Promoting Active Teaching Methods in Rural Thailand

A Case Study on Science Laboratory Activities

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by
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AUTHORSHIP PAGE

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ABSTRACT

The aim of this project, sponsored by H.R.H. Princess Maha Chakri Sirindhorn's projects, was to help teachers in Sakon Nakhon increase science literacy. Many schools in the rural areas of Thailand rely on science education that does not include science experiments. We collaborated with local teachers to implement, refine, and evaluate three science experiments in two schools in SN. Results suggested that these experiments and related short activities increased student engagement in class and often fostered learning of science concepts. We recommend that experiments be further researched and distributed, and teachers receive professional development in order to further develop science literacy.

EXECUTIVE SUMMARY

Educational reform can be used as a mechanism for addressing the social problems of poverty and economic disparity in developing countries. In Thailand, one of the goals of most current educational reform, the 1999 National Education Act (NEA), is to improve science literacy in order to develop well-rounded, educated citizens that are prepared to make decisions beneficial to their country. Experts consider the educational goal of science literacy as one of the most effective tools for economic and social development (Miller, 2001). Within the NEA, the definition of science literacy is one that emphasizes active teaching methods as a tool for developing critical thinking and problem solving skills (Office of the National Education Commission, 1999). However, it can be difficult for teachers to implement active teaching methods without previous experience. This can be aided through professional development.

Many organizations have been working toward the implementation of active teaching methods in rural areas, one of which is the Office of H.R.H. Princess Maha Chakri Sirindhorn's Projects. The Office has been primarily concerned with promoting development in poor areas. One of the focus areas of the Office in the Northeast Region is the Sakon Nakhon Province. This province is currently affected by environmental problems that include agricultural runoff, soil depletion, and overfishing. Schools in this area often face challenges. Lack of funding leads to a scarcity of qualified teachers and teaching materials, and the exclusive use of traditional, rote teaching methods decreases student engagement and attendance. Taking into consideration the challenges faced by the province, the Office sponsored us to work with two schools in the Kusuman District: the Potisan Wittaya School and the Baan Na Peang Sawang Wittayanukul School.

METHODS

The primary goal of our project was to design and implement three science laboratory activities in the Potisan and Baan Na Peang schools. We approached our project by helping Thai teachers learn new pedagogic tools, and by partnering with them to effectively create replicable science lab experiments. The main purpose of these science experiments was to engage the students while teaching core topics of the Thai National Curriculum. In order to achieve this, we structured our project to be completed through the following four major research objectives:

Select and adapt a list of experiments that are relevant and engaging for students in Sakon Nakhon. - Through interviewing educational professionals and conducting a literature review, we designed criteria through which we selected and adapted a set of experiments that could be modified and refined to the specific schools in Sakon Nakhon.

Partner with teachers to present new techniques, and to refine and implement the experiments we adapted. - Through a series of informal interviews with each teacher, we attempted to refine our experiments to arrive at the best possible outcome.

Analyze the effect of the experiments on teachers and students. - We examined the effect of the experiments on student engagement, student understanding, and teachers' and students' opinion on science literacy and our experiments through pre- and post- tests and informal interviews.

Disseminate information about science experiments to other schools in the Kusuman District. - In order to have a greater impact with our project, we used two methods to share our findings with the Kusuman District. First, we compiled our findings into a teacher's guide that could be delivered to the region. Next, we held a science fair that showcased the developed experiments, and contained stations to inspire excitement for science education.

PROJECT OUTCOMES

The following section outlines these experiments and their outcome after implementation in the classroom.

Mattayom 1 (Grade 7) Experiment: Salinity and Plant Growth

This experiment examined the effect of salinity and plant growth. Students exposed morning glory seedlings to differing solutions of salt and examined how this affected the size and health of the seedlings over a week.

During implementation, teachers were concerned that this experiment took too long to run, and that the concept of osmosis was too difficult for students to understand. Despite the difficulties associated with this experiment, students and teachers believed that this experiment did achieve some educational goals, and results from the pre- and post- tests suggested that this experiment had a positive impact on student understanding. Students and teachers believed that the information presented in this experiment could be related to the students' professions as farmers.

This experiment was supplemented with a short activity where students dramatized the mechanisms of osmosis. Both the students and teachers believed that this was the element of the experiment that the students would remember the most.

Mattayom 2 (Grade 8) Experiment: Incomplete Combustion and Air Pollution

This lab explored how the combustion of different fuels creates different amounts of air pollution. Students collected the particulate matter created in the combustion of ethanol and motor oil. The students were then asked to draw conclusions about the effects of combustion on air pollution.

This activity was extremely well received by the teachers and students, as it engaged both students and teachers. Teachers were also happy that this experiment and the concepts behind it

were simple enough to be taught in one class period. In addition, results from the pre- and post-tests suggested that this experiment had a positive impact on student understanding.

Mattayom 3 (Grade 9) Experiment: Algae Bloom and Local Ecology

In this experiment, students explored the effects of fertilizer on a population of algae. The algae exposed to the fertilizer grew into an algae bloom. Students then examined the effect of algae blooms on local food chains.

This experiment had mixed degrees of success. While the experiment was run successfully during testing in Bangkok, a different fertilizer was used in Sakon Nakhon. The fertilizer used in class did not stimulate algae growth. Instead, the fertilizer killed the algae. In addition, the time requirement to teach the use of scales and microscopes exceeded that which teachers were comfortable with. Despite these setbacks, we did collect data that showed this experiment was successful in some areas. Students were more engaged by the use of microscopes and scales, and teachers were excited about connecting the lesson to student's daily lives. Results from the pre- and post- tests suggested that this experiment had a positive impact on student understanding.

This experiment was supplemented by a short activity demonstrating the difference between a food web and food chain. Our data suggests that this activity was successful in demonstrating the difference between a food chain and a food web.

DISSEMINATION ACTIVITIES

One of the important elements of our project was compiling the finalized experiments into a teacher's guide that could be used to provide materials that may enable these experiments to be used elsewhere in Sakon Nakhon. The teacher's guide contains a variety of additional information to help teachers run these experiments in the classroom.

In order to increase excitement about science education and promote the use of our activities in Sakon Nakhon, we organized a teacher's fair. Many teachers and students from the region came to see our work at Potisan and Baan Na Peang schools. The refined experiments were showcased in the auditorium and presented by the teachers and students that performed them in class. In addition, we developed fun science stations to keep the students interested and promote science education.

CONCLUSIONS

The information we gathered while implementing activities in Sakon Nakhon led us to conclusions concerning how to execute science activities in similar poor rural regions. Following are the main conclusions we drew from our work on this project.

Our project demonstrated that lab experiments could be used to increase student engagement and understanding, and thus may be a worthwhile pursuit for education in Sakon Nakhon. More specifically, results from interviews and pre- and post- testing suggested that these two indicators of student learning were increased when science experiments were introduced to the classrooms.

Experiments tend to be easier to incorporate if they align with both the Thai National Curriculum and the topics covered in class. Teachers in the Kusuman District have the flexibility to determine the order and extent to which they cover the topics of the Thai National Curriculum. Experiments that align with what the teacher is currently covering in class may require less time and effort to implement.

Clear and detailed explanations aid teachers and students in completing lab activities. Due to the novelty of experiments to the Kusuman District, teachers and students feel more comfortable in completing experiments when they are given clear guidance. By including more explicit instructions, we noticed a greater ease in running experiments.

Short experiments and small, fifteen minute activities were more successful than lengthy experiments in the schools we worked with. Teachers stated they were more comfortable running short experiments and activities than those that took more than one class period. In addition, teachers stated that small, fifteen minute activities were more efficient at teaching information than passive lecture.

RECOMMENDATIONS

Based on the conclusions discussed above, our team has developed a set of recommendations for future educational development in Sakon Nakhon.

We recommend that the Kusuman District Department distributes the Teacher's Guide we prepared to other schools in the Kusuman district. The Teacher's Guide contains information that could help other teachers use our experiments in the region. By distributing the guide, the Office of Sakon Nakhon Educational Service Area 1 will begin to spread our experiments to other schools in the region. While this may be effective at letting other teachers learn about our experiments, the written instructions in the guide may provide insufficient support for teachers not used to running experiments in the classroom.

We recommend that Kusuman District use the schools we worked with as models for further professional development in the area. The teachers we worked with at Potisan and Baan Na Peang have keen insights in running our experiments in the classroom that may be useful to other teachers in the region. In addition, teachers may benefit from the additional guidance on the active teaching methods that they are not familiar with.

We recommend the Office of H.R.H. Princess Maha Chakri Sirindhorn's Projects to encourage the development and dissemination of more 15 minute activities that align with curriculum topics and are readily available to teachers. These shorter activities still promote the same active teaching methods as the adapted science experiments. However, the smaller scale of these activities allows teachers to be more comfortable with experiments, and they interfere less with teachers' schedules. Thus shorter activities could be used as a tool to better transition the teachers to the use of active teaching methods. We recommend that the schools continue to use these activities and the Office of Sakon Nakhon Educational Service should spread them around the region to show some basic scientific concepts. Additionally, we recommend that more short activities be developed and spread through the schools in Sakon Nakhon.

This project adapted three science activities for the Baan Na Peang and Potisan schools. During out limited time at these schools, we observed some short-term positive effects. While the precise long term effects are not yet clear, they do hold value as a small building block towards increasing science literacy through the adoption of active teaching methods in the region. If these experiments are run in conjunction with other projects developing education in the region, the people of Sakon Nakhon may benefit from a higher level of science literacy, and may one day use this knowledge to increase their quality of life.

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1. INTRODUCTION

Education can be used as a mechanism for solving the social problems of poverty and economic disparity in developing countries, such as Thailand. Thailand's most current wave of educational reform began with the 1999 National Education Act (NEA). One of the main goals of the NEA was to break away from traditional rote-memorization, instead emphasizing a balance between active and passive teaching methods. This educational reform, coupled with other financial and economic reforms which were enacted in the same period, appeared effective in reducing poverty throughout Thailand. However, the effect wasn't geographically homogeneous. The educational reforms caused by the NEA have yet to spread to the economically poor, rural regions (Thailand's Educational Reform, 1999).

