the astronomy activity. The teacher expressed in the post-opinion survey that the procedure was not clear enough for the students. One source of confusion for the students was a result of an unexpected last minute change in the procedure, which due to the lack of time was not included in the preliminary laboratory manual. This change specifically altered one step of the procedure. The overall procedure was clarified and the alteration was considered in the tailoring of the activity for the final laboratory manual.

The depth and scope of this activity is flexible. The chemistry teacher expressed in the post-opinion survey that she "liked all four [sections of the activity]." She did, however, request

that the activity include more sections and be made into a full report in which the students would hypothesis, analyze and draw conclusions. The team observed that her track 1 class completed the activity in only one 2 hour class period. The track 2 class needed three 1 hour class periods to conduct the activity though, and had lost focus by the end of the experiment. This shows that the activity could have been more effective for the track 2 class had only a select few of the four sections been conducted, and better for the higher level class had it been expanded on. The flexibility of the activity can be taken advantage of to relate it to varied levels and classes. This will be discussed in the teacher section of the final laboratory manual.

Evaluation of the Success of "What's in My Food"

The "What's in My Food" activity fulfilled all of the laboratory activity criteria set forth in the project goal. Materials for this activity were all **locally available** and the foods included in the experiment were typically part of the students' diets thus making the experiment **relevant** to the students' daily lives. The chemistry teacher especially liked this activity because it helped her students further develop their laboratory skills.

It was noted by the teacher in the post-opinion survey that the laboratory procedure was confusing in some sections. The students did not answer the question that required them to fill out a large chart on the post test which can be attributed to students not being comfortable with this type of question. The teacher also wanted to have students make predictions about results of the laboratory activity. In order to address these problems the project team made sure to use clearer wording in the procedure and the large chart was removed. In place of the chart two questions were added: one matching and one multiple choice. In the teacher preparation section a note was added to inform teachers that if desired they can lead a discussion about student predictions for what foods contain what nutrients.

Dissemination of Information Through an Open Science Fair

The open science fair was a success because it allowed teachers to showcase the activities we developed to teachers from a neighboring school and raised interest in science among primary school students.

Students happily attended the non-mandatory event. The project team observed that a majority of the students who regularly attended classes were present at the science fair. Almost all the students in attendance stayed through the entire event and seemed extremely excited to participate. After the fair we talked to a few students who expressed their enjoyment and stated that they were glad they had attended the fair.

Primary school students took a great interest in the presented activities. During the science fair the project team observed students from the primary school gathered around the various display boards for each activity showing great interest in reading about the activities and taking notes, as seen in Figure 13. After each activity we presented on the stage a number of trivia questions were asked for the students to answer about the information presented. The primary school students were extremely eager to answer the questions and got most of them corrected showing that they were attentive during the presentations and that they were interested in what was being presented. The fair presented the secondary school in a positive light. This will encourage the primary school students to continue onto secondary education.

Figure 13: Primary School Students at the Baan Na Yao Science Fair

The students who worked at the information booths at the science fair gained an increased understanding of the developed activities. The students who volunteered to describe the activities had to have a thorough understanding of the activities to answer any questions that were posed. This forced the volunteers to thoroughly understand the concepts so that they could explain the ideas to the younger students instead of just repeating memorized

facts that they were presented in the laboratory activity. This concept is explained in more detail in Appendix BB3: Subject Matter Research.

Limitations

Due to the nature of this project many of the findings are limited to opinions and non-quantifiable data. The observations made by the project team as well as those reported by the teachers and students have a bias which is difficult to control in analysis. This factor must be considered as a possible limitation in analyzing the findings of the project. These limitations are outlined below.

The students of the Baan Na Yao school are not an accurate representation of the general student population of the Na Yao area or of rural Thailand. The student findings are limited to those who already enjoyed science. The data we collected was only taken from students in tracks one and two classes who typically enjoy science more than those students in track three classes. Since the sample was not collected over the entire student body the data is skewed. The feedback does not give us the opinions and test results of student who do not enjoy science classes. In other schools they may not break up their students into different categories and therefore the classes would have a mix of those students who enjoyed science and those who did not.

Teachers gave most recommendations for activities *after* the activities were conducted. The teachers did not feel comfortable with us in the beginning of the project. This caused the teachers to feel anxious about giving honest recommendations on the activities. Most of the constructive recommendations on the activities were given by the teacher after the activities were conducted instead of before. This feedback would have been most practically used in tailoring prior to the conduction of the activities. We were not able to fully tailor the activities for conduction in the classroom because of the delayed feedback. The hindered tailoring process adversely affected the outcome of the laboratory activities.

Many students were unexpectedly absent from class. These absences caused a different number of students to be in class on pre and post test days which affected the results we obtained from the tests. Also missing the laboratory activity could cause a student to do worse on the post test which would negatively affect our results.

Conclusions and Recommendations

Based on the analysis of the project findings we developed a number of conclusions and corresponding recommendations. Listed below are the recommendations to future education research teams and to the Office of Her Royal Highness Princess Maha Chakri Sirindhorn's Projects. These recommendations present future project teams with a guide of strategies on how to design and implement new laboratory activities. These suggestions also serve as a tool for avoiding obstacles which may be encountered during education development projects. Recommendations directed to the Office of H.R.H Princess Maha Chakri Sirindhorn's Projects discuss the dissemination of our developed laboratory manuals and offer ideas for an alternative education project for the future.

Recommendations for Future Education Research Teams

1. **We recommend that future rural science education groups actively seek out opportunities to build relationships with the teachers in a social setting.** Open communication between members of the project team and the teachers of the Baan Na Yao School was inhibited during the initial phases of the tailoring process. Because of the limited time spent in the village the tailoring process was initiated before strong relationships were built with the teachers. Only after trust was built with the teachers, did they provide complete honest feedback on the developed activities. The building of these relationships with the teachers was driven mostly by interactions outside of regular work. We realized during our stay at the Baan Na Yao School that the best way to become comfortable with the teachers was by actively seeking out opportunities to mingle with them socially.

2. **We recommend that future education research teams allow ample time for the activity selection process**. It is important for the teachers to select the activities to be conducted in their classrooms. If the teachers are able to select an activity from a list of options, they will have greater ownership for the activities. This ownership would provide greater teacher confidence in conducting the activity in the classroom and positively affect the students' experience of the activity. Teacher ownership encourages the sustainment of the laboratory activities. Because of the rushed activity selection process the teachers of the Baan Na Yao School were not given the opportunity to select their activities. The teachers would have had greater confidence in the designed laboratory activities had the selection process been extended.

3. **We recommend that the design of any laboratory activity be flexible.** Flexible laboratory activities are easily tailored to target schools. The laboratory activities must be adapted to use local materials, equipment, and facilities, and must be at the appropriate difficulty level. Our tailoring process was facilitated by the flexibility built into the proposed activities.

4. **We recommend that future project teams design laboratory activities to have preparation which is short and simple.** The project team concluded that easy preparation was particularly important to the activities' sustainability. Teachers are very busy and do not always have time to set up elaborate laboratory materials. If the preparation time is short the activities are more likely to be conducted again.

5. **We recommend that all materials used in laboratory activities be locally available and inexpensive.** The project team concluded that the use of locally available materials was particularly important to the activities' sustainability. The teachers expressed that if the materials could not be obtained locally, they would not be able to use the activities in the following years. The most convenient materials were those that could be found around the school or adapted from recycled waste.

6. **We recommend that all materials developed for use in the classroom with teachers and students use simple wording and structure and avoid cliché.** Complex wording and sentence structure can cause confusion for both teachers and students. Translation of the laboratory material can also be complicated by unclear or complex wording. The project team found that laboratory materials that contain either intricate wording or cliché's are difficult to understand. This made performing the laboratory activities difficult for teachers and students.

7. **We recommend that future student evaluations include a variety of question formats.** Through analysis of each pre and post test we found that students were more confident and comfortable with multiple choice questions than open ended and analytical questions. The problem was resolved by including a mixture of multiple styles of questions. This mixture would cater to all the students so that they have the questions that they are comfortable with but are also challenged with a few that they are less comfortable with.

8. **We recommend that future project teams include a short proposal summary as a supplement to the larger document submitted to the project sponsor.** The proposal submitted by the project team to the Office of Her Royal Highness Princess Maha Chakri Sirindhorn's Projects was unclear. The complex language and structure used throughout the

report made some of the most important ideas unclear. It would have been beneficial to include a proposal summary of the entire document to help highlight these major points. This summary should emphasize topics of particular interest to the project sponsor.

Recommendations for The Office of Her Royal Highness Princess Maha Chakri Sirindhorn's Projects

1. **The project team recommends that the problem description from the Office of Her Royal Highness Princess Maha Chakri Sirindhorn's Projects include information about the school's laboratory facilities (including equipment), curriculum, and specific needs the school wants addressed**. We found that the information given in the project description lacked information needed to design appropriate laboratory activities for the school for which they were being designed. This would allow for better development of the activities before the project team's arrival at the school. It would be helpful for future project team to be supplied with this more detailed information.

2. **The project team recommends that the Office of H.R.H. Maha Chakri Sirindhorn's Projects make the laboratory manuals available to all schools who want to use these activities**. Through our findings and analysis we conclude that the developed laboratory activities fulfilled the project goals and thus are educationally valuable. This will allow the developed activities to have a greater impact in helping schools implement active teaching methods. These manuals will be presented to the Office of H.R.H. Princess Maha Chakri Sirindhorn's Projects in both English and Thai so that they can be used throughout Thailand.

3. **The project team suggests an option for an alternative project which focuses on teacher development.** Through this alternative project the team would work more directly with a teacher or teachers to help them design their own laboratory activities. A project like this would be beneficial for teachers because it would help enable them to continue designing their own science laboratory activities after the project team leaves the school. The Baan Na Yao School would be a prime candidate for this type of project because many of the teachers already understand the importance of science laboratory activities in the classroom. This project would be a significant time commitment on the part of any teacher. The chosen teacher(s) would need to be informed of this time commitment before accepting this project.

Concluding Remarks

The science laboratory activities designed in this project were educational, cost effective, engaging, interactive, sustainable, embraced by the teachers, and relevant to the national curriculum and the students of the Na Yao area. Findings collected from the conduction of the activities at the Baan Na Yao School were used for the final tailoring process of each experiment. The five developed activities included in our manual for dissemination are "Seasons Modeling", "Gravity is a Hammer", "What's in My Food?", "Colors of the Sun", and "Precipitation Reactions". We hope that this laboratory manual will be used by other schools throughout Thailand to help integrate active teaching methods into classrooms. We would like to thank the Office of H.R.H. Princess Maha Chakri Sirindhorn's Projects as well as Chulalongkorn University and Worcester Polytechnic Institute for allowing us the opportunity to work together on this project.

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Appendix A
Interview Notes

A1: Sponsor and Teachers of the Baan Na Yao School, conducted by Thanida Srisawasdi

Baan Na Yao School

Her Royal Highness Princess Maha Chakri Sirindhorn would like to emphasize the quality and the opportunity of education, because education is the process that empowers people to live well and become useful to themselves, their families and the society at large. The children should be given an equal opportunity to education, so H.R.H. Princess have tried to provide educational opportunity by various means, for example, by building schools at the sites where we have surveyed, and the villagers were very happy to help build the schools for their children. The schools can be under the responsibility of the Border Patrol Police or the Ministry of depending on the sites of the schools. Moreover, the Princess will concentrate on the activities like science projects for students to search for knowledge in their daily lives, for example, by interviewing people, organizing lectures, etc. The purpose of science projects is to stimulate the students learn science principles in physics, chemistry and biology through what happen in their daily lives, which the unsuccessful experiments will create a lot of questions for children to find out why they were not successful and the scientific project should develop in children creative ideas, love of art and designing skills too.

The full name of this school is Matthayomprarajchatannayao School. The establishment of this school came from the visiting of H.R.H. Princess Maha Chakri Sirindhorn at Baan Na Yao Border Patrol Police School since 1994, 1995, and 1997. The princess realized that there were many students, who graduated from primary school, was not study in higher education because of no middle school in their area, their poor status, and inconvenient transportation. Such that Border Patrol Police Bureau would like to respond the Princess's order. This school would be established to be a private school without any tuition fee. Baan Na Yao School was opened as the middle school as 1998 and expanded to high school level in 2004. The initial support came from the Princess, the budget for constructing the building is around 55 million baht. Later, office of the private education commission helped in tuition fee around 60% and increased to 100% since the academic year of 2004. Today, the Princess still supports the fund

of school building and lunch meals for every student. This school is also gotten the support from the government and public companies in form of academic seminars and media such as computers.