One of the goals of educational reform in Thailand is to improve science literacy. Experts consider the educational goal of science literacy as one of the most effective tools for economic and social development (Miller, 2001). Some educators commonly define science literacy as the knowledge of fundamental facts of science in order to make educated decisions. Within the NEA, the definition of science literacy is one that emphasizes active teaching methods as a tool for developing critical thinking and problem solving skills with the goal of making well-rounded, educated citizens that are prepared to make decisions beneficial to their country (Office of the National Education Commission, 1999).

Although Thai educational reform has promoted the use of active teaching methods, many rural regions, such as Sakon Nakhon, are still transitioning from the exclusive use of traditional, passive teaching methods. The addition of active teaching methods to classrooms exclusively using traditional, passive teaching methods can increase student understanding (Ross, 2001). Encouraging any professional to adopt new practices is a difficult task, which can be aided through professional development. Professional development helps educational professionals adopt new teaching methods and become comfortable using them in their classrooms.

One organization that is working to promote science literacy through increasing the use of active teaching methods in rural areas as a means of social and economic development is the Office of Her Royal Highness Princess Maha Chakri Sirindhorn's Projects. One of their focus areas is the rural province of Sakon Nakhon. We were sponsored by the Office to design and implement three science laboratory activities at a secondary education level in the Kusuman District of Sakhon Nakhon province. During the project we worked with teachers to develop, test, and implement a series of science experiments which focused on topics relevant to the community. One of our main goals was to help Thai teachers learn active pedagogic tools, and partner with them to effectively create replicable science lab experiments.

In order to implement experiments and analyze their effect, we started by selecting and modifying existing experiments based on criteria we developed through our literature review. These criteria were developed to make our experiments feasible for implementation in Kusuman. To introduce the experiments we partnered with teachers to present the new techniques and ran our activities in the classroom. Parallel to this process, we collected and analyzed information to further develop and evaluate our experiment's effectiveness in achieving our goals. We focused on obtaining formative and summative information. The formative evaluations gave us information on how to improve the experiments, and the summative evaluations obtained information to assess the effect of the experiments' implementation. We tried to get an idea of the effectiveness of our project through the examination of our activities' effect on student engagement, student understanding, and student and teacher opinions of the activities.

We also selected two dissemination methods, with which we attempted to distribute the refined experiments throughout the Kusuman District. We refined our experiments and approaches for a "Teacher's Guide" and developed an Education Fair, attended by teachers and students from the Kusuman District. The guide, presented in English and Thai so as to reach a larger range of schools, is designed to be reproduced, spread, and presented as a tool to help teachers implement active methods. During the Education Fair we presented examples of our experiments and their respective explanations as well as diverse fun experiments exemplifying easy science concepts to encourage student curiosity for science. Through the Teacher's Guide and the Education Fair, we hoped to have an impact in Sakon Nakhon beyond the Potisan and Baan Na Peang schools.

2. BACKGROUND

In this chapter we show how poverty and economic disparity are issues that affect the Northeast region of Thailand and how education can be a mechanism to address these problems. Studies have shown that improvements in environmental literacy and science literacy in rural communities can aid in solving problems affecting quality of life. One mechanism of increasing science literacy in these areas is the use of active teaching methods. The final section of this chapter investigates how active teaching methods can be applied to the poverty and education problems in Sakon Nakhon.

2.1. Education as Part of the Solution to Poverty and Economic Disparity in Thailand

Poverty and economic disparity are issues that affect the Northeast region of Thailand. We explain in this section how educational reform can be a mechanism to help solve these problems. According to Thailand's National Economic and Social Development Board, people living under the "poverty line", the amount of income needed to be able to afford the basic necessities of life, are classified as being impoverished (Thailand's Official Poverty Lines, 2004). Information from the CIA World Fact Book states that approximately 10 percent of Thailand's population lives under these conditions (Thailand Population below Poverty Line, 2008).

A chain of historical events, which led to the current poverty levels, was partially addressed by a new wave of reform in Thailand. From the 1980s to the late 1990s, the Thai economy grew dramatically and then collapsed due to varied economic failures (Leightner, J.E, 2007; Recovery through reform, 2004). The ensuing recession echoed through the neighboring countries, resulting in the Asian Economic Crisis of 1997. The Asian Economic Crisis was used by Thai government officials as a "wake-up call to reform" (Fry, 2004). This reform was multi faceted – social, economic, and educational, and ranged from a whole-scale reform of schools in the National Education Act to a healthcare reform that made healthcare accessible to more citizens in Thailand.

These reforms decreased poverty and economic disparity among the people of Thailand with a geographically varied effect. Figure 2-1 shows poverty distribution in Thailand through the years 1996 – 2004, using data taken by the National Statistics Office (NSO), compiled by Thailand's Chamber of Commerce. As seen from the figure, Bangkok and the Central regions of Thailand have fewer people living below the poverty line in comparison to the North and Northeast regions. The chart shows the increase, and later the gradual decrease, in poverty throughout Thailand reflecting the economic failures and the impact of the National Reforms.

The Northeast region of Thailand remained the most impoverished region of Thailand until 2004, when poverty levels decreased to equal those in the Northern region.

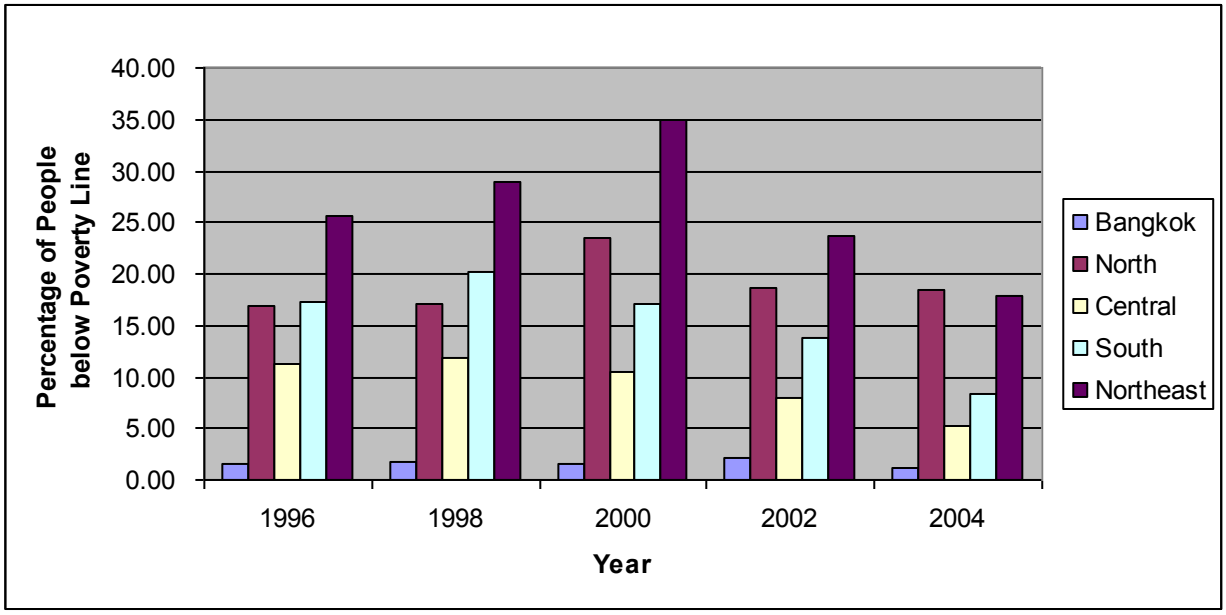

Figure 2-1: Region-Specific Poverty Distribution in Thailand (Thai Chamber of Commerce, 2006)

Data collected by the Office of the National Economic and Social Development Board not only depicts a trend of reduction in poverty in Northeast Thailand, but shows it is becoming concentrated in the Northern and Northeast regions of Thailand. Figure 2-2, using the same data collected by the NSO survey in Figure 2-1, shows that the geographic discrepancy in percentage of impoverished people is even more dramatic when comparing the Northeastern province of Sakon Nakhon with the averaged value for Thailand. The number of impoverished people dropped in Sakon Nakhon after the reforms, but did not see the continued improvement that most of Thailand did.

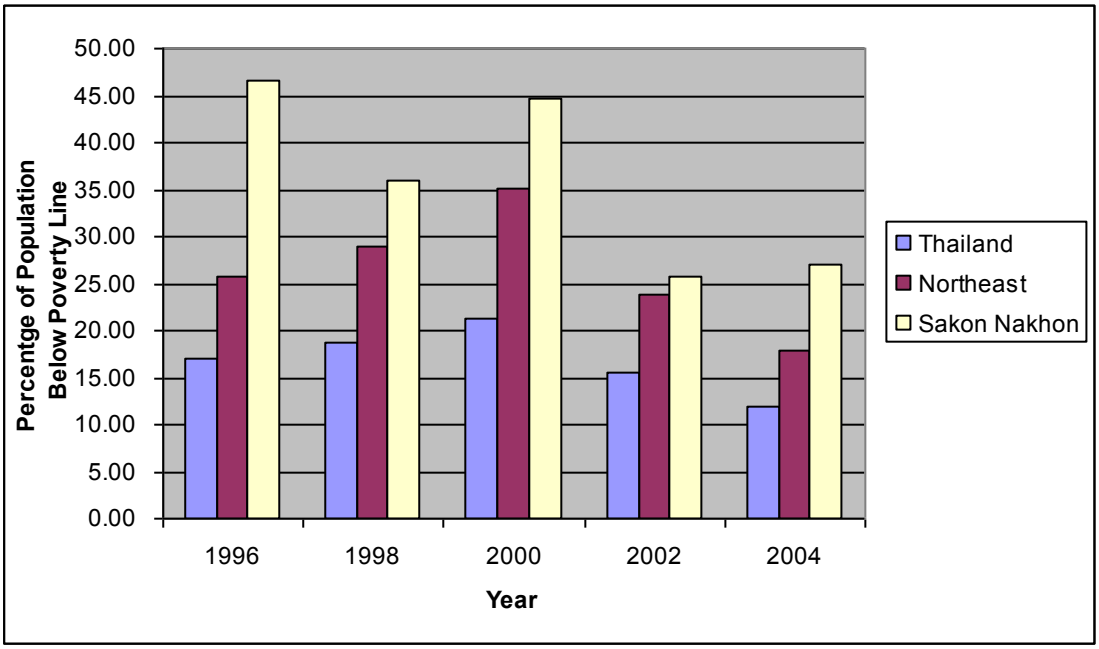

Figure 2-2: Poverty Distribution in Thailand with Focus on Sakon Nakhon (Thai Chamber of Commerce, 2006)

The previous figures show, and experts agree, that large scale reform such as the one implemented in Thailand can be an effective tool in the fight against economic disparity and poverty. One aspect of reform that has been shown to be effective in fighting poverty and economic disparity is educational reform (Fry, 2000). Research shows a mathematically inverse correlation between the level of education of the head of household in Thailand, and the likelihood that the family will be below the poverty line, as shown in Figure 2-3. This data demonstrates how education can have a strong impact on reducing the poorest class of citizens. One of the largest drops in poverty is between no education and lower primary education, and between higher primary and lower secondary education. This shows that students, who stay in school past the higher primary level, as required by the NEA, are more likely to live above the poverty line.