This school has quite completed equipments and teaching media for their study and entertainment such as self-access learning room, computer rooms, learning via satellite room, foreign language lab, digital/media room, library plant tissue culture lab. The management of curriculum is based on their students and their community. Despite of the limited budget, this school will use the concept of sufficient economy to improve the teaching style. The strategy of Baan Na Yao school is the applying the resources in 240,000 m^2 to be a fundamental in each subject matter. The usages of their resources are harvest rice, spicy/herb garden, chicken farm, fish farm, mushroom culture, botanic garden and using the co-operation as a free elective course.

Ms. Wimol Suwannasom, one of the teachers in Baan Na Yao School, told that the period is 1 hour in each subject, but it can be adjusted with the laboratory activities. The amount of the students in each class is approximately 30 students. The culture of teaching style right here is that the students pay a respect to their teacher and the students are quite shy, so teacher must activate them. The students, who graduated from high school, mostly 70% study on university level, 25% will be working as an employee, and the other 5% will be working on agricultural career in their community. Teachers will create course syllabus which is suitable to students and can be adapted in daily life especially on agricultural manner. Ms. Suwannasom suggested that the laboratory activities should be simple, challenge, and interesting, but the materials and equipments should be low-cost and available in that area.

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- Ms. Wimol Suwannasom
- Development of children and youth in the remote areas: A lecture by Her Royal Highness Princess Maha Chakri Sirindhorn.
- Ms. Panarat Seeharach

A2: Professor William Clark

12/02/09 9:30AM

Present: Professor William Clark
Hannah Israel
David Saxner

Questions and Comments:

Why was the ChE curriculum changed?

- Students were not adequately prepared for problem solving work after graduation.
- Students tended to forget, material learned at the beginning of the year, by the end of the year.

How was the new system chosen and why?

- The new system was chosen because it would incorporate problem solving projects into the classes which would make students more prepared tackles posed problems.
- In the new system each topic would be taught in the first class and the classes after that would build on each topic.
- "Baseball example" you practice throwing, batting, catching, etc. All at the same time so you will be able to play in a game.

What was the process involved in initiating the change?

- One year of planning: reviewed old course and determined what topics/material was important and what was not.
- Proposal and Grant

What was the process in initiating the change?

- Taught some classes in the old method and some with the new method (Does not recommend this).
- The test grades from the two classes were compared and not significant difference was found.
- A project competition was presented at the end of the year.

- The results were analyzed by WPI professors as well as professors from other universities.
- The students who had been taught in the new curriculum classes did significantly better than those in taught from the old method. The students taught with the old method performed very poorly on the project. The NEW curriculum was used from then on.

Suggestions/tips/additional information

- Suggestion: pose an unanswerable question at the beginning of the class. This will motivate student to learn so they can answer the question.
- Additional information: Hawthorne effect- people will perform better if they know they are part of a study.

A3: Professor Chrysanthe Demetry

12/07/09 1:00 pm

Present: Professor Chrysanthe Demetry
Sarah Lax
Todd Alexander

Discussion Topics:

Downfalls of previous IQP's in this area:

- Teachers viewed project team as assistant teachers and expected them to aid in the classroom. It is important that we establish initially that we are not teachers.
- Long activities (especially those spread over multiple days) are difficult. Students will lose interest and teachers may be intimidated. Come prepared with a "toolbox" of activities all of varied lengths and difficulty.
- The given curriculum in the project description may not be exactly what the teachers are covering while we are there.

Further general advice and suggestions:

- In interactions with teachers, focus on "student learning" not "teacher performance."
- Designing pre and post tests will be very difficult; this requires a lot of thought and planning as to the questions which will be asked.
- Teachers in the past have been very good educators have not always had solid understanding of background material.
- Do not use the Thai students as translators, be ready to take input from them and change the proposal.

A4: Dinner with School Director Sumpan Patumthanaruk

1/26/10

Present: All team members and advisor Ajarn Brigitte Servatius

This meeting was an informal dinner which served as an introduction for Ajarn Brigitte to the school and the director. Through the discussion, useful background information for the project was discussed. Any new information gained is summarized below:

History of Baan Na Yao School

- Founded because at the time there was no school above primary education in the area. This school allows students to continue past a middle school education if they choose to.
- Students do not pay for tuition at any school in the area, but this school also pays for clothing and lunch for the students.
- The school was founded by the Princess and is funded by the Office of H.R.H. Princess Maha Chakri Sirindhorn's Projects.
- The Princess had the Border Patrol Police help set up and build the school. They continue to help the school when needed and visit frequently.
- Money collected from the sale of the school's food products go back into the school.

Relevant Student Work

- Every Saturday a different grade level participates in a weekend camp at school. On 1/23 the director lectured on the history of Thailand and assigned that each student research the history of the Na Yao Village. Each student will talk to their parents and other elders in the village to form a report. These reports will be helpful information for this project if they are completed in time.

Appendix B
Supplementary Research

B1: PISA Scoring Rubric

Level	Lower score limit	Percentage of students able to answer questions at each level or above (OECD average)	What students can typically do at each level on the science scale
6	707.9	1.3% of students across the OECD can answer questions at Level 6	At Level 6, students can consistently identify, explain and apply scientific knowledge and *knowledge about science* in a variety of complex life situations. They can link different information sources and explanations and use evidence from those sources to justify decisions. They clearly and consistently demonstrate advanced scientific thinking and reasoning, and they demonstrate willingness to use their scientific understanding in support of solutions to unfamiliar scientific and technological situations. Students at this level can use scientific knowledge and develop arguments in support of recommendations and decisions that centre on personal, socio-economic, or global situations.
5	633.3	9.0% of students across the OECD can answer questions at least at Level 5	At Level 5, students can identify the scientific components of many complex life situations, apply both scientific concepts and *knowledge about science* to these situations, and can compare, select and evaluate appropriate scientific evidence for responding to life situations. Students at this level can use well-developed inquiry abilities, link knowledge appropriately and bring critical insights to situations. They can construct explanations based on evidence and arguments based on their critical analysis.
4	558.7	29.3% of students across the OECD can answer questions at least at Level 4	At Level 4, students can work effectively with situations and issues that may involve explicit phenomena requiring them to make inferences about the role of science or technology. They can select and integrate explanations from different disciplines of science or technology and link those explanations directly to aspects of life situations. Students at this level can reflect on their actions and they can communicate decisions using scientific knowledge and evidence.
3	484.1	56.7% of students across the OECD can answer questions at least at Level 3	At Level 3, students can identify clearly described scientific issues in a range of contexts. They can select facts and knowledge to explain phenomena and apply simple models or inquiry strategies. Students at this level can interpret and use scientific concepts from different disciplines and can apply them directly. They can develop short statements using facts and make decisions based on scientific knowledge.
2	409.5	80.8% of students across the OECD can answer questions at least at Level 2	At Level 2, students have adequate scientific knowledge to provide possible explanations in familiar contexts or draw conclusions based on simple investigations. They are capable of direct reasoning and making literal interpretations of the results of scientific inquiry or technological problem solving.
1	334.9	94.8% of students across the OECD can answer questions at least at Level 1	At Level 1, students have such a limited scientific knowledge that it can only be applied to a few, familiar situations. They can present scientific explanations that are obvious and follow explicitly from given evidence.

B2: Additional Thai Education System Information

Curriculum for each subject and grade level is created by the Thai government in order to advance the goals set forth by the educational reform enacted in 1999. This curriculum is controlled by the Ministry of Education, and developed by its subsidiaries. For example the Institute for the Promotion of Teaching Science and Technology or ISPT develops the mathematics, science and technology curriculum for all grade levels and public schools throughout Thailand. The ISPT aims to "promote, coordinate and undertake studies and research to improve and produce lessons, exercises, academic documents and all kinds of materials and equipments for teaching and learning of science, mathematics and technology..." (The Institute for the Promotion of Teaching Science and Technology, n.d.). This style of curriculum development acts as a base for Thailand's educational reform.

Since 1997 Thailand has used the School-Based Management system (SBM) in order to administer the schools within its borders. "SBM identifies the individual school as the primary unit of improvement by relying on the re-distribution of decision-making authority to stimulate and sustain improvements in a school… Accordingly, a school community, together with the principal and teachers, could be seen as followers of a dream who are committed to make it real, thus rendering leadership nothing more than a means to make it happen" (Gamage & Sooksomchitra, 2004). The system works well because the schools are still under the control of the public and makes the stakeholders accountable. "Improving the quality of education is often offered as a goal of decentralization, reflecting the notion that local people can solve local education problems better than the centralized state system" (Gamage & Sooksomchitra, 2004). The SBM system has been embraced by school principals and teachers in Thailand. This system allows for the school to customize its focus and goals based on the needs of the students and the needs of the community it serves (Gamage & Sooksomchitra, 2004). The success of the SBM system relies on the preparedness and skills of the administrators and teachers within the system.

B3: Subject Matter Research

Chemistry

A worldwide problem in chemistry education is that students can memorize chemical reaction formulas and processes without being able to interpret the meaning of these formulas on a molecular level. Formula memorization alone does not instill students with real problem solving skills and concept understanding (Wolfer & Lederman, 2000). Many approaches have been used to approach the memorization issue including (but not limited to): the use of concrete examples, step by step equations, and dimensional analysis. These methods are questioned in a study conducted by Hand, Yang and Bruxvoort (2007). Their study emphasizes science writing to boost qualitative understanding over solely quantitative memorization. Students in an experimental group were required to write an explanation of what they had learned to a younger age group instead of the usual summary passed in to the teacher. The teaching process forced them to explain the concepts in everyday terms so that the explanation would be easily comprehended by the younger students. This process, along with feedback and further required explanation from the younger students, gave the experimental group a more complete understanding of the material because they had to think about the concepts more thoroughly (Hand, Yang, & Bruxvoort, 2007). The teaching method used the fundamentals of active teaching by incorporating critical and analytical thinking, creativity, and communication into the exercise.

Astronomy

A major obstacle in teaching astronomy is the existing widespread misconceptions which many people have. These misconceptions are a result of mixed observations and incomplete facts which lead people to form false concepts about astronomy. An approach found to help solve this issue was to design activities that disprove the common misconceptions. A study was conducted by Valerie Frede in the *Astronomy Education Review* to do just this. The laboratory activity was designed so that the students could use given background information to formulate models to represent each hypothesis that they form. They then analyzed the model and tried to answer the same questions for each hypothesis. This analysis showed that one hypothesis was clearly correct while the other hypotheses were proven incorrect. The students were able to arrive at this conclusion with minimal guidance. This activity taught the astronomy concepts and showed the students how to use the scientific method of testing hypotheses and analyzing and comparing results. The results of this study showed that the majority of students gained a solid grasp on the material, and retained it at a high level in a later post test. Table B- 1 summarizes the results of the study through three specific questions asked of the students (Frede, 2008). Overall, the students shed their original misconceptions in exchange for the correct answer and then retained that information for the delayed post test (Frede, 2008).

Table B- 1: Answer percentages in misconception study- The data collected represents the percentage of each response for a class of 20 students (Frede, 2008)

Category of answer	Varying distance between the Earth and the Sun (distance hypothesis)			Tilt oscillation hypothesis			No answer or other (Sun energy, or wrong tilt value…)			Right answer (constant tilt)		
	P	IP	DP	P	IP	DP	P	IP	DP	P	IP	DP
Qa	30%	0%	5%	30%	0%	0%	0%	5%	5%	40%	95%	90%
Qb	35%	0%	5%	30%	0%	10%	5%	0%	0%	30%	100%	85%
Qc	20%	0%	0%	10%	0%	10%	10%	5%	10%	60%	95%	80%
All questions	28%	0%	3%	23%	0%	7%	5%	3%	5%	44%	97%	85%

Qa: Why is it hotter in summer than in winter in Toulouse?
Qb: The different seasons that we observe each year are mainly due to. . .
Qc: Why are days longer in summer than in winter in France?

There are three main categories of answers: usual misconceptions (the idea that the distance between the Earth and the Sun varies and tilt oscillation belief); rare misconceptions (reported as no answer or other); and the right conception (constant tilt of the rotation axis, last column of table). For each category, the percentage of answers in the pretest (P), immediate posttest (IP), and delayed posttest (DP) are given.