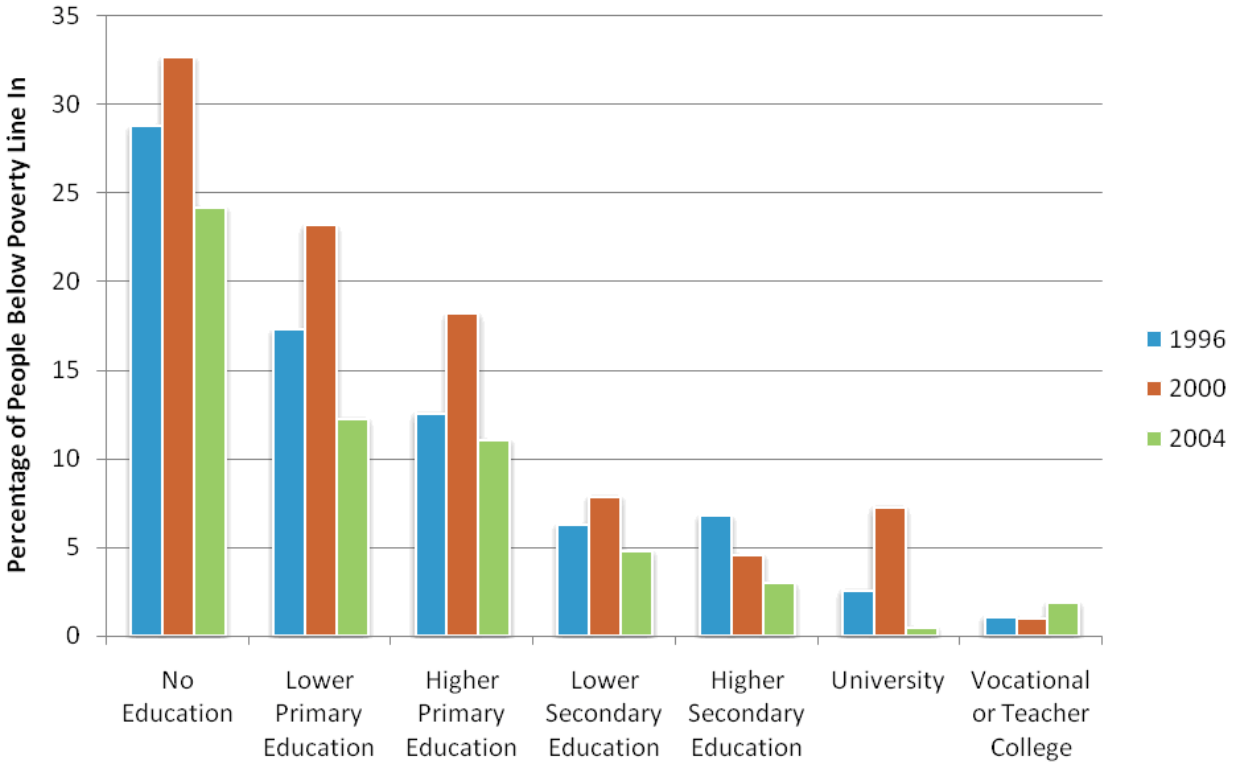

Figure 2-3: Poverty and Education Level in Thailand (Adapted from: Poverty in Thailand, 2004)

The most pertinent part of the post-1997 reforms to our project was the educational aspect, in the form of the 1999 National Education Act (NEA) (Thailand's Educational Reform, 1999). Before this reform, only six years of school were theoretically compulsory for Thai students. The NEA increased the compulsory number of years to nine, and provided funding for students to continue for twelve. One of the goals of this reform was to improve science literacy in order to develop well-rounded, educated citizens that are prepared to make decisions beneficial to their country. Within the NEA, the definition of science literacy is one that emphasizes active teaching methods as a tool for developing critical thinking and problem solving skills (Office of the National Education Commission, 1999).The Thai government recognized that non-traditional education plays an important role in poverty reduction and a country's ability to thrive in a global environment (Thailand's Educational Reform, 1999).

2.2. Science Literacy as a Goal of Education

Improving science literacy is considered by experts to be a goal of education, and is often argued to be an important tool for economic and social development (Miller, 2001). Although the precise definition and success of this goal is a topic of constant debate among experts, many agree that science literacy levels are insufficient in both developed and developing countries.

Some researchers believe lack of basic scientific knowledge on hygiene and agriculture can dramatically reduce the quality of life of people in developing regions (Shen, 1975; Laugksch, 1999). In developed countries, some experts consider the gap in scientific understanding the cause of uninformed decisions made by both government offices and local parties (Sadler, 2004).

One common definition of science literacy used by educators is knowledge of the fundamental facts of science in order to make educated decisions. In this viewpoint, knowledge of scientific principles can aid society by allowing people to make informed decisions (Sadler, 2004; Laugksch, 1999). A view that is sometimes shown in conjunction with the previous definition is that science education should develop an understanding of the scientific method. Proponents state that learning the scientific method will allow students to apply scientific thought to problems. Some researchers believe that the process of science is too broad to be taught in a class room. Others think that the process is changed and modified for each problem and field. By limiting scientific inquiry to a specific methodology, people may be using the wrong procedure to solve their problems (Bauer, 1994).

Views on science literacy tend to change in response to current events and opinions. One example from the United States, cited by DeBoer, explored the view of science literacy around the end of World War II. At this time, people feared the power of science and technology because of the invention and use of the atomic bomb. Educators believed that the goal of science education was to allow people to know the risks associated with technology and make informed decisions. In the light of growing globalization in the 1990's, the goal of science literacy was aimed more toward raising general scientific knowledge and intelligence in order to help the United States compete in the global economy (DeBoer 2000).

DeBoer, a Professor of Educational Studies at Colgate University, states that without a clear definition of science literacy, attempts at reform face serious problems (DeBower, 2000). When selecting a definition of science literacy as a goal for this project, we looked toward the current opinions of education in Thailand. Within the NEA, the current definition of science literacy is one that emphasizes active teaching methods as a tool for developing critical thinking and problem solving skills with the goal of making well-rounded, educated citizens that are prepared to make decisions beneficial to their country (Office of the National Education Commission, 1999). As the foundation of our project, we adapted this definition to make it more relevant to students of science education in the rural Northeast region of Thailand. Our project takes place in Kusuman, Sakon Nakhon, which has not seen the same international influences as urban areas of the country. The goal of science literacy in this setting is one that allows students to make educated decisions based on science concepts and the rural circumstances that surround them in order to improve their quality of life.

Different cultures have different views of science education which were taken into account during the shaping of the project. There is a general concern among experts that the values of

western science education may conflict with traditional values found in other cultures (Mayer, 2002). Modern scientific thought has its roots in Western values, and can conflict with typical Eastern views. Mayer, a professor of education at Ohio State University, explains that Eastern and Western cultures hold differing values in regards to nature. While Western cultures tend to believe that nature is a tool, typical Eastern and Buddhist values tend to support the idea that humans are a part of nature. In education, this can be applied to the fact that focusing on the aesthetic view of nature is inappropriate for science in Western cultures, but acceptable in Eastern teaching practices (Mayer 2002). Another article, based on an exploration into the beliefs of a small village called "Seablast" in Trinidad and Tobago, theorized that the use of "traditional knowledge" can conflict with science teaching. Students in the area are committed to their traditional practices and beliefs, and are reluctant to accept concepts that defy or modify them. Opposing these traditions and beliefs can cause the failure of a science education program (George 1997). Thus, our view of science literacy should reflect the cultural concerns and traditions found in Sakon Nakhon.

Both George and Shen state that science will only be an effective tool in combating social and economic problems if science literacy is viewed as being "practical science literacy." Practical science literacy implies that science education needs to teach topics that will aid communities in their daily lives (George, 1997; Shen, 1975). From these definitions, we can conclude that our goal of "science literacy" in Sakon Nakhon should be to give practical scientific knowledge, with respect to the local culture, that can improve the quality of life for the students. Many problems currently affecting the quality of life in this area are related to economic disparity and environmental sustainability.

2.3. Aiding Community Development through the Improvement of Science Literacy with a focus on Environmental Sustainability

Studies have shown that improvements in environmental sustainability in developing communities can aid environmental problems affecting quality of life. These problems are often due to unsustainable agricultural practices and the unplanned development of communities (UNESCO, 2007; World Bank, 2000). In this section, we discuss the environmental problems in Sakon Nakhon, and how these environmental problems can be aided using teaching methods which lead students to connect scientific concepts to experiences from their daily lives.

Rural communities in Sakon Nakhon, Northeast Thailand are often affected by environmental problems, including agricultural runoff, soil depletion, and overfishing (Hortle and Suntornratana, 2008; World Bank, 2000). The Northeast Region is mainly comprised of wetlands. Most of its tropical forest has been cleared for agriculture. Approximately 54% of the land is used for agriculture. Of this agricultural land, 72.2 % is used for growing rice (Blake, 2006). Since rural areas do not have developmental plans, centralized population pressure is

beginning to affect the fish population. The use of unsustainable agriculture practices, such as slash-and-burn farming, is currently affecting communities through soil erosion and depletion. Another growing problem is the salination of agricultural soils due to irrigation with salty groundwater. This occurs because most villages don't have access to irrigation water from less salinated surface water sources (Hortle and Suntornratana, 2008).