Physics

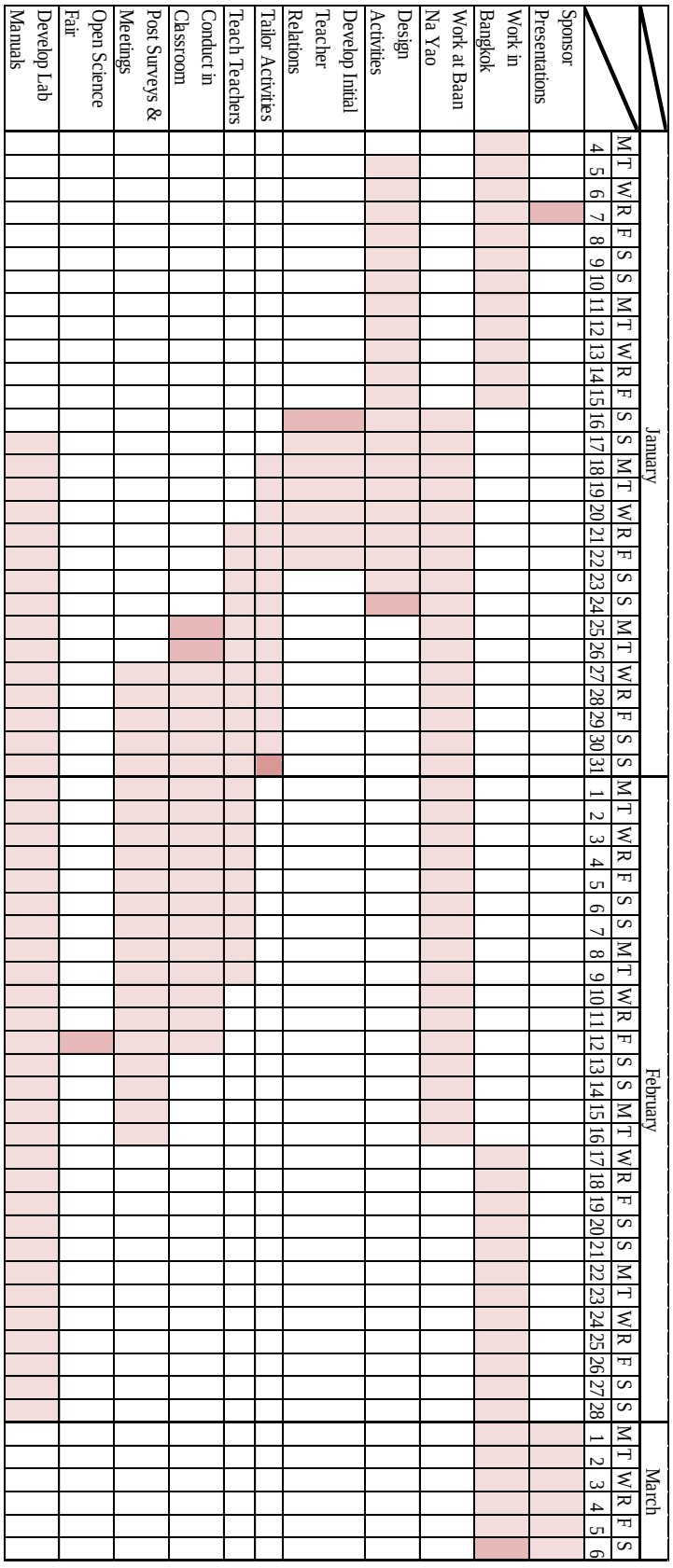
General research into physics laboratory activities focusing on energy shows a stress of project based work. Renata Holubova claims in her article "Effective Teaching Methods – Project Based Learning in Physics" that "project-based education requires active engagement of students' effort over an extended period of time. Projects are adaptable to different types of learners and learning situations" (Holubova, 2008). This means that by designing project type activities a connection and customization can be made to the students' lives. The use of project-based learning is further validated by a study conducted at Worcester Polytechnic Institute headed by Professors William Clark, David DiBiasio, and Anthony Dickson. The overall study involved a change in the Chemical Engineering Curriculum. Within this change, a stress on team projects was added to each course. There were groups of students divided into a control group using the old curriculum and an experimental group using the new curriculum. At the end of one school year with the new curriculum in place, students from each group participated in a design project. The final projects were evaluated by WPI professors as well as unbiased professors from other universities. The overall findings of the study showed that the students in the new project-based curriculum had a much greater understanding of the subject matter. These students were clearly able to apply what they had learned to real problems and they are therefore able to transition easily into the working world (Clark, 2009). Project-based learning is successful because it uses the fundamentals of active teaching which have shown up repeatedly in successful methods. Project work specifically uses creativity, teamwork, critical thinking and analytical and inquiry skills throughout.

As research into more existing physics experiments, an interview was conducted with an American high school physics teacher, Mr. Douglas Hutton (Hutton, 2009). The interview helped the brainstorming process for laboratory experiment ideas. One idea which was later fully developed was the *If I Had a Hammer* Lab. The modified developed experiment is included in the attached laboratory manual as "Gravity is a Hammer".

B4: Teacher Education in Thailand

Plans have been designed to better teacher education in Thailand. The Office of the Basic Education Commission (OBEC) has developed a strategic Teacher and Education Personnel Plan for 2006-2009 which includes developing standards to ensure the quality of teachers and education personnel, implementing an effective professional development system and supporting a network of trained trainers, supporting research and development for effective training, and implementing effective information systems for individual teacher and education personnel (Ministry of Education Thailand, 2006). Another plan called Teacher Watch has been organized to examine different dimensions: teacher workload; relationship with communities; teachers' debt; attitudes toward their career; teaching issues and challenges; and career development problems (Ministry of Education Thailand, 2006). The United Nations Educational, Scientific and Cultural Organization (UNESCO) Next Generation of Teachers Project has been designed to assist Teacher Education Institutions (TEIs) in Thailand and the Asia-Pacific region to prepare the next generation of teachers to judiciously use technologies for teaching and learning (Ministry of Education Thailand, 2006). Intel Teach to the Future, an organization developed in 2003, has trained more than 20,000 teachers from all over Thailand with the goal of training teachers in student-centered learning and supporting teachers in exploring the development of project and inquiry based learning models to promote team working, thinking and inquiry skills (Ministry of Education Thailand, 2006). Teachers who are trained with these skills can arm their student with the same skills using active teaching methods.

Appendix C
Project Timeline



Appendix D

Budget

D1: Allotted Funds

Budget	Lab and Science Fair equipment	Initial Meeting	Food for Science Fair
Amount given	15,000 Baht	3,000 Baht	12,000 Baht

D2: Expenses

Costs

Assumption: 6 groups per class

Budget: 15000 for lab equipment

All Costs in Baht (1 Dollar= approximately 33 Baht as of 2010)

Physics								
Object Name	Cost Per Item	Quantity per Group	Quantity Per Class	Total Cost	Already Available ?	Cost to Implement at Baan Na Yao School	Reusable	Cost for Future years
Oasis	10	1	6	60	No	60	No	60
Bag of Nails	20	N/A	1	20	No	20	Yes	0
Mass Scale	3430	N/A	1	3430	Yes	0	Yes	0
Empty Water Bottles	2	1	6	12	Yes	0	Yes	0
Tap Water	0	N/A	N/A	0	Yes	0	No	0
Heavy Paper	10	1	6	60	No	60	No	60
Tape	5	N/A	1	5	No	5	No	5
Totals				3587		145		125

Chemistry								
Object Name	Cost Per Item	Quantity per Group	Quantity Per Class	Total Cost	Already Available?	Cost to Implement at Baan Na Yao School	Reusable	Cost for Future years
Rice	38	N/A	1	38	No	38	No	38
Carrots	10	N/A	1	10	No	10	No	10
Peanuts	10	N/A	1	10	No	10	No	10
Jackfruit	30	N/A	1	30	No	30	No	30
Milk	15	N/A	1	15	No	15	No	15
Green Vegetable	5	N/A	1	5	No	5	No	5
Water	0	N/A	N/A	0	Yes	0	No	0
Mineral Oil	20	1	6	120	No	120	No	120
Test Tubes	18	N/A	50	900	No	900	Yes	0
Test Tube Rack	118	N/A	1	118	Yes	0	Yes	0
Brown Paper	20	1	6	120	No	120	No	120
Foil Paper	60	N/A	1	60	No	60	No	60
Mortar and Pestle	49	N/A	3	147	Yes	0	Yes	0
Hot Plate	6290	N/A	1	6290	Yes	0	Yes	0
Pot	9	N/A	1	9	Yes	0	Yes	0
Tongs	27	N/A	1	27	Yes	0	Yes	0
Graduated Cylinder	230	N/A	1	230	Yes	0	Yes	0
Eye Droppers	30	4	24	720	No	240	Yes	0
Clock	218	N/A	1	218	Yes	0	Yes	0
Lugol's Iodine Solution	189.75	N/A	1	189.75	No	189.75	Restock as necessary	0
5% Glucose Solution	10	N/A	1	10	No	10	No	10
Benedict's Solution	396	N/A	1	396	No	396	Restock as necessary	0
Biuret's Solution	148.5	N/A	1	148.5	No	148.5	Restock as necessary	0
Totals				9811.25		2292.25		418

$MgCl_2$	247.5	N/A	1	247.5	Yes	0	Restock as necessary	0
$CaCl_2$	33	N/A	1	33	Yes	0	Restock as necessary	0
NaCl	13.53	N/A	1	13.53	Yes	0	Restock as necessary	0
Na_2CO_3	9.54	N/A	1	9.54	Yes	0	Restock as necessary	0
Na_2HPO_4	29.7	N/A	1	29.7	Yes	0	Restock as necessary	0
KNO_3	25	N/A	1	25	Yes	0	Restock as necessary	0
Na_2SO_4	72.27	N/A	1	72.27	Yes	0	Restock as necessary	0
Water	0	1	6	0	Yes	0	No	0
Test tubes	18	10	60	1080	Yes	0	Yes	0
Test tube racks	118	1	6	708	Yes	0	Yes	0
Droppers	30	7	42	1260	Yes	0	Yes	0
Graduated cylinders	230	1	6	1380	Yes	0	Yes	0
Beakers	150	2	12	1800	Yes	0	Yes	0
Totals				6658.54		0		0
Astronomy								
Small Soccer Balls	15	1	6	90	No	90	Yes	0
Flashlight	45	1	6	270	No	270	Yes	0
Cardboard Boxes	10	1	6	60	Yes	0	Yes	0
Paint	17	N/A	4	68	No	68	N/A	0
String	8	1	6	48	No	48	No	48
Scissors	12	N/A	1	12	Yes	0	Yes	0
Batteries	20	N/A	2	40	No	40	No	40
Lacquer	32	N/A	2	64	No	64	N/A	0
Totals				652		580		88

Biology								
Used Water Bottles	2	4	24	48	Yes	0	Yes	0
Soil	0	1	6	0	Yes	0	No	0
Water	0	1	6	0	Yes	0	No	0
Colored paper	10	2	12	120	No	120	No	120
Seeds	20	N/A	1	20	No	20	No	20
Toilet paper	10	N/A	1	10	Yes	0	No	10
Ruler	20	1	6	120	Yes	0	Yes	0
Totals						140		150

Appendix E
Focus Group and Survey Details

E1: Focus Group Questions

How long have you been teaching at the Baan Yao School?

How long have you lived:

- In Thailand?
- In the Na Yao area?

What do you enjoy most about teaching?

How do you run your classroom?

- How often do you conduct laboratory activities?
- In what ways are students engaged in the classroom?
- During what type of activities do the students seem more engaged?

How do you feel about hands-on activities in the classroom?

What type of activities are you looking for from us?

Now present activities

What do you think about the activity? (Ask after each activity is presented)

- Is the activity at an appropriate difficulty level?
- Are the materials needed for the activity locally available?
- Does the activity fit into the curriculum?
- General feedback

E2: Student Pre-Opinion Survey

Student Opinion and Attitude Pre Survey

What do you want to do after you leave the Baan Na Yao School?					
What is your favorite subject?	Thai Language	Math	Foreign Language		Social Studies
	Health/ Physic Ed.	Art	Career/Technology		Science
What is your favorite type of school activity?	Experiments	Note taking	Problem solving		Reading
	Projects	Group Work	Demonstrations		Other:_____
Science is important in my daily life.	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
Science will be important in my future profession.	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
My knowledge in science will help me achieve my goals.	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
My knowledge in science can help my community.	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree

Adapted from (Hegarty et al., 2009)

E3: Student Post-Opinion Survey

What is your favorite subject?	Thai Language	Math	Foreign Language		Social Studies
	Health/ Physic Ed.	Art	Career/Technology		Science
What is your favorite type of school activity?	Experiments	Note taking	Problem solving		Reading
	Projects	Group Work	Demonstrations		Other:_____
Science is important in my daily life.	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
Science will be important in my future profession.	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
My knowledge in science will help me achieve my goals.	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
My knowledge in science can help my community.	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
Do you feel that you have a better understanding of _____ as a result of the _____ activity?	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
What did you like about the _____ activity?					
What did you dislike about the _____ activity?					