Scientists believe an effective way to address such environmental problems and prevent more harm would be to change people's environmental conduct through education (Lakshmanan, 2000). Many educators are calling for science education which improves environmental literacy to be incorporated in rural communities.

Rural communities in KwaZulu-Natal, South Africa obtained positive outcomes from the implementation of environmental education into their traditional science education curriculum. The communities used a pilot environmental education program developed in South Africa in order to guide communities towards sustainable development. The program was triggered by a national educational reform that required teachers of most science courses to include principles of environmental sustainability, human rights and social justice in their course plan and relate them to current community issues. The focus was new to most teachers in the area, and ended up pointing to the need of teacher development programs. The Rhodes University Environmental Education and Sustainability Unit (RUEESU) piloted such a course, titled 'Schools and Sustainability.' The course focused on guiding and encouraging teachers to fuse their current teaching methods with new active practices in order to present environmental concepts in ways that allowed the students to apply them sustainably to the community. Three features of their teacher development approach apply to our work in Sakon Nakhon. These features promote the following:

1 – **Active, cooperative participation and feedback of teachers during the program and the development of professional relationships amongst participants –** Through this process, teachers learned from each other while providing the pilot program with feedback to make the program more effective and engaging for other teachers.

2 – **Engagement and openness to applying knowledge gained by program towards actively addressing local environmental and social concerns –** The pilot program worked to promote openness in the teachers they worked with while encouraging them to produce impacts in the communities from what they learned in the classroom.

3 – **Design of scaffold learning classroom activities that teach students while using only locally available materials and resources –** Through this process, teachers learned how to create classroom activities that would engage their students and help them to conceptualize the information taught, while not requiring any materials that were not easily accessible.

The program generated a positive response in participant engagement, and many of the teachers embraced the new teaching approach. After conclusion of the program, teachers were able to identify local problems and engage their students in addressing the problems using knowledge gained in class. With the aid of external organizations, some schools were able to conserve water and plant nutritious crops to address the local students' food and water security needs. Evidence of social and structural changes in schools and communities were observed as a result of the implementation (UNESCO, 2007). This case study presents successful solutions to problems similar to the ones in Sakon Nakhon.

Some researchers believe that teachers' roles in development are of the utmost importance. They can inspire others by creating environmental awareness and supporting sustainable development. According to experts in the environmental field, in order for students at secondary levels of education to become aware of environmental issues and the detrimental impacts of certain practices, they need current facts, examples, and case studies (Earth Focus, 1998). A GreenCOM 1996 report states that it takes more than 10 years for important new scientific information to be adapted into the formal education curricula. Therefore it is important for teachers to be able to research and present current environmental problems in the classroom, instead of waiting for the information to become part of the curriculum. Teacher development oriented toward the inclusion of updated information and it's relation to the daily life of the student can help teachers promote change more effectively (TEI, ONEP & DANIDA, 2007). The following section exposes a larger view of the beneficial impacts that professional development can have on the advancement of education.

2.4. Benefits of a Large Range of Educational Methodologies through Professional Development

Although Thai educational reform has promoted the inclusion of active teaching methods, many rural regions, such as Sakon Nakhon, are still transitioning from the exclusive use of traditional, passive teaching methods, including rote memorization, to a more balanced approach involving both active and passive teaching methods. Studies show that learning outcomes can be affected by the presence or absence of a student's preferred teaching methodology (Hativa 2000). Some students are active learners, and need to be presented with information in a way that engages them, whereas others are more accustomed to passive learning and rote memorization (Ross 2001). A greater number of students can be reached when presented with a variety of teaching methods.

The following methods cited by various researchers emphasize science learning through inquiry-based approaches, which are a type of active teaching. The process of inquiry-based learning involves students investigating answers to questions. These questions should be about a problem that is relevant to the student (Kahn and O'Rourke, 2004). Many education reformers emphasize

that science should be taught with a combination of methods (McBride 2004). Constructivist pedagogy, place-based instruction, hands-on activities, and cooperative learning are all active teaching methods that together could have significant impact in Sakon Nakhon.

Constructivist pedagogy is an approach that states that in education, information is interpreted through the lens of cultural norms and past experiences of students. This information, once interpreted, becomes knowledge. Constructivist pedagogy requires the active learning of the student, where he or she will create knowledge through inquiry and experience. Knowledge is not just as simple as acquisition of information (Yilmaz 2008). Learning through inquiry can be a very important process that will develop the student into a better problem solver. Instead of failing to solve a problem based on lack of previous information, students experienced in constructivist learning will be able to investigate the problem, make conclusions about the information that they gather and turn it into a solution. This result allows students to advance their knowledge through adaptation and to be versatile when solving problems instead of relying on a set of standard information to solve the problem.

Place-based instruction is an engaging teaching approach which uses local environments and experiences that the learner is already familiar with to teach concepts. Education then applies to their real life and becomes more interesting, because they can apply this knowledge through the context of something that is real to them. It removes the boundaries of fabricated situations or environments and places knowledge in a real situation for the learner (Sarkar 2008). Students will become more engaged when knowledge can actually apply to their life. When students investigate why things happen in the environment around them it significantly increases their knowledge of the impacts of their actions in the selected environment.

Activities which physically engage students through manipulation of objects to understand science are considered *hands-on* (Haury 1994). Participation in these types of activities, such as classroom activities and science projects, is associated with increased test scores (House 2006). Along with increased proficiency in learning the material, students are more likely to enjoy learning. Hands-on learning also increases the learners' ability to draw conclusions on evidence through independent thinking (Haury 1994). A hands-on learning approach focuses on teaching students to solve problems through practice.

Cooperative learning is one approach to active teaching in which students of different aptitudes can help each other learn. This method addresses the needs of students of all levels instead of teaching to the average students (Lapp 1989). Cooperative learning is characterized by small groups of students working together to solve problems. The teacher guides the groups to achieve their goals and monitors their success. An appropriate group size is around three to five students (Lapp 1989). Studies show that by effectively using the cooperative approach in secondary schools, learning can significantly increase (Lapp 1989).

Many researchers encourage these methods to be integrated together. They are not independent of one another but rather can complement each other when the target approach is active teaching. Often active teaching will include a number of these methods in one lesson or experiment.

While many teachers may understand the benefits of active teaching, adopting these new teaching practices can be challenging. Assistance through professional development is often beneficial. Research has shown that professional development is a mode through which active teaching methods can be instituted in poor rural regions (Ashraf 2005). Implementation of professional development and in-service training of teachers face many challenges. Most teachers have gone through pre-service training and have varying amounts of experience in the field of education before they encounter in-service training. These previous experiences shape the pedagogic methods of a teacher (Ashraf 2005). Experts in the field of science education have stated that teacher development should include acknowledgement that teachers will have tension in accepting any new methods, reflection by teachers on past experiences, and an interactive learning environment (Keys, 2001; Ashraf, 2005).

A report that supports this important reform process was produced by a group of teachers from developing nations who went through the Aga Khan University Institute for Educational Development (AKU-IED). The two practices that enable education ideology to be reformed at this institute are instruction in new methods and field-based practice (Ashraf 2005). Participants in this program learn about a variety of active teaching methods. In doing this, the participants cite that learning the professional vocabulary associated with active teaching gave them the resources to embrace active teaching (Ashraf 2005). After learning the concepts, teachers are given the opportunity to use their new skills in a classroom setting, reinforcing the lesson, through field based practice.

This report by the participants from AKU-IED addresses how to professionally develop through reconceptualization at the institute level, but fails to address the issues teacher's face when returning to their own schools. According to Walberg, without reinforcement, the benefits of professional development may fade with time. Collaborative teaching and peer coaching, even after in-service training is complete, will help to ensure lasting impacts of instruction in active teaching methods (Walberg 1991). If the training is reinforced, active teaching methods could be successfully integrated into teachers pedagogic tool sets in a poor rural region of Thailand.

2.5. The Current State of Education and Existing Educational Projects in the Province of Sakon Nakhon

Educational development is taking place throughout Northeast Thailand to try to address several issues which the region faces. In rural Northeast Thailand, people are heavily reliant on agriculture and fishing as their employment options. 90% of the inhabitants in this region are

farmers and 80% have fishing as a second job (Hortle and Suntornratana 2008). Fishing has a very important impact to the communities because fish is the main source of protein. These occupations are labor and time intensive. A significant portion of youth, 33.5% of 15 to 19 year-olds and 73.1% of 20 to 24 year olds, participate in the economy, thus limiting the time they can dedicate towards formal educational development.

Although the educational reform has spread to great success in more industrialized parts of the country, such as Bangkok, it still isn't reaching the poor, rural regions. Many organizations have been working to aid spread the educational reform to the rural areas. One such organization is The Office of Her Royal Highness Princess Maha Chakri Sirindhorn's Projects. This Office was formed by H.R.H. Princess Maha Chakri Sirindhorn to aid solving problems of "poverty, malnutrition, a deteriorating environment, and fragile health in local people, especially children and youth…focusing on development through the learning process" (The Office of H.R.H. Princess Maha Chakri Sirindhorn's Projects, 2007). She has been working on improving science literacy and education for rural Thai schoolchildren since she founded the Project for Child and Youth Development in Remote Areas in 1980. Since then, the Office has built schools and libraries, introduced distance learning via satellite to help cover the shortage of teachers, and worked to improve teacher training by encouraging teachers to continue learning either at universities or via distance learning.

Given the problems in the Kusuman District, the Office of H.R.H. Princess Maha Chakri Sirindhorn's Projects is exploring the introduction of hands-on, inquiry-based science experiments that focus on issues of local concern, especially regarding local environmental issues. These experiments were requested for the secondary education levels of M1 through M3, the equivalent of grades 7 – 9 in the United States. We were sponsored by The Office of the Princess to begin the introduction of science experiments in two schools located in Kusuman District in the Sakon Nakhon Province. The names of these two schools are the Potisan Wittaya School and the Baan Na Peang Sawang Wittayanukul School. Our work was a continuation of a project which was completed in 2008, entitled "A Sustainable Laboratory Program for the Advancement of Secondary Science Education in Rural Thailand."