Adapted from (Hegarty et al., 2009)

E4: Teacher Post-Opinion Survey

What did you like about this experiment and why?

What did you dislike about this experiment and why?

What would you change in particular about this activity?

Were you comfortable leading this activity, if not why?

Do you anticipate that it will be difficult to obtain the materials needed for this activity?

The students were engaged more than normal	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
This gave the students a better understanding of the material	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
I would consider using this activity again next year	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree

Do you have any additional comments and recommendations?

Appendix F
Detailed Opinion Survey and Pre and Post Test Results

The detailed results from each activity include data from a teacher post-opinion survey, student pre and post opinion surveys, and student pre and post tests which evaluate student understanding. The results of these tests and surveys were tabulated and summarized in the tables and graphs to follow.

Appendix F Table of Contents

F1: Astronomy – "Seasons Modeling"
Opinion Surveys

Table F1- 1: Astronomy Teacher Opinion Survey

#	Question	Astronomy
1	What did you like about this experiment and why?	That the lab shows the where the sun hits the earth causes seasons.
2	What did you dislike about this experiment and why?	The light source is small and hard to see. The model can't show how the earth orbits the sun. This made it harder for the students to visualize what was going on.
3	What would you change in particular about this activity?	It would be better if the tilt of the earth could be done without using your hands.
4	Were you comfortable leading this activity, if not why?	Yes, it was a pleasure to have new media to use in the classroom.
5	Do you anticipate that it will be difficult to obtain the materials needed for this activity?	No, the materials are not very hard to find and can be set up easily.
6	The students were engaged more than normal	Strongly disagree /disagree/neutral/***agree***/strongly agree
7	This gave the students a better understanding of the material	Strongly disagree /disagree/neutral/***agree***/strongly agree
8	I would consider using this activity again next year	Strongly disagree /disagree/neutral/***agree***/strongly agree
9	Do you have any additional comments and recommendations?	The post test questions should be easier to understand.

*Note in this chart and opinion surveys to follow, positive results are highlighted in green, neutral in yellow, and negative in red.

6-1 Class

Pre-Opinion Open Ended Questions

Table F1- 2: Class 6-1 Opinion Survey – "What do you want to do after you leave the Baan Na Yao School?"

Student Responses	Unanswered or inconclusive		Occupation			Continue Academics
			Teacher	Medical	Non Specific	
	Blank	Whatever	Become a math teacher	Veterinarian	Get a good job, good friends, and not work too hard	
#	1	2	1	1	1	0
%	16.70%	33.30%	16.70%	16.70%	16.70%	0%
Total %	50%		50%			0%

Multiple Choice Question Comparison

Table F1- 3: Class 6-1 Opinion Survey – "What is your favorite subject?"

Student Responses		Thai Language	Math	Foreign Language	Social Studies	Health/ PE	Art	Career/ technology	Science
Pre-Opinion Survey	#	0	1	3	0	0	2	0	1
	%	0.0%	16.7%	50.0%	0.0%	0.0%	33.3%	0.0%	16.7%
Post-Opinion Survey	#	0	1	0	0	1	1	0	5
	%	0.0%	9.0%	0.0%	0.0%	9.0%	9.0%	0.0%	45.0%
Increase	%	0.0%	-7.7%	-50.0%	0.0%	9.0%	-24.3%	0.0%	28.3%

Table F1- 4: Class 6-1 Opinion Survey – "What is your favorite type of activity in school?"

Student Responses		Experiments	Note tacking	Problem Solving	Reading	Projects	Group Work	Demonstrations	Other
Pre-Opinion Survey	#	0	0	3	2	0	0	1	0
	%	0.00%	0.00%	50.00%	33.30%	0.00%	0.00%	16.70%	0.00%
Post-Opinion Survey	#	4	1	1	0	0	0	2	0
	%	50.00%	12.50%	12.50%	0.00%	0.00%	0.00%	25.00%	0.00%
Increase	%	50.00%	12.50%	-37.50%	-33.30%	0.00%	0.00%	8.30%	0.00%

Likert Scale Comparisons

Table F1- 5: Class 6-1 Opinion Survey – Likert Scale Questions

Pre-Opinion Survey

Question Number		Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	Science is important in my daily life:	0	0	2	3	2
		0%	0%	28.60%	42.90%	28.60%
2	Science will be important in my future profession:	0	0	3	4	0
		0%	0%	42.90%	57.10%	0%
3	My knowledge of science will help me achieve my goals:	0	0	3	4	0
		0%	0%	42.90%	57.10%	0%
4	My knowledge of science can help my community	0	1	1	5	0
		0%	14.30%	14.30%	71.40%	0%
Post-Opinion Survey						
1	Science is important in my daily life:	0	0	0	5	3
		0%	0%	0%	62.50%	37.50%
2	Science will be important in my future profession:	0	0	0	5	3
		0%	0%	0%	62.50%	37.50%
3	My knowledge of science will help me achieve my goals:	0	0	0	7	1
		0%	0%	0%	87.50%	12.50%
4	My knowledge of science can help my community	0	0	0	8	0
		0%	0%	0%	100%	0%
I have a better understanding of astronomy and seasons as a result of the "Seasons Modeling" experiment		0	0	0	6	2
		0%	0%	0%	75.00%	25.00%

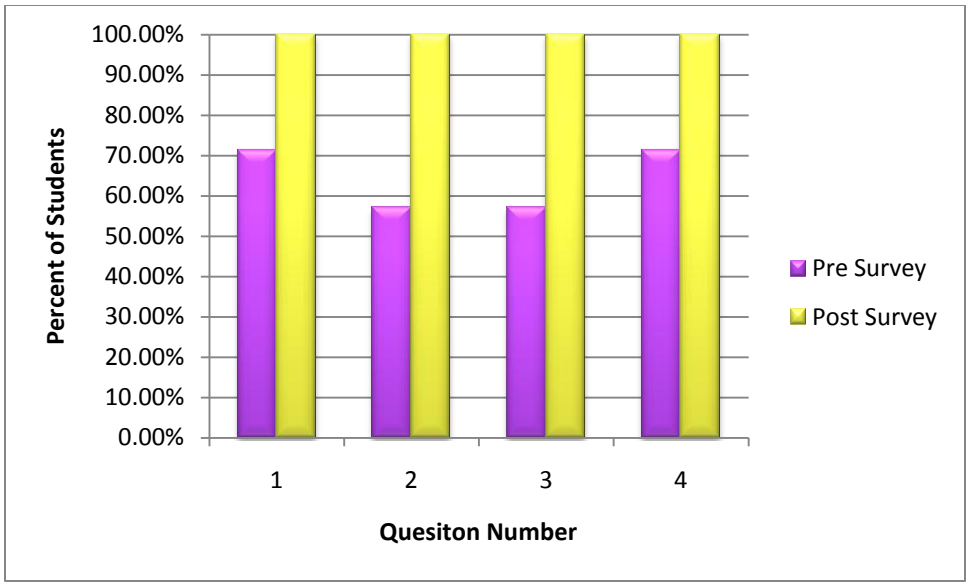


Figure F1- 1: Class 6-1 Increase in the number of students who agree or strongly agree on Likert Scale questions

Post-Opinion Open Ended Questions

Table F1- 6: Class 6-1 Opinion Survey – Post Survey Open Ended Questions Responses

What did you like about the astronomy lab activity?	What did you not like about the experiment?
The experiment	Nothing
Good experiment. I had never done it before	Nothing
The difference of the seasons	Nothing
Earth's orbit	Trouble understanding the media
I got to experiment by myself rather than study from the black board	It was a little confusing
I learned more things and liked the experiment	It was a little confusing
The model because it was easier to understand because we could see what was happening	It needed a little more explanation
Answering questions	the experiment *NOTE* the same person marked note taking as his/her favorite activity in school

6-2 Class

Pre-Opinion Open Ended Questions

Table F1- 7: Class 6-2 Opinion Survey – "What do you want to do after you leave the Baan Na Yao School?"

		Occupation						Continue Studying		
		Teach	Medical	Non Specific		Business	Military			
Student Responses	N/A	Become a teacher	Veterinarian	good job & friends, and not work too hard	Get a good Job	Own a business to support a family	Work in the military	Continue Studying	While working	to get a steady job
#	4	2	1	1	1	1	1	4	5	4
%	16.70%	8.30%	4.20%	4.20%	4.20 %	4.20%	4.20%	16.70%	20.80%	16.70 %
Total %	16.70%	29.20%						54.20%		

Multiple Choice Question Comparison

Table F1- 8: Class 6-2 Opinion Survey – "What is your favorite subject?"

Student Responses		Thai Language	Math	Foreign Language	Social Studies	Health/ PE	Art	Career/ technology	Science
Pre-Opinion Survey	#	0	4	5	3	3	4	3	2
	%	0%	17%	21%	13%	13%	17%	13%	8%
Post-Opinion Survey	#	0	1	2	1	2	2	2	3
	%	0%	8%	15%	8%	15%	15%	15%	23%
Increase	%	0.0%	-9.0%	-6.0%	-5.0%	2.0%	-2.0%	2.0%	15.0%

Table F1- 9: Class 6-2 Opinion Survey – "What is your favorite type of activity in school?"

Student Responses		Experiments	Note tacking	Problem Solving	Reading	Projects	Group Work	Demonstrations	Other
Pre-Opinion Survey	#	3	1	5	6	1	5	2	1
	%	12.50%	4.20%	20.80%	25.00%	4.20%	20.80%	8.30%	4.20%
Post-Opinion Survey	#	5	0	0	2	0	5	1	0
	%	38.50%	0.00%	0.00%	15.40%	0.00%	38.50%	7.70%	0.00%
Increase	%	26.00%	-4.20%	-20.80%	-9.60%	-4.20%	17.70%	-0.60%	-4.20%

Likert Scale Comparisons

Table F1- 10: Class 6-2 Opinion Survey – Likert Scale Questions

Pre-Opinion Survey						
Question Number		Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	Science is important in my daily life:	0	0	2	13	2
		0%	0%	11.80%	76.40%	11.80%
2	Science will be important in my future profession:	0	0	1	12	4
		0%	0%	5.90%	70.60%	24%
3	My knowledge of science will help me achieve my goals:	0	0	8	7	2
		0%	0%	47.10%	41.10%	12%
4	My knowledge of science can help my community	0	0	2	14	1
		0%	0.00%	11.80%	82.30%	6%
Post-Opinion Survey						
1	Science is important in my daily life:	0	0	3	8	2
		0%	0%	23%	62%	15%
2	Science will be important in my future profession:	0	0	2	10	1
		0%	0%	15%	77%	8%
3	My knowledge of science will help me achieve my goals:	0	0	6	6	1
		0%	0%	46%	46%	8%
4	My knowledge of science can help my community	0	0	0	12	1
		0%	0%	0%	92%	8%
I have a better understanding of astronomy and seasons as a result of the "Seasons Modeling" experiment		0	0	0	12	1
		0%	0%	0%	92%	8%

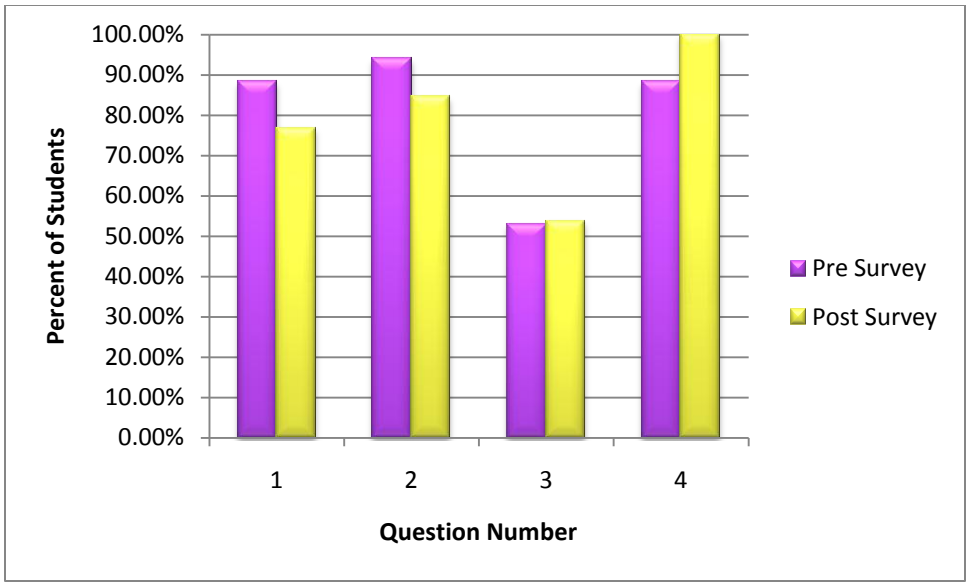


Figure F1- 2: Class 6-2 Increase in the number of students who agree or strongly agree on Likert Scale questions

Post-Opinion Open Ended Questions

Table F1- 11: Class 6-2 Opinion Survey – Post Survey Open Ended Questions Responses

What did you like about the astronomy lab activity?	What did you not like about the experiment?
Earth	Nothing
Earth's orbit	Nothing
Earth	Nothing
Answering the questions and doing the experiment	Nothing
Cute Staff	Nothing
Cute Staff	Nothing
Seasonal Changing	Nothing
It was easy to understand and everybody was involved	It was a little confusing
Brainstorming and discussion	It was a little confusing
Gaining new knowledge and doing experiments together in a group	It was difficult to understand at the beginning but better after the teacher explained more
Doing the experiment together with friends	It was too short
Having a lab activity and discussion	It was too short
Working in a group on an experiment	It should be longer

Pre and Post Tests

Class 6-1

Table F1- 12: Class 6-1 Pre test

Question	Answers				Number Incorrect	Number Correct
	A	B	C	D		
What is a season?	A body of gasses surrounding the earth	The distance of a place form the equator	Any of the quarters into which a year is divided	Sheets of high level clouds	1	6
What is the tilt of the Earth's axis in degrees?	22	22.5	23	23.5	0	7
The main reason that it is hotter in the summer than in the winter in Thailand is that:	The earth is closer to the sun	The earth is farther from the sun in summer	The earth's rotation axis is tilted and oscillates relative to the sun	The earth's rotation axis is tilted but constantly points toward the sun	1	6
The different seasons that we observe each year are mainly due to:	The variation of distance between the sun and the earth	The variation of tilt of the rotation axis of the earth on its orbit plane	The constant tilt of the earth's rotation axis on the orbit plane	The variation of the distances between the earth, the moon, and the sun	3	4
Days are longer in the summer than in the winter because:	The rotation axis oscillates from +23.5 degrees in summer to -23.5 degrees in the winter	The earth is closer to the sun in summer	The earth has a tilted rotation axis of 90 degrees on its orbit plane	The earth has a tilted rotation axis of 23.5 degrees	5	2

Overall Score	Percentage Score	Number of Students
0	0%	0
1	20%	1
2	40%	0
3	60%	1
4	80%	4
5	100%	1

Average Score	71%

Table F1- 13: Class 6-1 Post Test

Question	Answer Given		Number Incorrect	Number Correct
	True	False		
Seasons result from both revolution of the earth around the sun and the tilt of the earth's axis relative to the plane of revolution			0	8
The seasons are caused by the elliptical path of the earth around the sun			1	7
The northern and southern hemispheres have opposite seasons because the earth's axis is tilted to its orbital plane by 23.5 degrees			0	8
Earth's rotation takes one year, and it revolves around the sun in 24 hours			0	8
The elliptical orbit of the earth does not affect seasonal differences between hemispheres			5	3
There is no significance between the distances between the sun and the earth and the seasons			4	4
It is hotter in the summer because the earth is closer to the sun, following the same reasoning it is colder in the winter because the earth is farther from the sun			4	4
The hemisphere which is tilted toward the sun receives a greater flux of solar energy than the hemisphere which is tilted away			1	7
The changes in the intensity of sunlight which reaches the earth's surface cause three seasons in the temperate and polar regions			2	6
There is a noticeable change in the amount of sunlight in the tropical zone throughout the year			6	2

Overall Score	Percentage Score	Number of Students
0	0%	0
1	10%	0
2	20%	0
3	30%	0
4	40%	0
5	50%	0
6	60%	3
7	70%	3
8	80%	2
9	90%	0
10	100%	0

Average Score	69%

Class 6-2

Table F1- 14: Class 6-2 Pre Test

Question	Answers				Number Incorrect	Number Correct
	A	B	C	D		
What is a season?	A body of gasses surrounding the earth	The distance of a place form the equator	Any of the quarters into which a year is divided	Sheets of high level clouds	6	10
What is the tilt of the Earth's axis in degrees?	22	22.5	23	23.5	2	14
The main reason that it is hotter in the summer than in the winter in Thailand is that:	The earth is closer to the sun	The earth is farther from the sun in summer	The earth's rotation axis is tilted and oscillates relative to the sun	The earth's rotation axis is tilted but constantly points toward the sun	2	14
The different seasons that we observe each year are mainly due to:	The variation of distance between the sun and the earth	The variation of tilt of the rotation axis of the earth on its orbit plane	The constant tilt of the earth's rotation axis on the orbit plane	The variation of the distances between the earth, the moon, and the sun	13	3
Days are longer in the summer than in the winter because:	The rotation axis oscillates from +23.5 degrees in summer to -23.5 degrees in the winter	The earth is closer to the sun in summer	The earth has a tilted rotation axis of 90 degrees on its orbit plane	The earth has a tilted rotation axis of 23.5 degrees	10	6

Overall Score	Percentage Score	Number of Students
0	0%	0
1	20%	0
2	40%	6
3	60%	6
4	80%	3
5	100%	1

Average Score	59%

Table F1- 15: Class 6-2 Post Test

Question	Answers		Number Incorrect	Number Correct
	True	False		
Seasons result from both revolution of the earth around the sun and the tilt of the earth's axis relative to the plane of revolution			0	13
The seasons are caused by the elliptical path of the earth around the sun			9	4
The northern and southern hemispheres have opposite seasons because the earth's axis is tilted to its orbital plane by 23.5 degrees			0	13
Earth's rotation takes one year, and it revolves around the sun in 24 hours			0	13
The elliptical orbit of the earth does not affect seasonal differences between hemispheres			2	11
There is no significance between the distances between the sun and the earth and the seasons			3	10
It is hotter in the summer because the earth is closer to the sun, following the same reasoning it is colder in the winter because the earth is farther from the sun			8	5
The hemisphere which is tilted toward the sun receives a greater flux of solar energy than the hemisphere which is tilted away			1	12
The changes in the intensity of sunlight which reaches the earth's surface cause three seasons in the temperate and polar regions			5	8
There is a noticeable change in the amount of sunlight in the tropical zone throughout the year			11	2

Overall Score	Percentage Score	Number of Students
4	40%	0
5	50%	1
6	60%	3
7	70%	4
8	80%	5
9	90%	0
10	100%	0

Average Score	70%

Table F1- 16: Overall Astronomy Pre and Post Test Comparison

Class	Pre test	Post Test	**Percent Increase**
6-1	71%	69%	**-2%**
6-2	59%	70%	**11%**

F2: Physics – "Gravity is a Hammer"

Opinion Surveys

Table F2- 1: Physics Teacher Opinion Survey

#	Question	Physics
1	What did you like about this experiment and why?	Calculating the velocity by energy conservation.
2	What did you dislike about this experiment and why?	None
3	What would you change in particular about this activity?	Find additional materials to calculate work from friction on the object.
4	Were you comfortable leading this activity, if not why?	Yes, and it was an interesting activity because students got to learn from a real-life situation. This activity helped the students to understand the topic more than a lecture would have.
5	Do you anticipate that it will be difficult to obtain the materials needed for this activity?	The materials are easy to find
6	The students were engaged more than normal	Strongly disagree /disagree/neutral/***agree***/strongly agree
7	This gave the students a better understanding of the material	Strongly disagree /disagree/neutral/***agree***/strongly agree
8	I would consider using this activity again next year	Strongly disagree /disagree/neutral/***agree***/strongly agree
9	Do you have any additional comments and recommendations?	It is good that the activity used materials that can be found in this area. I would like to use similar activities for other topics.

5-1 Class

Pre-Opinion Open Ended Questions

Table F2- 2: Class 5-1 Opinion Survey – "What do you want to do after you leave the Baan Na Yao School?"

	Occupation		Continue Studying						
	Teach	Medical							
Student Responses	Become a teacher	Become a biology teacher or nurse	Continue Studying	to get a job	to bring knowledge to the developing country	and be in military	in architecture and teaching	in law	and get a dental degree
#	1	1	3	3	1	1	1	1	2
%	7.10%	7.10%	21.40%	21.40%	7.10%	7.10%	7.10%	7.10%	14.30%
Total %	14.30%		85.70%						

Multiple Choice Question Comparison

Table F2- 3: Class 5-1 Opinion Survey – "What is your favorite subject?"

Student Responses		Thai Language	Math	Foreign Language	Social Studies	Health/ PE	Art	Career/ technology	Science
Pre-Opinion Survey	#	1	4	5	2	3	1	1	8
	%	4.00%	16.00%	20.00%	8.00%	12.00%	4.00%	4.00%	32.00%
Post-Opinion Survey	#	2	4	5	3	1	0	1	9
	%	8.00%	16.00%	20.00%	12.00%	4.00%	0.00%	4.00%	36.00%
Increase	%	4.0%	0.0%	0.0%	4.0%	-8.0%	-4.0%	0.0%	4.0%

*Note: Some students chose more than one favorite subject or activity

Table F2- 4: Class 5-1 Opinion Survey – "What is your favorite type of activity in school?"

Student Responses		Experiments	Note tacking	Problem Solving	Reading	Projects	Group Work	Demonstrations	Other
Pre-Opinion Survey	#	5	4	5	1	1	2	0	0
	%	23.80%	19.00%	23.80%	4.80%	4.80%	9.50%	0%	0%
Post-Opinion Survey	#	7	1	5	1	1	1	4	0
	%	35.00%	5.00%	25.00%	5.00%	5.00%	5.00%	20.00%	0.00%
Increase	%	11.20%	-14.00%	1.20%	0.20%	0.20%	-4.50%	20.00%	0.00%

*Note: Some students chose more than one favorite subject or activity

Likert Scale Comparisons

Table F2- 5: Class 5-1 Opinion Survey – Likert Scale Questions

Pre-Opinion Survey						
Question Number		Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	Science is important in my daily life:	0	0	0	7	7
		0%	0%	0.00%	50.00%	50.00%
2	Science will be important in my future profession:	0	0	0	4	10
		0%	0%	0.00%	29.00%	71%
3	My knowledge of science will help me achieve my goals:	0	0	0	11	3
		0%	0%	0.00%	79.00%	21%
4	My knowledge of science can help my community	0	0	0	10	4
		0%	0.00%	0.00%	71.00%	29%
Post-Opinion Survey						
1	Science is important in my daily life:	0	0	0	8	5
		0%	0%	0%	62%	38%
2	Science will be important in my future profession:	0	0	0	5	8
		0%	0%	0%	38%	62%
3	My knowledge of science will help me achieve my goals:	0	0	0	7	6
		0%	0%	0%	54%	46%
4	My knowledge of science can help my community	0	0	0	10	3
		0%	0%	0%	77%	23%
5	I have a better understanding of astronomy and seasons as a result of the "Gravity is a Hammer" experiment	0	0	0	10	3
		0%	0%	0%	77%	23%

Post-Opinion Open Ended Questions

Table F2- 6: Class 5-1 Opinion Survey – Post Survey Open Ended Questions Responses

What did you like about the Physics lab activity?	What did you not like about the experiment?
Getting to do fun activities	None
Cooperating with group members and the experiment	Doing the report
Cooperating with group members	The conclusion
Working in a group	Note taking
Problem solving	Note taking
Problem solving	Not exciting
The experiment	Listening to the teacher
The experiment	Listening to the teacher
The experiment	Listening to the teacher
The experiment	Not enough time
The experiment	Not enough time
The experiment	Not enough time
The experiment	Waiting for results

Pre and Post Tests

Table F2- 7: Class 5-1 Pre Test

Question		Answer	Number Incorrect	Number Correct
Describe each type of energy involved in this lab:	Gravitational Potential-	The potential energy of the mass at the top of the cylinder is converted into kinetic as the mass falls and accelerates downward. It is potential energy because the mass has the "potential' to move. PE=mgh	0	12
	Kinetic-	The kinetic energy is the energy of the mass dependent on its motion. The energy of the mass is converted from potential to almost entirely kinetic energy as it falls toward the nail. KE=1/2 m v^2	0	12
When will the mass have the most potential energy, when will it have the most kinetic?		Max potential energy is at the top of the cylinder, max kinetic energy is at the moment it hits the nail (when it has the highest velocity).	0	12
Explain in terms of the physics involved, why does the nail move when the mass hits it?		The kinetic energy of the nail is entirely converted into work to push the nail into the foam against friction.	0	12

Overall Score	Percentage Score	Number of Students
0	0%	0
1	20%	0
2	40%	0
3	60%	0
4	80%	0
5	100%	12

Average Score	100%

Table F2- 8: Class 5-1 Post Test

Question		Answer	Number Incorrect	Number Correct
Describe each type of energy involved in this lab	Gravitational Potential-	The potential energy of the mass at the top of the cylinder is converted into kinetic as the mass falls and accelerates downward. It is potential energy because the mass has the "potential' to move. PE=mgh	0	12
	Kinetic-	The kinetic energy is the energy of the mass dependent on its motion. The energy of the mass is converted from potential to almost entirely kinetic energy as it falls toward the nail. KE=1/2 m v^2	0	12
When will the mass have the most potential energy, when will it have the most kinetic?		Max potential energy is at the top of the cylinder, max kinetic energy is at the moment it hits the nail (when it has the highest velocity).	0	12
Explain in terms of the physics involved, why does the nail move when the mass hits it?		The kinetic energy of the nail is entirely converted into work to push the nail into the foam against friction.	5	7
Why does the force vs. distance graph represent the total work done by the mass?		Work is equal to the force applied to the nail times the distance the nail moves (W=Fd). This is a graph of the function of force over distance. So the area under the function is equal to the force times the distance.	0	12
Why is the force in each trial slightly different?		There is error involved in this lab including: slightly inconsistent drop height, possible bending of the nail, and error in measurement. There is also a buildup of foam under the nail as it pushes into the block, which may slow it down.	0	12
Analyze why each group had different results (consider the varied masses and heights that each team used)		A larger mass or longer fall will create a larger impact force and therefore perform more work and push the nail into the foam in fewer trials.	0	12

Overall Score	Percentage Score	Number of Students
0	0%	0
1	17%	0
2	33%	0
3	50%	0
4	67%	0
5	83%	5
6	100%	7

Average Score	83%

F3: Chemistry – "What's in My Food?"