The schools are both sponsored by the Office of H.R.H. Princess Maha Chakri Sirindhorn's projects. In each school students are divided into classes based upon skill level. The Potisan Wittaya School, with 734 students, is the more developed school of the two we worked with. Students who attend this school pay additional tuition for their textbooks and uniform. The school has three science laboratory rooms, for physics, biology, and general science. For each science grade level, there is one science teacher. Each grade is split up into five classes and there is a large discrepancy between the first class level and the fifth, where students had difficulty with reading and writing.

The Baan Na Peang Sawang Wittayanukul School has 576 students. This school receives extra funding by the Office of H.R.H. Princess Maha Chakri Sirindhorn's Projects, so that students do not have to pay for uniforms or textbooks, and receive one complete meal per day in the form of a healthy lunch. The school has one science lab and two science teachers. One science teacher teaches the grade level M1 and one science teacher teaches both M2 and M3. There are three classes per grade level. Teachers at this school have stated that many students in the school are not interested in academic subjects and do not have the opportunity for further study. However, they try to provide the students with skills they can use after graduation in their careers.

Both schools face similar problems. Students often come from economically poor families and cannot afford to spend time outside the school day on study or homework. Because the material they learn in school is not being reinforced through extra study, the students learn the material slowly, and do not finish the syllabus by the end of the school year. Already often unable to finish the syllabus, teachers often feel that experiments and in-class activities take up too much class time to be run often, if at all. The continued use of traditional, rote teaching methods leads to decreased participation and engagement in classes. Although rote teaching methods are very successful for teaching certain types of information, they are not conducive to all subjects of education, and often don't connect what is being taught to the student's daily life. Teachers state that, especially in low-income households, students don't feel motivated to participate when they don't see a correlation between what they're learning in school and how they can apply it in their daily lives. Finally, due to the shortage of qualified teachers in the rural areas, science teachers in the Baan Na Peang School taught subjects other than science. This problem is common in Northeast Thailand. These teachers do not always have a thorough background in some or all of the subjects that they teach, due to teacher training which covers how to teach, but not necessarily the specific subjects. In addition to this, they may not have the time or energy to spend a lot of time on preparing experiments or activities to run in their classrooms.

A previous project team worked hard in the Kusuman District in 2008, accomplishing many things from their stay. Through discussions with the teachers from the Kusuman District who worked directly with the researchers, we built upon the previous research and attempted to make our work more beneficial at the Potisan and Baan Na Peang Schools. We learned that only one in four of the experiments developed in 2008 were used in succeeding years. This was the experiment based upon the "Tragedy of the Commons", which taught students about the consequences of overfishing. The other experiments were not used, either because they were at too high of a level for the students, or because they did not fit the Thai National Curriculum. However, the researchers learned ways to better work in a cross-cultural setting and around the language barrier through the use of visual aids and other tools. We made every effort to learn from this project and apply the information to our work.

3. METHODOLOGY

The Office of H.R.H Princess Maha Charkri Sirindihorn's Projects, the sponsor of our project, has been concerned with promoting development in poor areas, focusing on 40 rural districts around the country. One of the districts in which the Office has launched several successful projects is Kusuman Amphoe, where we were asked to work with two schools: Potisan Wittaya School and Baan Na Peang Sawang Wittayanukul School. There we designed and implemented three science laboratory activities with the primary goal of aiding the Office in an effort towards increasing science literacy levels. We approached our objective by helping Thai teachers learn new pedagogic tools and partnering with the teachers to create replicable science lab experiments. We designed the experiments to engage the students and teach the core topics of the Thai National Curriculum. In order to achieve this, we structured our project to be completed through the following four major research objectives:

- Select and adapt a list of experiments that are relevant and engaging for students in Sakon Nakhon
- Partner with teachers to present new techniques, and to refine and implement the experiments we adapted
- Analyze the effect of the experiments on teachers and students
- Disseminate information about science experiments to other schools in the Kusuman District

In this chapter, we describe the approach we took to communicate cross-culturally, the methods we developed to select, modify and implement the experiments focusing on allowing the teachers to feel comfortable with the experiments, and the analysis methods we utilized to refine our experiments as well as identify a few aspects of our project's impact. We also describe our efforts to distribute our findings in hopes of creating wide spread benefits.

3.1. Select and Adapt a List of Experiments that are Relevant and Engaging for Students in Sakon Nakhon

We developed science experiments that would give practical scientific knowledge, with respect to the local culture, that can improve the quality of life for the students. We determined a set of criteria that our experiments should follow in order to be applicable to the poor rural region of Sakon Nakhon. We hoped that this would give us a good foundation for developing our program. With this information we selected a preliminary list of feasible experiments which we discussed with professionals in the field of education.

According to Columbia's University Science Teachers' Community, the design of successful experiments requires extensive research, testing, and refinement (Anderson 2006). In order to use our time most efficiently, we selected experiments that had been already developed and adapted them to Sakon Nakhon. These experiments were found from the National Science Digital Library and the Digital Library for Earth System Education. By redirecting our time, we were able to concentrate on reviewing scholarly journals for information that we hoped would help us select the best experiments possible for the region.

We determined criteria for good experiments, in order to select out experiments. We drew from our literature review to begin developing this list of criteria. In addition, we conducted preliminary interviews with WPI professors Martha Cyr (K-12 Outreach Coordinator, WPI), Mike Buckholt (Director of Biology Project Lab, WPI), and Lauren Mathews (Assistant Professor of Biology and Biotechnology, WPI) regarding the development and implementation of science experiments. This gave us key information on the process professionals use to develop and adapt experiments for classroom settings. After we completed this research, we further developed these guidelines into our criteria for selecting, developing, and authoring the science activities. The notes from these interviews are presented in Appendix A, Appendix B, and Appendix C.

To complement our research on criteria we conducted a review of previous work in Sakon Nakhon. We examined the effect of the experiments developed for a similar project in the year 2008 on teachers and students, and examined the findings of this project through the report. In addition, we interviewed the teachers that participated in the project last year.

Through the analysis of our aforementioned research we decided that in order for our experiments to be beneficial and effective in Sakon Nakhon they must be:

Relevant to the curriculum and suitable for the education level – As teachers stated in interviews (see Appendix D), they wouldn't be able to regularly use the experiments in their classrooms if they did not fit into the curriculum or were at too high of a level for their students to understand.

Replicable by using readily available materials and equipment – Teachers would not be able to replicate our experiments if the materials were difficult to find or out of their budget.

Simple and easy to implement – One reason this is important is that teachers in Sakon Nakhon do not always have a thorough scientific background, which could present difficulties when teaching and running a complex experiment.

Involve hands-on activities - Hands-on activities engage students through manipulation of objects and can increase their ability to draw conclusions (Haury, 1994).

Relevant to students from rural agricultural areas – Active teaching users believe that students who can relate the experimental concepts to their daily lives can better conceptualize the material and use the knowledge in practical ways to improve their quality of life (Lakshmanan, 2000).

We made use of this list of criteria to research and create a preliminary list of six experiments, which we narrowed down to three with the feedback from the Office of H.R.H. Princess Maha Chakri Sirindhorn's Projects, Assistant Professor M.L. Siripastr Jayanta (Liaison for the Office of H.R.H. Princess Maha Chakri Sirindhorn's Projects), Khun Prapatsorn Kosulwat (Teacher Supervisor, Office of Sakon Nakhon Educational Service Area 1), and the teachers of the two schools we worked with. In the following section, we describe the methods we used to further refine our final three experiments.

3.2. Partner with Teachers to Present New Techniques, and Refine and Implement our Experiments

We decided to refine our selected experiments to fit the classroom situations found in Sakon Nakhon. In this section, we outline how we collected information to further adapt the activities to our schools' needs and worked with the teachers to implement our experiments.

An important challenge we had to overcome was how to successfully begin our partnership with the teachers in Sakon Nakhon. We decided that two different issues should be addressed so that an effective relationship could be established. The first issue stems from the existence of a language and cultural barrier. We tried to address this by creating a foundation for effective cross-cultural communication. Most of the teachers that we worked with had either rudimentary or non-existent English. During our professional work, the team would discuss in English before the two Thai team members would relay the information to the teachers in Thai.

The second issue was the need to create a comfortable working environment among the teachers so as to establish a partnership. We drew this from conclusions from similar case studies, and it was reiterated in our interview with Martha Cyr. Teachers are more confident in their decisions, and therefore more willing to be innovative when they are comfortable with their partners (UNESCO, 2002; UNESCO, 2005). In order to encourage the teachers to feel comfortable with us, we initiated our partnership by having informal meetings with the science teachers where we developed relationships with the teachers. We tried to portray ourselves as assisting the teachers rather than presenting ourselves as education professionals, and we expressed that we were not there to evaluate the teachers' or their students' abilities.

Once we established a relationship with the teachers, we held many different meetings with teachers to provide them with information and receive their input. We held informal interviews with them to determine their familiarity with scientific principles and active learning methods.

We used this information to estimate how much time to reserve for testing and refining the experiments with each teacher. In these meetings we attempted to determine what expectations the teachers had for us, which allowed us to align our project goals with their own in order to prevent misunderstandings.

We next held meetings with each individual science teacher, to refine the experiments and run them with the teachers. This allowed us to gain teacher feedback as well as to allow each teacher to become familiar with the materials and the equipment. As in any other profession, it is difficult for teachers to direct and manage an activity if they are not comfortable with the equipment or material. One of the main goals of these sessions was to allow the teachers to modify the experiments and create a sense of ownership. Professionals in the field of teacher leadership state that teachers get more engaged with their projects if they feel a sense of ownership (Smith-Burke, M. T. 1996). To structure these meetings, we developed a set of formative informal interview questions. These questions addressed how the teacher felt about the following aspects of the experiment in review:

- Appropriate alignment with curriculum, grade level, and students' daily life
- Depth, scope, and clarity of background
- Clarity of instructions
- Clarity and degree of difficulty of worksheets
- Ways to improve the experiments
- Extra activities or supplemental information required

The exact questions we used to gather this information are listed in Appendix E.