Opinion Surveys

Table F3- 1: Chemistry Teacher Opinion Survey

#	Question	Chemistry
1	What did you like about this experiment and why?	I like all four activities.
2	What did you dislike about this experiment and why?	The procedure was not clear enough for the students.
3	What would you change in particular about this activity?	The students should know how to prepare the solutions they are using to test for the nutrients. The students should have to come up with their own hypothesis and point out variables before the activity. The students should write up their conclusions after the lab.
4	Were you comfortable leading this activity, if not why?	Yes, the activity supported their lab skills.
5	Do you anticipate that it will be difficult to obtain the materials needed for this activity?	No, the materials can be found easily in the market and village.
6	The students were engaged more than normal	Strongly disagree /disagree/neutral/***agree***/strongly agree
7	This gave the students a better understanding of the material	Strongly disagree /disagree/neutral/***agree***/strongly agree
8	I would consider using this activity again next year	Strongly disagree /disagree/neutral/***agree***/strongly agree
9	Do you have any additional comments and recommendations?	The lab should have another part about atomic structure or atom modeling because this lab can involve the reaction of the substances. The lab should also have testing for vitamins and minerals in the food.

5-1 Class

Pre –Opinion Open Ended Questions

Table F3- 2: Class 5-1 Opinion Survey – "What do you want to do after you leave the Baan Na Yao School?"

		Occupation				Continue Studying		
		Business	Performing Arts	Military	General			
Student Responses	Blank	Own a business	actress, singer and dancer	Work for the police	Work	Continue Studying	to be successful in life	in physical education
#	1	4	1	1	2	11	1	1
%	4.50%	18.20%	4.50%	4.50%	9.10%	59.10%		
Total %	4.50%	36.40%				59.10%		

Multiple Choice Question Comparison

Table F3- 3: Class 5-1 Opinion Survey – "What is your favorite subject?"

Student Responses		Thai Language	Math	Foreign Language	Social Studies	Health/ PE	Art	Career/ technology	Science
Pre-Opinion Survey	#	6	6	2	7	11	5	6	6
	%	12.2%	12.2%	4.1%	14.3%	22.4%	10.2%	12.2%	12.2%
Post Survey	#	Results not available. This class did not complete the post-opinion survey							
	%								

*Note: Some students chose more than one favorite subject or activity

Table F3- 4: Class 5-1 Opinion Survey – "What is your favorite type of activity in school?"

Student Responses		Experiments	Note tacking	Problem Solving	Reading	Projects	Group Work	Demonstrations	Other
Pre-Opinion Survey	#	14	3	0	3	0	11	7	0
	%	36.8%	7.9%	0.0%	7.9%	0.0%	28.9%	18.4%	0.0%
Post Survey	#	Results not available. This class did not complete the post-opinion survey							
	%								

*Note: Some students chose more than one favorite subject or activity

Likert Scale Comparisons

Table F3- 5: Class 5-1 Opinion Survey – Likert Scale Questions

Pre-Opinion Survey						
Question Number		Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	Science is important in my daily life:	0	0	0	15	7
		0%	0%	0.00%	68.00%	32.00%
2	Science will be important in my future profession:	0	0	0	14	8
		0%	0%	0.00%	64.00%	36%
3	My knowledge of science will help me achieve my goals:	0	0	1	16	5
		0%	0%	5.00%	73.00%	23%
4	My knowledge of science can help my community	0	0	0	12	10
		0%	0.00%	0.00%	55.00%	45%
Post-Opinion Survey results not available						

4-2 Class

Pre-Opinion Open Ended Questions

Table F3- 6: Class 4-2 Opinion Survey – "What do you want to do after you leave the Baan Na Yao School?"

	General		Occupation	Continue Studying					
Student Responses	Blank	Travel to outer space	Be a teacher	Continue Studying	to be successful in life	to improve my country	in law	to become a pharmacist	to become a dentist
#	1	1	1	6	1	1	1	1	1
%	7.10%	7.10%	7.10%	42.90%	7.10%	7.10%	7.10%	7.10%	7.10%
Total %	14.30%		7.10%	78.60%					

Multiple Choice Question Comparison

Table F3- 7: Class 4-2 Opinion Survey – "What is your favorite subject?"

Student Responses		Thai Language	Math	Foreign Language	Social Studies	Health/ PE	Art	Career/ technology	Science
Pre-Opinion Survey	#	0	4	6	1	4	2	2	10
	%	0.00%	13.79%	20.69%	3.45%	13.79%	6.90%	6.90%	34.48%
Post Survey	#	1	3	3	1	0	1	0	6
	%	6.67%	20.00%	20.00%	6.67%	0.00%	6.67%	0.00%	40.00%
Increase	%	6.7%	6.2%	-0.7%	3.2%	-13.8%	-0.2%	-6.9%	5.5%

*Note: Some students chose more than one favorite subject or activity

Table F3- 8: Class 4-2 Opinion Survey – "What is your favorite type of activity in school?"

Student Responses		Experiments	Note tacking	Problem Solving	Reading	Projects	Group Work	Demonstrations	Other
Pre-Opinion Survey	#	9	0	4	1	0	1	4	0
	%	47.37%	0.00%	21.05%	5.26%	0.00%	5.26%	21%	0%
Post Survey	#	5	0	3	1	0	1	2	0
	%	41.67%	0.00%	25.00%	8.33%	0.00%	8.33%	16.67%	0.00%
Increase	%	-5.70%	0.00%	3.95%	3.07%	0.00%	3.07%	-4.39%	0.00%

*Note: Some students chose more than one favorite subject or activity

Likert Scale Comparisons

Table F3- 9: Class 4-2 Opinion Survey – Likert Scale Questions

Pre-Opinion Survey						
Question Number		Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	Science is important in my daily life:	0	0	0	10	4
		0%	0%	0.00%	68.00%	32.00%
2	Science will be important in my future profession:	0	0	1	6	7
		0%	0%	0.00%	64.00%	36%
3	My knowledge of science will help me achieve my goals:	0	0	0	9	5
		0%	0%	5.00%	73.00%	23%
4	My knowledge of science can help my community	0	0	1	9	4
		0%	0.00%	0.00%	55.00%	45%
Post-Opinion Survey						
1	Science is important in my daily life:	0	0	0	5	4
		0%	0%	0%	62%	38%
2	Science will be important in my future profession:	0	0	0	5	4
		0%	0%	0%	38%	62%
3	My knowledge of science will help me achieve my goals:	0	0	0	5	4
		0%	0%	0%	54%	46%
4	My knowledge of science can help my community	0	0	0	5	4
		0%	0%	0%	77%	23%
5	I have a better understanding of astronomy and seasons as a result of the "What's in My Food?" experiment	0	0	0	3	3
		0%	0%	0%	77%	23%

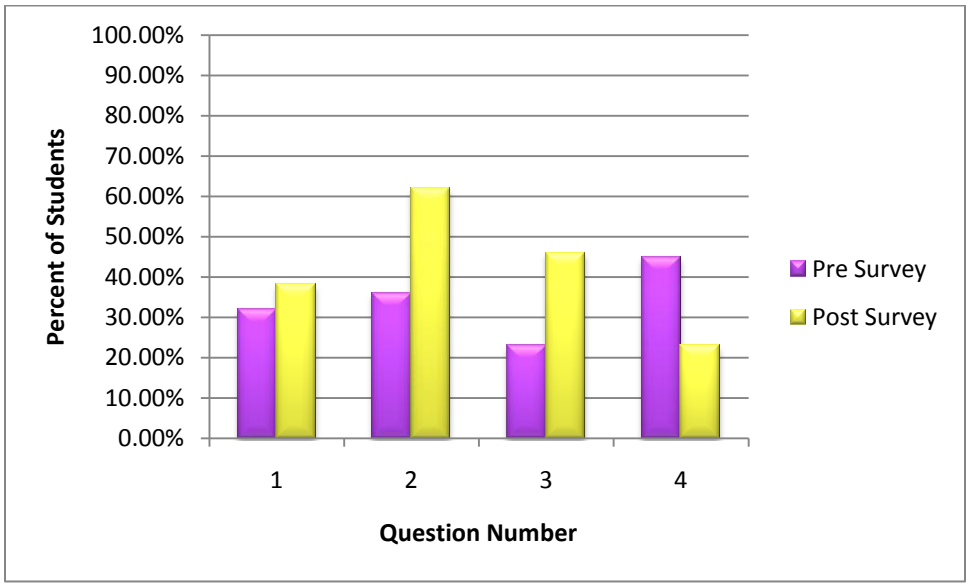


Figure F3- 1: Class 4-2 Increase in the number of students who agree or strongly agree on Likert Scale questions

Post-Opinion Open Ended Questions

This information is not available; the final class did not complete this question on the post surveys.

Pre and Post Tests

Table F3- 10: Class 5-1 Pre Test

Question	Answers				Number Incorrect	Number Correct
	A	B	C	D		
What are some of the main nutrients needed in a daily diet?	Carbohydrates, proteins, lipids, vitamins and minerals				0	22
What is the bodies most preferred source of energy?	Complex carbohydrates				3	19
The more physical work you perform daily, the more complex carbohydrates you must consume.	True		False		0	22
Simple carbohydrates supply a significant amount of nutrients and fiber.	True		False		0	22
What is your favorite food that has a lot of simple carbohydrates?	Anything with sugar				11	11
Which of the following foods is the best source of carbohydrates?	Nuts	Rice	Mangoes	Milk	0	22
What are the building blocks of proteins?	Amino acids				1	21
Name one thing proteins do in the body.	Muscle repair, tissue growth, hormone regulations, metabolism control, illness defense, etc.				0	22
Which of the following foods is the best source of proteins?	Nuts	Rice	Mangoes	Milk	0	22
What is an important function of lipids?	Energy storage				1	21
How could you tell if a food is abundant in lipids?	If the food leaves an oily spot on a piece of paper that does not evaporate				0	22
Lipids should be a large part of your diet.	True		False		0	22
Why would water be used as a control when testing for nutrients?	Water would be used as a control in the experiments because it does not contain any of the nutrients that are being tested for and therefore will not react with the testing reagents.				1	21

Overall Score	Percentage Score	Number of Students
8	62%	0
8.5	65%	0
9	69%	0
9.5	73%	0
10	77%	0
10.5	81%	1
11	85%	0
11.5	88%	0
12	92%	11
12.5	96%	2
13	100%	8