After we applied the information discovered in our initial meetings to the experiments, the teachers implemented the experiments in the classroom. During this implementation, we withdrew ourselves from the class as much as possible. Members of the research team only helped when absolutely necessary.

Aiming to obtain information to refine our experiments a second time in order to achieve an improved final product, we held informal interviews with teachers and students after implementation. These questions are listed in Appendix F, and they intend to identify the following aspects relative to the interviewee's perspective:

- Difficulties understanding background, instructions, and worksheets
- Amount of time and effort necessary to explain experiment
- Topics the students did not understand
- The degree of student interest
- Repeatability of experiment in the future
- Possible improvements to experiment and instructions

The responses to these interviews are found in Appendix G.

We decided that in order to insure the reliability of the data we gathered, we should use multiple methods of assessment to evaluate the effect of our project. The next section presents the methods we used to complement our previous assessment of experiments and try to evaluate the outcome of our experiments.

3.3. Evaluate and Analyze the Effect of Our Project on Teachers and Students

Due to the short length and the challenges of our project, we recognized that it was not possible to evaluate long term reactions to the project or to expect a drastic change in the students' perception of science. In order to progress towards a successful project, we determined some of the outcomes we wanted to accomplish. We attempted to determine qualitatively, and in some instances quantitatively, the effect of our experiments in three areas:

- Student engagement
- Student understanding of covered topics
- Teacher's and student's opinions of the effect of our project and active teaching methods

We decided to use a cross examination or triangulation approach in an attempt to collect more information that might help clarify our results. For this evaluation we selected the following three in-the-field research methods: a behavioral observation protocol, pre and post questions and informal interviews and discussions with the teachers and students.

3.3.1. Evaluate Student Engagement

The first area of our evaluation explored student engagement. An expert in education, states that education quality can be identified by determining how attracted students are to their work, how persistent they are despite challenges, and how delighted they are in accomplishing their tasks (Schlecty, P., 1994). Several researchers have identified that student engagement is a precondition for learning progress (NCSALL, 2006; AERA 2004). We attempted to determine whether the experiments and activities increase levels of student engagement compared to a passive lecture, which would allow us to estimate the effect of our work on student learning.

Our first approach to assessing engagement was through observation. Two experts agree that one of the best methods to effectively assess student engagement is by direct observation. One main reason for this is that the validity of data yielded by self evaluations depends on the students' ability to recognize their own behaviors, responses, and cognitions (Assor & Connell, 1992). The behaviors measured by existing protocols vary considerably. However some researchers agree that using a momentary time sampling system and having all the observers follow a standardized

set of behaviors are necessary approaches. One researcher also advises that different observers should observe the same groups of students and alternate among them to avoid bias (Chapman, 2003).

Following guidelines and protocols from the Annenberg Institute for School Reform and the Practical Assessment, Research and Evaluation Journal, (Ludwiget al 2008; AISR, Brown University, 2004; Chapman 2003) we designed a protocol to observe classes in a standardized way. According to the Annenberg Institute for School Reform and several other sources, student engagement can be evaluated by observing the following behaviors: motivation, attentiveness to task, and obedience (Ludwig et al 2008; Annenberg Institute for School Reform at Brown University 2004; Chapman 2003). We initially designed a protocol based on the non-verbal cues of engagement including student posture, student-teacher interaction, and student attentiveness found in these protocols to allow for cross-language evaluation.

We ran the protocol in a sample classroom in order to determine the effectiveness before collecting actual data. We interviewed teachers, and compared findings of each observer after the observation. In the trial run, English speaking observers often misunderstood what the students were working on in class, when the students were being reprimanded, and when the students asked questions. Findings from interviews with teachers on indicators of engagement also concluded that non-verbal cues were insufficient in determining student engagement. These interviews led us to the conclusion that it was necessary to modify our observational protocol because we were not highly competent with the Thai language or culture.

Based on these findings, we revised the protocol to include verbal signals and we modified the student posture and teacher – student interaction cues. The new protocol was executed by native Thai speakers, with a *farang* (westerner) in the room to provide a standardized protocol between classes run with passive teaching methods and those run with active teaching methods. Teachers sometimes asked for assistance in active classes, so we decided it was important to have a researcher who wasn't observing in the classroom to provide any help necessary so that the observers would not get distracted. The final protocol can be seen in Appendix L. We divided the experimental activity into a passive stage, where the teacher goes over the background information using traditional lecture, and an active stage, where the same information was presented to the students through the experiment itself. We ran the observation three times per Mattayom (grade level) of each school: a normal class, the passive element of our experiment, and the active element of our experiment. This allowed us to compare the observations between all differing settings, so that we could approximate the effect of our experiments by comparing student behavior in both a passive and active class with quantitative data.

Our observational protocol gave us one measurement of the engagement of the students. Unfortunately, this type of project does not lend itself well to analysis techniques. There were significant issues that we could not solve in the development of the protocol that made our data

unusable for assessing engagement. First, teachers and students were not used to working in an active setting. This created a disorganized environment that made our observations unfeasible. Our observational protocol was additionally limited because this type of evaluation relies heavily on the observers' ability to be undistracted throughout the observation periods. Due to cultural factors, our observers sometimes had to act as teaching assistants. Due to hierarchical differences, it would have been rude to say no. However, this interrupted their observations. Moreover, the presence of any observer in the class, Thai or *farang,* could distract students.

If other researchers attempt a similar cross-cultural observational study of student engagement in the future, we would recommend that the protocol designer should observe a passive class at least twice before completing a design. Having more than two observers per classroom would allow the observers to measure behaviors in shorter intervals, which would allow the researcher to establish a behavioral trend throughout the class period. These passive observations should be performed before any discussion of the results of active teaching. Even when teachers are suggested that they should stick to their previous teaching methods, it is possible that they will try to include some of the new techniques into their lecture during the observational periods. Lastly, the questions in the protocol should be specific enough so that multiple behaviors cannot be counted in the same question. This will allow researchers to standardize their data and obtain data that reflects the true behavior of the class.

Because the observation protocol in its current design failed to collect data on student engagement, we relied on the other evaluation methods, interviews and pre- and post- testing, to measure student learning and engagement. During the interviews, we asked teachers to estimate student engagement during their classes and compare them to their experience while running the experiment.

3.3.2. Evaluate Student Understanding

Because of the limitations found in our engagement studies, we also studied the effect of our experiments on student's ability to understand scientific principles. We accomplished this through the use of student performance assessments. According to research, professionals often use examinations of student understanding to evaluate the effectiveness of science activities. Examinations are often used by teachers, not only to determine student achievement, but also to evaluate what effect their teaching has on their students. These assessments can be used to determine whether or not students have achieved educational goals (Treagust et.al 1999).

There are many ways of evaluating student understanding. Several researchers and teachers have used pre- and post-test procedures in the past to determine the effectiveness of an educational program on student understanding. (Öztürk et.al. 2008; Maloney et.al. 2001; Hestenes 1992; Treagust et.al. 1999) In these tests, the students take two tests to evaluate their understanding of

the material. In our adaptation, the first test (pre-test) was taken after the students had gone over the background sections of the lab but before they completed the experiments. Our analysis of the pre-test suggested how much of the provided content the students learned when the topic was delivered with a traditional passive method. The second test (post-test) was taken after the students had completed the conclusion questions of the developed activities. The results of the post-test helped to show how much the experiments reinforced the topic and whether it helped the students learn the material better or not. The percentage of correct answers per class for the pre-test and the post-test were then compared to see how student understanding is affected by running the experiments. Each student took the pre- and post- tests which we wrote to cover the same content in an attempt to ensure we were testing for a variance in student understanding. These questions are listed in Appendix J. The results of this test can be found in Appendix K.

The data that we gathered through the tests helped us to describe the effect our experiments had on student understanding. This data may be limited by the fact that, since we are not professionals in educational research, we did not portray the purpose of the pre and post tests accurately enough to the teachers, and so the tests were not carried out in a standardized fashion.

3.3.3. Teacher and Students' Opinions of the Effect of our Project and Active Teaching Methods

An evaluation of student understanding is not complete without acknowledging and attempting to assess what both students and teachers believed the impact of our project was. A study was conducted on teacher development in urban schools by researchers at the University of California. The researchers focused on the process of teachers learning new teaching methods. They determined that teachers need other teachers' guidance and observations as much or more than the guidance of researchers. Teachers respond well to observations by experienced teachers on what works and what doesn't work in the classroom (Anderson 2006). It is often difficult for teachers to learn new teaching methods without the opinions and perspectives of other experienced professionals who have made use of the methods.

Through this study, we determined that an important part of our evaluation protocol was to obtain the opinions of teachers at the schools running the experiments in Sakon Nakhon. This allowed us to determine whether the teachers thought the experiments were worthwhile, so that we could present a more compelling case to those that didn't experience the experiments first-hand. In order to accomplish this, we developed a set of questions to be asked in an informal interview to teachers and students both before and after our project. These interviews were completed by the native Thai speaking researchers on our team, and allowed us to gain information on the following topics:

- Comfort with the idea of using active teaching methods in the classroom

- Degree in which student's relate experiments to daily life
- Identify student conceptualization of topics covered in experiment
- Relevance to curriculum
- Degree to which teachers like the experiments and would use in yearly curricula
- Difference in student engagement

The results of these interviews are relative to each individual teacher. Teachers may respond differently depending on their scientific background, personal teaching preferences, and level of passion for science. Additionally, the teachers may have been indirect with their responses due to the culture of most Thai people. Finally, because we developed a professional relationship with the teachers, the teachers' answers might have been biased to reflect well on us, themselves, or their students.

An example of this would be when asking teachers how many students they thought were engaged during the class period, whether passive teaching methods were used or active teaching methods. The teachers could have under- or overestimated the numbers, so that their answers would reflect well on their students, the project team, or our expectations. Another example is the selection process for student interviews. Although we wanted to do a random sampling, the teacher chose five students from the class. We believe these students were likely the top students. Although their answers would reflect a positive impact from the experiment, it may not reflect the impact given to the entire class.

The exact questions and interview structure can be seen in Appendix F. The answers to these interview questions can be seen in Appendix G.

3.4. Disseminate Information about Science Experiments to Other Sakon Nakhon Schools

Since our project is part of an effort to expand science education in rural areas, we hoped to disseminate information about our experiments throughout the province of Sakon Nakhon, so as to broaden the impact of our project beyond our two schools. In order to accomplish this, we wrote a manual for teachers which we called the Teacher's Guide. In addition, we organized and conducted an Education Fair. Both of these sources of dissemination were researched prior to implementation.

3.4.1. Teacher's Guide

Our initial planning for a Teacher's Guide included detailed descriptions of our three finalized experiments, complete with teacher instructions, student instructions, and student evaluation worksheets. Based on different teacher manuals that have successfully provided guidance and

support to their users, we established that it would be helpful to include additional information for teachers. Thus we also included information on subjects such as instrument instructions and an overview of active teaching methods (Hoffman, Lurie & McDaniel 2001; Matarasso & Viet Dung 2002). Additionally, we decided it would be helpful to create a list of possible topics and activities that align with the criteria we used to select our original experiments, and could be further developed by interested teachers for use in their classrooms. These were the elements that we decided were most important in the development of the Teacher's Guide

Several challenges had to be overcome in order to create the Teacher's Guide. One such challenge was that the target audience included teachers who may lack proficiency in English. We determined guidelines for the development of the guide. The guide must:

- Use simple English
- Be translated into Thai
- Include easily understood sketches and graphs
- Include an in-depth background for teachers

We deemed the above four guidelines as a priority in order to facilitate the spreading of the guide to regions where English speakers are scarce. Two members of our team, who are both native speakers of Thai, translated the guide to ensure that the translation was completed and correct.

Also, our experiments follow a simple template which we created with the notion that some teachers may be uncomfortable with teaching experiments or may lack an in-depth science background. These concerns were addressed by creating a teacher and student version of the experiments. While the student version contains only what the student needs to complete the experiment, including scientific background, procedures, and worksheets, the teacher's version includes everything the teacher would need to set up and run the experiment. The teacher's version includes the following sections:

- Scientific concepts exposed by experiment in a background section
- Educational goals
- Introduction of experiment containing a brief summary
- Teacher relevance describing student learning outcomes
- Required materials and costs
- Instructions for Teacher preparation
- Worksheets including expected answers

We hoped these documents will provide teachers in rural schools with the full amount of information required to run the experiment without personal guidance. However, a common practice in professional development of teachers is to use written materials, such as the Teacher's Guide, as a supplement to personal guidance. (UNESCO-UNITWIN Chair, 2005; McKeown, R. 2007; UNESCO, 2002)

3.4.2. Kusuman's Education Fair

For the second step of our dissemination method, we organized and carried out Kusuman's Education Fair. The fair took place over the course of one school day at the Potisan Wittaya School. Teachers and students from across the district came to participate in this fair. There were several goals to this fair including:

- Presenting the results of the experiments to teachers
- Creating awareness about using experiments in science education
- Exciting students about science
- Expanding the impact of our project beyond the two schools we worked with

The fair had two different sections, a science exhibition and fun science activities exhibition, which targeted different audiences. In the science exhibition, we targeted teachers and tried to inform them about the experiments and encourage them to use the experiments in their own classes. This attempt was strengthened by having the teachers that we worked with present this portion of the fair. They could express their own successes and difficulties that other teachers might encounter when implementing experiments into their own classrooms.

The fun activities exhibition was geared towards increasing excitement about science education within Kusuman's student population. Students from the schools we worked with presented the fun science activities and related science concepts. We structured the fair to run these two exhibitions simultaneously. The fair layout and brochure can be seen in Appendix N and Appendix O respectively.

4. RESULTS AND ANALYSIS

The design and implementation of experiments in the Baan Na Peang and Potisan Wittaya schools revealed significant information relating to the designed experiments and the process of conducting evaluation of educational intervention in schools. First, we describe the content of each experiment and the outcomes we observed from each. Next, we explain which methods worked and which didn't in our attempt to help increase science literacy in these schools. Throughout our research, we recorded our observations about effectively working with teachers in Sakon Nakhon.

4.1. Summary and Outcomes of the Experiments Adapted for Sakon Nakhon

In collaboration with science teacher from Sakon Nakhon, we developed experimental lab activities for their classrooms. These activities were selected, modified, and run in alignment with the methodology in chapter 3. In the descriptions that follow, we summarize the topic, procedure, and main findings for each experiment. The experiments can be found in full in section 1.3 of the Teacher's Guide (Appendix M).

4.1.1. The Effect of Salinity on Plant Growth

For the Mattayom 1 level, which is the equivalent of grade 7, we adapted an experiment from the University of Adelaide (Salty Soil: Effect of Salinity on Beans, 2009) to explain the impact of salinated water on plants. This issue is becoming more important because the salt concentration in the groundwater system of Sakon Nakhon is increasing. The aim was to show how an excess of salt in water causes water to move outside a plant cell through the process of osmosis causing a negative effect on the plant.

In this experiment, the teacher presented a background on osmosis and diffusion (see Figure 4-1). Based on a teacher's request, we supplemented the background with a fun, fifteen-minute game, where the students dramatized the movement of water into and out of a cell based on existing concentrations of salt (see Figure 4-2). For a complete description of this game, see Section 2.2 of the Teacher's Guide in Appendix M.

Based on the background information combined with the fifteen-minute game, the students were instructed to answer hypothesis questions about the effect of salinated water on the growth of plants. The students then were instructed to plant morning glory seeds in four different containers. The seeds were left to grow about a week to reach the height of one centimeter. Teachers then prepared solutions with varying levels of salinity. The students watered each of

their plants with the solutions daily for an additional week. Students observed the size and the health of the plants during this period, and were asked to record these observations through drawing pictures. Students ended this experiment by answering conclusion questions to determine the effect of salinated water on plants.

Based on assessment data gathered from students and teachers, we came to the following conclusions about the salinity experiment:

Figure 4-1: Teacher explaining Salinity Experiment to students at Baan Na Peang

Figure 4-2: Students participating in osmosis activity at Baan Na Peang.

The background and procedure of the salinity experiment were difficult for students to understand. Students from both schools had difficulty understanding the background information without the addition of the osmosis/diffusion game, and found that the procedure was not very clear. After running the experiment in class, the teacher from one of the schools explained that students from rural areas often need a lot of repetition to understand material. This is because the students do not like to read the background, but instead depend on the explanation the teacher gives in-class. She suggested that we revise the student procedures to make them more detailed, so that students who do not read the background can still understand and complete the experiment. The teacher from the other school suggested that we could try to overcome this problem by adding a summary of the main points of the background which students can review as they complete the experiment. We took these suggestions into account when editing the final experiments for the Teacher's Guide.

The salinity experiment instructions were insufficient to ensure consistent results. Although the experiment eventually led students to the same conclusions, the degree to which the plants were affected by the salt water varied greatly. In one school, there was a large difference in the size and health of the plants watered with each solution of salt water. In the other school, there was a noticeable difference between each of the plants, but it was gradual and the plant watered with the "ocean-strength" solution of salt water did not die. While this may have been due to differing conditions at each school, other factors may have contributed to the difference.

Because all groups did not obtain the exact same results, the problem may lie in the salinated water solutions which were used to water the plants. From this, we determined that the instructions for creating these solutions may have been insufficient for teachers. In addition, the

student and teacher instructions may not have been specific enough to ensure consistent watering by the students. Unfortunately, our observation did not reveal the specific errors that occurred during implementation.

The current design of the salinity experiment takes too much time to explain to be attractive for teachers to run in the schools we worked with. In order for the students to complete the experiment, the teachers needed two full class periods to both explain the background of the experiment, and begin the experiment with the students. Although the time to water and observe the plants took place in the free time of the students, the teachers were still required time out of their normal class schedule to conclude the experiment and have the students fill out the final worksheet. It is possible that this experiment takes too much time for teachers in Sakon Nakhon to consider it a valuable addition to their curriculum. The teachers we collaborated with often mentioned that the main reason that they did not run experiments in class is that experiments take too much time.

Students showed increased engagement when running the salinity experiment in class. In our interviews, teachers estimated that 50 – 70% of the students were engaged during the activity. Although this figure is less than the percentage found in other experiments, it still shows significant improvement compared to the teachers' estimate of 30% engagement in passive classrooms. The teachers also stated that the engagement levels were more constant than in a passive class, where students will often only concentrate for the first 10 – 20 minutes.

The salinity experiment appears to have a positive effect on student understanding about osmosis. We collected data on the salinity experiment's effect on student understanding through pre- and post- tests. These questions revolved around student's understanding of osmosis and its effects on plant growth. These data are shown in Figure 4-3. There was an increase in between the scores of both schools, suggesting that the students could better understand the questions after running the experiment.

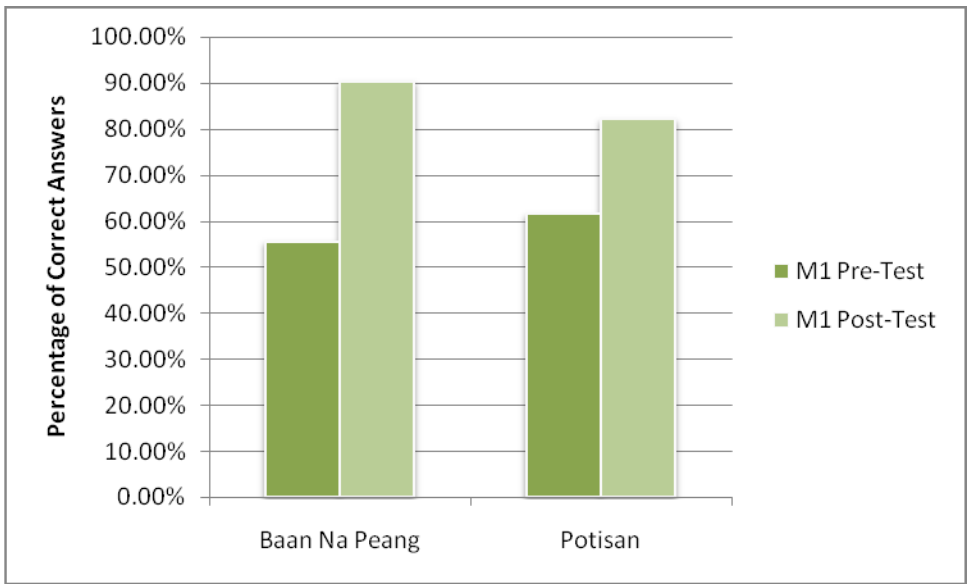

Figure 4-3: Student performance on questions related to osmosis and the effects of salinated water on plant growth

We supplemented our pre- and post- tests with information gleaned through teacher interviews. Teachers stated that they believed students absorbed more information because they were more involved in the activity than they would have been in a normal passive class. The teachers believed that the students understood the main point of the experiment – that salinated water kills plants – though they believed that the students were still having some difficulty understanding the concept of osmosis. During our interviews with the students, they mentioned that they had trouble understanding the concept of osmosis, specifically when it pertains to water moving with the concentration gradient. Before the experiments, teachers had mentioned that students believed that osmosis was simply diffusion through a membrane.