Average Score	95%

Table F3- 11: Class 5-1 Post Test

Question	Answers				Number Incorrect	Number Correct
	A	B	C	D		
What are some of the main nutrients needed in a daily diet?	Carbohydrates, proteins, lipids, vitamins and minerals				2	13
What is the bodies most preferred source of energy?	Complex carbohydrates				3	12
The more physical work you perform daily, the more complex carbohydrates you must consume.	True		False		1	14
Simple carbohydrates supply a significant amount of nutrients and fiber.	True		False		1	14
What is your favorite food that has a lot of simple carbohydrates?	Anything with sugar				0	15
Which of the following foods is the best source of carbohydrates?	Nuts	Rice	Mangoes	Milk	1	14
What are the building blocks of proteins?	Amino Acids				0	15
Name one thing proteins do in the body.	Muscle repair, tissue growth, hormone regulations, metabolism control, illness defense, etc.				0	15
Which of the following foods is the best source of proteins?	Nuts	Rice	Mangoes	Milk	0	15
What is an important function of lipids?	Energy storage				0	15
How could you tell if a food is abundant in lipids?	If the food leaves an oily spot on a piece of paper that does not evaporate				1	14
Lipids should be a large part of your diet.	True		False		0	15
Why would water be used as a control when testing for nutrients?	Water would be used as a control in the experiments because it does not contain any of the nutrients that are being tested for and therefore will not react with the testing reagents.				0	15
Did any of the results obtained for each test surprise you? Which ones surprised you? Why did they surprise you?	No right or wrong answer				3	12

In the indicator box, on the following data table, write what indicator was used to detect the listed biomolecules in each test. In the specified boxes describe the appearance of positive and negative results for each nutrient.	Nutrient	Indicator	Positive Result	Negative Result	12	3
	Starch	Lugol's Iodine solution	Dark Purple	Yellow/Clear		
	Sugar	Bendict's solution	Orange	Blue		
	Fat	Paper	Transparent	Non Transparent		
	Protein	Biuret's solution	Purple	Blue		

(Note: the last two questions were not considered in analysis of the activity)

Table F3- 12: Class 4-2 Pre Test

Question	Answers				Number Incorrect	Number Correct
	A	B	C	D		
What are some of the main nutrients needed in a daily diet?	Carbohydrates, proteins, lipids, vitamins and minerals				0	14
What is the bodies most preferred source of energy?	Complex carbohydrates				9	5
The more physical work you perform daily, the more complex carbohydrates you must consume.	True		False		0	14
Simple carbohydrates supply a significant amount of nutrients and fiber.	True		False		6	8
What is your favorite food that has a lot of simple carbohydrates?	Anything with sugar				0	14
Which of the following foods is the best source of carbohydrates?	Nuts	Rice	Mangoes	Milk	0	14
What are the building blocks of proteins?	Amino acids				0	14
Name one thing proteins do in the body.	Muscle repair, tissue growth, hormone regulations, metabolism control, illness defense, etc.				0	14
Which of the following foods is the best source of proteins?	Nuts	Rice	Mangoes	Milk	0	14
What is an important function of lipids?	Energy storage				0	14
How could you tell if a food is abundant in lipids?	If the food leaves an oily spot on a piece of paper that does not evaporate				2	12
Lipids should be a large part of your diet.	True		False		0	14
Why would water be used as a control when testing for nutrients?	Water would be used as a control in the experiments because it does not contain any of the nutrients that are being tested for and therefore will not react with the testing reagents.				0	14

Overall Score	Percentage Score	Number of Students
8	62%	0
8.5	65%	0
9	69%	0
9.5	73%	0
10	77%	0
10.5	81%	2
11	85%	1
11.5	88%	1
12	92%	4
12.5	96%	1
13	100%	5

Average Score	93%

Table F3- 13: Class 4-2 Post Test

Question	Answers				Number Incorrect	Number Correct
	A	B	C	D		
What are some of the main nutrients needed in a daily diet?	Carbohydrates, proteins, lipids, vitamins and minerals				0	14
What is the bodies most preferred source of energy?	Complex carbohydrates				6	8
The more physical work you perform daily, the more complex carbohydrates you must consume.	True		False		0	14
Simple carbohydrates supply a significant amount of nutrients and fiber.	True		False		5	9
What is your favorite food that has a lot of simple carbohydrates?	Anything with sugar				0	14
Which of the following foods is the best source of carbohydrates?	Nuts	Rice	Mangoes	Milk	0	14
What are the building blocks of proteins?	Amino Acids				0	14
Name one thing proteins do in the body.	Muscle repair, tissue growth, hormone regulations, metabolism control, illness defense, etc.				0	14
Which of the following foods is the best source of proteins?	Nuts	Rice	Mangoes	Milk	0	14
What is an important function of lipids?	Energy storage				0	14
How could you tell if a food is abundant in lipids?	If the food leaves an oily spot on a piece of paper that does not evaporate				3	11
Lipids should be a large part of your diet.	True		False		0	14
Why would water be used as a control when testing for nutrients?	Water would be used as a control in the experiments because it does not contain any of the nutrients that are being tested for and therefore will not react with the testing reagents.				0	14
Did any of the results obtained for each test surprise you? Which ones surprised you? Why did they surprise you?	No right or wrong answer				-	-

In the indicator box, on the following data table, write what indicator was used to detect the listed biomolecules in each test. In the specified boxes describe the appearance of positive and negative results for each nutrient.	Nutrient	Indicator	Positive Result	Negative Result	10	
	Starch	Lugol's Iodine solution	Dark Purple	Yellow/Clear		
	Sugar	Bendict's solution	Orange	Blue		
	Fat	Paper	Transparent	Non Transparent		
	Protein	Biuret's solution	Purple	Blue		

(Note: the last two questions were not considered in analysis of the activity)

Class	Pre test	Post Test	**Percent Increase**
5-1	95.0 %	92.3%	**-2.7%**
4-2	93.0 %	95.4%	**2.4%**

Appendix G: Project Team Experience

G1: Contributions

Summarized below are each team members' major contributions to this project.

Todd Alexander

Todd Alexander was one of the main editors of the project report. He significantly contributed to the flow of each written section and the continuity of the overall document. He had many original ideas on the writing of this document and actively discussed these to better the report. In addition, Todd's personable character allowed him to communicate effectively with the Director of the Baa Na Yao School and build trusting relationships between the project team and the school teachers.

Hannah Israel

Hannah Israel took on an important leadership role within the group and kept the group organized and on task through maintaining "to do lists" and delegating tasks with skill taking into account the strengths of each team member. Hannah also wrote many sections of this document with finesse and skill which contributed greatly to the overall quality and flow of the document. She played a large role in the editing and wording of this document which further demonstrated her writing expertise. Her upbeat attitude contributed greatly to team moral.

Sarah Lax

Sarah Lax greatly contributed to this project with her extensive knowledge and skill with formatting and professional presentation. The project team could rely on her to fix all technical problems with the written documents. She was also responsible for the major formatting of the final report and laboratory manuals. Sarah also played a significant leadership role through the duration of this project taking charge when needed, suggesting innovative ideas on writing content, and keeping the team on task.

Pokchat Lohaphansomboon

Pokchat Lohaphansomboon's optimistic attitude kept the team positive through the most stressful of situations encountered during the project process. She played a significant role in communications with the Baan Na Yao teachers and administrators. She organized many of the project team's interactions with the school particularly in dealing with the design of our open science fair. Together with Thanida, Pokchat was responsible for the translation of the laboratory manuals. In addition she connected the WPI members of the project team to Thai culture by explaining events that they encountered.

David Saxner

David Saxner was responsible for organizing all references used for this project and ensuring correct citation throughout the report. He also served as the chief photographer for the images used in the developed laboratory manuals. David was also responsible for the organization of the project poster. He showed great skill in catching technical writing problems throughout the document including grammar, and spelling.

Thanida Sirsawasdi

Thanida Sirsawasdi was an extremely reliable member of this project team as she could be trusted with any last minute task. Thanida played a significant role in the large undertaking of formatting and translating the laboratory manuals. In addition she aided in the communication between the WPI members of the team and the teachers of the Baan Na Yao School. Her enthusiastic communications with the students of the Baan Na Yao School promoted student interest and excitement in the laboratory activities and open science fair.

You'd have to walk a thousand miles in my shoes…
Todd Alexander

One night while hanging out and playing cards our group started talking about school and our majors and why we chose to major in what we were. This followed with the next question that almost anybody might ask after that, "What did we each want to do after school?". For the four of us from the United States it seemed pretty clear why we chose our majors but we each had no idea what we wanted to do in a landscape filled with many opportunities and possibilities. For our Thai counterparts it seemed like they already knew what they were going to do with certainty. In Thai culture it is common to follow the career path that the family has chosen. An example of this tradition can be seen in one of our group members who is going to run a hotel when she graduates because her parents are in the hotel business. Her family wants and expects her to continue running this family enterprise. She already has responsibilities in running the hotel and is expected to help her parents run the business while still attending school. This conversation peaked my interest in this topic and caused me to look closely at how the system works in the Na Yao village.

Since having the conversation mentioned above, I realized I have been surrounded by this tradition all along whether it is seeing students at the market helping out at their family stand to seeing them working in their family's convenient store. One case in particular intrigues me because of the connection I feel with this student. The student's name is Det. Since arriving at the village I have played basketball at least three days a week with him, observed his determination both on and off the court, fun loving nature, and kindness. In talking with Bee and Beauty, our two Chulalongkorn group members, I found out that he is an A student and well liked by all his teachers and peers. He is a very talented individual and for our science fair designed and built a model of the sun and earth where the earth revolved around the sun as well as its own axis. He did this using some motors which he modified and junk he got from the junkyard. This model was the most popular attraction at the science fair. Something unique about Det is that he has a scholarship from Toyota which would pay for his college tuition. His family is excited about this and would like for him to go to college instead of farming which would be a break from the normal tradition.

There are many possible interpretations to explain why Thai people often follow in their parents' footsteps. One reason is that they have great respect for their family and their family's values. Thai parents expect at least one of their children to carry on the family's line of work whether that is farming or banking or any number of careers. With this value in mind, Thai children grow up knowing what they are likely going do to for the rest of their lives. To them, family is so important that it does not matter what job they are supposed to carry on; they are happy to do it to keep the family's work tradition alive. One of our Thai group partners even said that this is the reason why in a lot of Asian cultures they want a male child to be the firstborn so that a male can

carry on the occupation of his parents. This shows that the most pressure is put on the firstborn to carry on the family's tradition and that there is less pressure put on the younger siblings to follow in the same path as their parents (although often times they do as well). Thai families would take great offence if one of their children refused to follow the path that their parents want them to follow.

Another reason that Thai children follow the line of work that their parents do is the respect they have for their community and its values. By following in their parents' footsteps they ensure that the community has all the skilled workers and laborers that it needs to continue thriving. The community fears that if a certain working tradition is not carried on that the community loses something important and is harmed. Following in the footsteps of one's parents is not only encouraged by the parents themselves but the community at large due to this fear. Growing up in this environment it is not hard to see why Thai children often follow in the footsteps of their parents.

A third interpretation of this value incorporates economics. Though it may not seem cultural at first, economics is related and plays a role in this decision. Children who grow up in poor families have to get a job as soon as they can in order to help their family. This cuts off opportunities that they may have had (like the chance of going to a university). This further demonstrates the cultural importance of family where a child will value the needs of their family over their own personal desires. Although this is more out of necessity and permeates throughout many cultures Thai people clearly place the needs of their family first and foremost over their own needs and desires. This will play a large role in Det's decision to continue onto a University. Unfortunately Det's family is too poor to pay for the housing, food and books that the Toyota scholarship does not cover. Det's family is a family of farmers whose main source of income comes once a year and who supplements their income by performing whatever jobs are needed. As a result of this Det needs to help his family out by working on the weekends, (when he is not in school) working all day for small amounts of money. The decision of whether he goes to college is based largely on his family needs.

This is very different culturally from the environment I grew up in both personally and communally. In the United States we are told with hard work and determination we can do whatever we want and are encouraged to pursue whatever dream we personally have independent of what anyone else thinks. This can best be stated in something my mom used to say to me before I went to bed "you can do, have, or be anything you want all you have to do is set your mind to it mom and dad love you and we're here for you and support you in whatever you decide to do". For me this was something that was totally different and it initially troubled me. It surprised me that most if not all people growing up in this system were not bitter about this lack of choice. In fact they seem happy with this arrangement. After evaluating the cultural values surrounding this tradition I can see why children are happy to carry on the tradition of their parents due to a strong bond that they have with their family and their community who in turn is like an extended family. I believe that if I were a part of the culture that I would also be

happy with this fact of life partially because I would be immersed in this culture but also because I would understand many of the intricacies I may not even see yet. Growing up in this culture it would be a fact of life which is accepted as normal though it may seem burdensome to people of another cultural tradition like that of the United States.

"Do You Use Whitening Cream?"
Hannah Israel

"Do you use whitening cream?" I was sitting in a Chulalongkorn student common room when I was asked this. My skin is very light but still, I was confused by the question. I quickly answered that I did not use the product. My answer seemed a little surprising to the Chulalongkorn student but the topic of conversation moved on. Later while walking through the pharmacy section of the local Tesco Lotus I noticed rows upon rows of skin whitening and lightening products. These skin products came in many different forms from oils to powders to creams. The abundance of these products made it clear to me that the desire for lighter skin was common among Thai People.

Weeks later at the Baan Na Yao School I was asked again about my light skin color. A student pointed to my arm and in English said "white skin." Then pointing to her own arm she said "tan skin, I want white skin." I told her that I wanted tan skin and she jokingly said that "maybe we can trade!" We laughed for a little while and kept talking. After talking with this student I thought back to the whitening cream question and how the desire for lighter skin was so foreign to me.

At first I was surprised by the Thai desire for whiter skin. The concept of whitening cream was completely new to me as I had never found this product in the United States. Growing up, I was taught to view all skin colors equally, one no better than the next. My background led me to interpret this want for lighter skin as a sign of racism. I saw the Thai people's efforts to keep their skin light as a message that dark skin is bad or undesirable.

Though my culture and background led me to believe that the whitening lotion was a sign of racism, my observations of the Thai people did not. The WPI students and I were often called *farang*, the Thai word for foreigner, but we were never treated as inferiors. Instead we were normally greeted with smiles and kind words. While at the Na Yao village I spoke to a man who praised America for its diversity. He commented that he wished Thailand would follow in America's footsteps and become a more diverse nation for we are all human and so, all equal. My experiences with Thai people led me to reconsider my initial interpretation of the reason for whitening cream.

As I thought more about the whitening product I considered the use of tanning lotion in the United States. People do not apply tanning lotion because they feel that tanner skin will make them superior to someone with lighter skin. Those who use this product do so because they feel it makes them more attractive. Bearing this in mind I thought again about whitening lotion. The whitener might not have so much to do with racial superiority but with the Thai image of beauty. This caused me to think back on the trip to Kanchanaburi which was attended by both WPI and Chulalongkorn students. While most of the WPI students spent much of their time in the sun trying to tan their skin, most of the Chulalongkorn students stayed in the shade,

shielding their skin from the sun. I later asked a Chulalongkorn student, about this. She explained that her friends and she do not like to tan because they feel that tan lines are very unattractive. As I did not completely understand why she or her friends preferred lighter skin, she did not fully understand why I or other WPI students would want tanner skin. Discussing the Thai image of beauty helped me to more fully understand that beauty is truly in the eye of the beholder, or the culture.

I later brought up the topic of whitening cream with the same Chulalongkorn student. Her explanation of the product surprised me. She explained that many foreign tourists believe they can take advantage of Thai women. Because some Thai women flatter these foreign men, the men think that all Thai women will do the same. Even so, foreigners are less likely to attempt to take advantage of well off Thai women than of working Thai women. To prevent these types of interactions with foreigners, many Thai women strive to keep their skin as white as possible in hopes of distinguishing themselves from working women, whose skin is typically tanner. This is not something I worry about at home so I did not initially make the connection between skin color and the interactions with Foreigners.

My experiences in Thailand have taught me not to jump to conclusions. Through these experiences I have determined that my initial interpretation of the Thai use of whitening cream was not entirely correct. The Thai people as a whole do not whiten their skin to feel superior to those with darker skin. Instead I have found that the desire for whiter skin is based in multiple facets of Thai culture. One of which is the Thai interpretation of what is beautiful. Currently in America many people view tanned skin as beautiful but in Thailand lighter skin is commonly viewed as more desirable. The desire for lighter skin in Thailand is unfortunately also due to Thai interactions with tourists as many foreigners take Thai people more seriously if they have lighter skin. Observing my surroundings and asking questions has given me a better understanding of Thai culture and how it has lead to the Thai desire for lighter skin.

"Please, Come join us!" – Thai Hospitality

Sarah Lax

"Treat people the way you would like to be treated." "Don't stare." "Stop pointing its rude." All of these phrases echoed through my childhood as a typical American kid. My parents, like most in our country, were doing their best to engrain these ideas into my head so that I would be a good polite person. It seems to me like American people in general are confident that they are both polite and hospitable to the people they meet. Of all the cultural experiences and observations I've made during my time in Thailand I've noticed an even greater level of hospitality in the Thai culture. In my time here thus far I've been stared at, giggled about, and photographed; but I've also been treated with much greater hospitality then I could ever have imagined in the U.S.

My time spent in the rural area of the Na Yao village in Chachoengso has been the most culture-filled experience I've ever had. I've been treated here, more as a visitor than as a tourist. One person from a previous rural education IQP advised that the people in rural areas would appreciate you more because you took the time and effort to come out of the city to see what their culture is really like. I have had a much different experience because of that.

The first thing I noticed when I began working at this school was the completely different standard on politeness with strangers. The first day that I walked around the campus I noticed that students were pointing, laughing and clearly talking about us. Very few kids tried at all to speak to us and those who did typically giggled and ran away. Even worse, if any of us Americans made some sort of mistake, we were made fun of further. Eventually though, the students became more accustomed to our presence and they stopped laughing and pointing at us every time we saw them. Many students began talking to us and wanted to hang out, play sports, and learn English from us.

There have been other experiences to show this extreme form of hospitality and politeness. On a few weekends, the four of us foreign WPI students were left alone in the village (with no Thai group partners around to help us communicate). We decided to venture into the town on foot to see what or who we could find. To our surprise we found ourselves sitting around a grand lunch of homemade papaya salad and noodles, soon to be in a photo-op with a group of native Thais whom we had only just met. We were just walking by and they beckoned us over to sit with them. They fed us lunch and we all sat around talking for an hour, in very broken Thai and English. The language barrier wasn't even an issue because everyone was so open and friendly that we were always laughing it off when there was any confusion.

Every time that we have gone into the village since that incident, we have met both people that we recognize as well as new people. One man even gave us a ride home and then came to the school later to sit down and talk with us. We talked with just him for another hour, but this time in English. He talked to us about the importance of different cultures and explained why he loves English and American people. This man hadn't spoken English to anyone for over ten years, but was still completely proficient in the language because he studied so hard reading every morning to learn more.

Initially, the most confusing thing about these incidents was that none of the Thai people expected that we would be shocked by their actions. To them, the giggling and pointing wasn't rude; and the great hospitality wasn't abnormal. In America, people would rarely act in those ways, or at least not to those extremes. I have developed two interpretations of this difference: 1. the Thai people outside of the city have never interacted with foreigners before and are shocked or confused by us, 2. they are genuinely more hospitable people as a result of their cultural values and do not have that same standard for the rudeness of pointing and laughing at people as does American culture.

My first interpretation is the gut instinct that I had when I first started observing these Thai responses to our presence at the school. Through conversations with the students and teachers as well as observations during my time here, I've seen just how isolated this village is: there are only two real roads running through the town (only one of which can take you far out of town), the population is small enough that I have begun recognizing faces in the market every week. I thought that because of this isolation many of the people here would have never seen an

American person before and would therefore be shocked that all of a sudden there were four living here. Many of the younger children especially, are extremely shy and would actually be afraid to talk to us before literally running away. These simple factors led me to believe that the seemingly peculiar behavior was just a response to the shock of seeing people who are so different in an area which is populated by only Thai people and Thai culture.

Upon further observation and thought, I came to a second interpretation. The adults showed a similar reaction as the young people we encountered, but in a very different way. Adults are not shy or giggly like the children here but they do show that same curiosity and hospitality. I talked with one of our Thai group members about the topic of hospitality and she told me that it is a major part of the Thai culture to be kind to everyone. She said that Thai children are raised to treat any person (even strangers) like family and give freely to them as you would to your own true family. This explains why the people we encountered in the village were so excited to talk to us and offered us so much food. They were just treating us the way that they would any other person wandering down the street; it had nothing to do with our nationality or any other foreign trait that they saw in us. The one man who we spoke to at length in English described his idea of an ideal world, where many cultures could mix together in diversity like in America. He wanted people to "treat each other the same…we are all the same." This demonstrates that the Thai people don't show such great hospitality because we are strangers, it's because they treat everyone with great hospitality because they view every culture as equals; that is how they were raised.

My evaluation of these events pulls from both of my initial interpretations. I see now that my original interpretation was based on American cultural values and simple observations. I needed to consider the Thai point of view on why they were acting this way. I now believe that the reason I encountered both hospitality and perceived rudeness was the varied age groups and situations that I was interacting in. Familial hospitality and openness is a strong Thai cultural value which parents likely work to instill in their children. Just like any other culture though, that value is not entirely widespread because there cannot be a sweeping generalization over the entire country. There is also the factor of age. Thai children will not have yet fully embraced their cultural values like adults have. In countries worldwide it is somewhat expected that younger people will be less knowledgeable and poised than their elders, so they are occasionally allowed those social faux pas depending on their age. This may be why I received giggles and teasing from children, but respect and hospitality from adults. I also considered the situation I was in. I was out in a rural village with traditional Thai people. After returning to the bustling city of Bangkok I realized that the hospitality and openness comes not only with age but with region as the people of the city are used to having tourists around all the time and do not always treat them the same way.

This understanding of the Thai cultural value of hospitality has been a result of both first-hand experience and conversations with close friends about the subject. I feel much wiser for having viewed the idea of hospitality from both the American and Thai perspectives. Without that Thai

perspective I would see their generosity as peculiar, when really it is normal and expected as a value across the Thai culture. This shows one great difference between the Thai and American people. Both the American and Thai people feel that they are polite and hospitable, because they are raised in separate societies with varied standards set to define those values. But the two traits are actually very different when compared side by side. Neither one is better than the other but it is interesting to see first-hand the differences from both points of view.

Differences in Respect of Elders

David Saxner

It was 10 am on the last Sunday of January and four farangs were walking down a small paved two lane road in the Na Yao village. They had woken up with a goal in mind that morning: to explore the village they were in without the assistance of their Thai group partners who were in Bangkok for the weekend. After breakfast ended at 9:30 am they departed on their journey to see the village and gain a greater knowledge of Thai culture. During their walk they had passed a few houses and a couple of people on motorcycles. After approximately half an hour of walking they had rounded a bend and encountered a party going on across the street from where they were. At the party were some of the students from the school they had been working at to create science laboratory activities. The students had waved them over and the farangs crossed the road to join the students. After they arrived at house where the party had been happening an older gentleman, perhaps one of the students' fathers had grabbed two of the farangs and pulled them over to the area where he had been sitting. They were given chairs and motioned to sit by the other three older gentlemen sitting nearby. The farangs had a conversation using their slight knowledge of Thai and one of the gentlemen's partial knowledge of English. While large amounts of delicious food were provided a crowd slowly gathered around the farangs. After an hour had passed the four farangs decided it was time to move on, but not before many group pictures were taken. The entire time the students who invited them over had been watching the interactions between the elders and the farangs, but they had never attempted to interact with the farangs that they had invited to the party. The way the students acted and the respect they instilled upon the elders by allowing the elders to monopolize our time caused me to think about the differences between American and Thai cultures related to respect for ones elders.

View 1- My View Using American Culture

What occurred was slightly disrespectful to the students who invited us over. There is a level of mutual respect between people that if you invite someone to a sit down party in the manner that occurred you expect them to sit at the same table as you or at the very least to hold a conversation with you for a while. While it would be disrespectful to the elders to not allow them to talk to the guests for a while, it was disrespectful to the students to not allow them to have a conversation with the people they invited.

View 2- One Thai Group Partners View using Thai Culture

It is completely normal and the students were just providing the elders with the respect they deserved. "It is just an aspect of Thai culture." It does not seem out of the ordinary for this to happen, especially with teachers. Families like to know their childrens' teachers and have trust

in them. Parents and elders talking to teachers is just a way for the families to get to know the teachers and strengthen bonds between them.

View 3- Another WPI Group Partners View Using American Culture

This would not occur in the United States as parents expect us to spend time with the people we would invite over. If the parents or elders wanted to hold a conversation with the farangs they would have invited them over. Because the students invited the guests over it should be assumed that the students would talk to the guests and the elders had no interest in doing so.

I felt uneasy about the situation at the beginning since Thai culture differs from American culture greatly in this area. As time progressed I became more at ease with the situation once I looked at it from the Thai perspective. Both cultures have respect for elders and parents, but Thai culture contains complete respect for elders while American cultures respect for elders is less absolute. I feel that at some point the elders should have invited the students to join us so that they could hold a conversation with the guests they had invited to the party. Had I been in the students place I would have felt disrespected by the elders. At the same time I completely understand why the students and elders acted the way they did. Had I been brought up in a Thai culture where respect for elders is more than just general respect for others, I would have done the same thing had I been in the students place. For them allowing the elders to monopolize the guests was just providing the elders with their due respect. If I had been one of the students I would have not felt disrespected, as the elders had earned the privilege to do so. After looking at both American and Thai perspectives my feelings are that it would have been nice had the elders invited the students to join us, but it is completely understandable that they chose not to.