The teachers and students gave opinions that the salinity experiment can be linked to students' daily lives. The teachers at both schools agreed that the students were able to draw connections between the information presented in the experiment and their personal experiences. Since the students live in an agricultural area, most students had experience with growing plants. This experiment gave them an extra foundation in farming by giving them an understanding of the reason why plants do not grow in salinated soil. This finding was reinforced in the student interview at the Baan Na Peang School, when one student stated that she could apply this knowledge by carefully selecting her water source for her garden

4.1.2. Incomplete Combustion and Air Pollution

For the Mattayom 2 level, which is the equivalent of grade 8, we selected an experiment adapted from the Material Science and Technology Teachers Workshop conducted at the University of

Illinois-Urbana-Champaign (MAST) that related the process and by-products of complete and incomplete combustion of different fuels with the growing problem of pollution and air quality in Thailand, mainly caused by transportation vehicles and slash and burn farming. The aim was to introduce chemical reactions in the environment and show how different types of fuel produce different amounts of particulates when combusted.

This experiment was held entirely in one class. Students began this experiment by reviewing background of the combustion reaction. Students were then asked hypothesis based questions relating to how clean they thought the fuels involved in the experiment would burn. The instructions next asked students to light wicks soaked in methanol and motor oil, and catch the resulting particulate matter in an overturned beaker (see Figure 4-4). Students next examined the difference in the extent of the stains, and were asked to draw a conclusion on which fuel burns more completely and thus cleaner (see Figure 4-5). These conclusion questions relate to chemical reactions and their environmental effects, a topic covered in the curriculum.

Based on assessment data gathered from students and teachers, we came to the following conclusions about the combustion experiment:

Figure 4-4: Students performing combustion experiment at Potisan school

Figure 4-5: Students taking observations on the results of the Combustion Experiment

Inexperience and lack of comfort with teaching experiments led one teacher to have difficulty executing the experiment with her class. The teacher at Potisan exhibited discomfort with the experiment by continually asking observers for help throughout the experiment. She did not let any of the students complete the experiment on their own and instead would focus on one group at a time, and completed many steps of the experiment for each group.

There was a very high level of student engagement in the experiment. Teachers at both schools said that 90% to 95% of their students were engaged in the combustion experiment. These impressions are reinforced from the overwhelmingly positive responses students gave to the experiments. At the Baan Na Peang School, all five students said that they not only liked the experiment but loved the experiment. They showed their engagement for the experiment when saying that they liked how the experiment examined the material in a deeper perspective. Some students even suggested that they would like to learn more information regarding combustion.

Students appear to have understood the material better though the experiment than when it was presented in a passive manner. Our assessment of students through pre- and post-tests suggests that there was an increase in student understanding in at least one school when the post-test took place. This test asked students questions related to the incomplete combustion reaction, and the effects of air pollution. These data are shown in Figure 4-6. There was a slight increase

in the test scores at Baan Na Peang. While the change is small it begins to suggest that students understood the concept of combustion better.

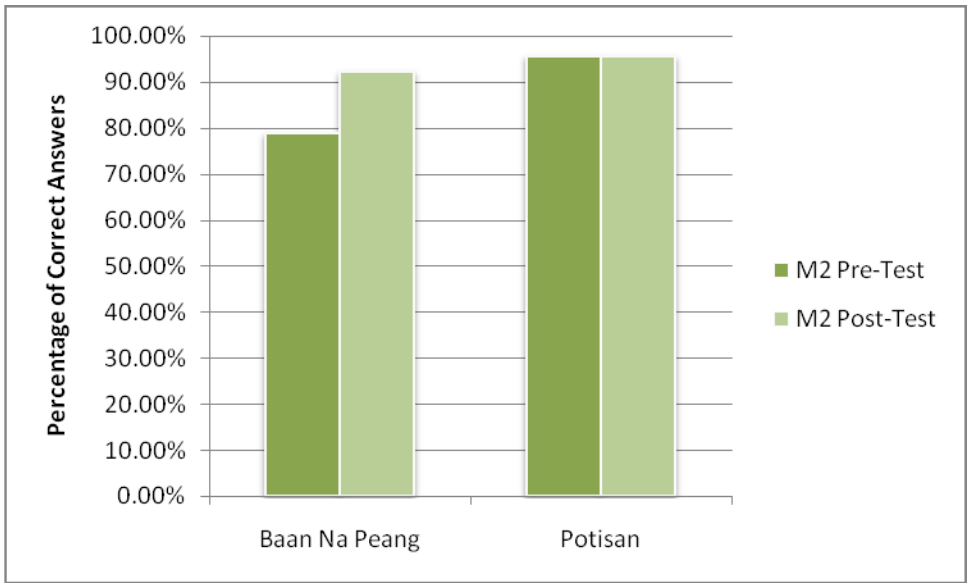

Figure 4-6: Students performance on questions related to incomplete combustion and the reactions effect on air pollution

Additionally, comments resulting from the post-experiment interviews yielded results that are consistent with information garnered through testing. Teachers commented that at first some students may not have understood the directions to the experiment but by the end they understood around 80% of the information presented (incomplete combustion) through the experiment. The information that was not understood may have been information regarding chemical reactions, which students cited was the only information difficult to understand.

Students we interviewed were able to connect incomplete combustion and its negative consequences to their daily lives. Students commented that they now notice the problem that pollution through combustion can have on the environment which they did not know before. The teachers believe that the students will be able to apply this information in their daily lives. The modes through which students can utilize this information are by understanding the pollution that motorbikes cause and by possibly asking their parents to burn less materials on their farms.

Teachers reported that although running the experiment takes more effort on their part, the benefits make the additional effort worthwhile. At both schools, teachers thought that running the experiment caused them to feel more tired after the completion of teaching the class. However, they believed it was worth the effort because students responded well to the information and enjoyed completing the experiments.

Teachers from the two different schools had varying opinions on whether the experiment could be used again next year. An overwhelmingly positive response was received from the teacher at Baan Na Peang. She believed that the experiment followed the curriculum, engaged students, and was received well. She commented that if there was enough time in the year to cover all topics with experiments she would.

Conversely the teacher from Potisan believed that the experiment did not touch on the curriculum of Mattayom 2 students but it was relevant to second semester Mattayom 1 students. However, she did not believe students in Mattayom 1 would have the maturity to complete such an experiment.

4.1.3. Algae Blooms and their Effect on Local Ecology

For the Mattayom 3 level, which is equivalent of grade 9, we developed an experiment related to the field of ecology. This experiment explored how fertilizer run off could cause an algae bloom, and examined the damages that this run off can cause to the local food web.

Students first reviewed how nutrients travel through local systems through food webs. This background was supplemented with a short activity to demonstrate the differences between a food chain and a food web. This was accomplished through having students identify the food web links of a series of animal pictures displayed at the front of the classroom (see Figure 4-7).

The students used this information to develop predictions on how adding fertilizer to pond water would affect an organism, and how this effect would resonate through the food web. Students next examined pond water underneath the microscope (see Figure 4-8), and were asked to count the number of organisms they saw. The students then collected two dishes of pond water. The students weighed an amount of fertilizer (see Figure 4-9), and added this fertilizer to one of the dishes. The dishes were left in the sun to allow algae to grow for one week. The students were then asked to observe the samples under a microscope, and make a conclusion on the growth of algae over the past week.

Through observing the operation of this experiment, assessing the students, and holding informal interviews with teachers, we collected many findings about this experiment. This section outlines these findings.

Figure 4-7: Food chain and food web activity being performed at Potisan school

Figure 4-8: Students using microscope in algae bloom experiment at Baan Na Peang

Figure 4-9: Students using scale during algae bloom experiment at Baan Na Peang

The equipment and concepts involved in the algae bloom experiment were too complex for the teachers to run the experiment in a normal class period. Both at Baan Na Peang and Potisan, there were significant challenges from this experiment. The first challenge was a concern expressed by one teacher that there was difficulty in making the connection between algae blooms and the local ecology for students. In addition, the experiments took too much time to run. Because of students' unfamiliarity with equipment, the teachers stated that they needed to take more class time to teach how to use equipment, causing the time that was required to run the experiment to increase. Teachers stated that this caused the background and procedure to be very rushed.

The current design of the algae bloom experiment did not create expected results in class, and thus may not be able to be used in future years. There were mixed results when investigating the algae bloom experiment's repeatability. The teachers did state that the topic of the experiment related well to the curriculum, and thus may be used in future years. However, there were significant obstacles that are likely to impede the use of this experiment.

The fertilizer used in class was not the same fertilizer we tested in Bangkok. This different fertilizer caused all the algae in the sample to die. In later testing, minute amounts of this fertilizer caused the water to become clear rather than grow algae faster. Because this experiment has not been tested successfully in the classroom, we have insufficient data to support the continued use of the experiment.

Teachers stated that students were engaged when participating in the algae bloom experiment. Despite the difficulties presented by the experiment, the teachers and students both stated that performing the experiment increased classroom engagement. The teacher interviews revealed many points that showed that students were more engaged. When asked to estimate how many students were engaged, teachers from both schools responded that 80%-90% were engaged, compared to lower levels of engagement in passive classrooms. Teachers and students stated that using the equipment, including microscopes, excited the students. The teachers believed that this was due to the novelty of using microscopes.

The students went on to comment that the small activity demonstrating the difference between the food web and food chain was the most enjoyable and worthwhile part of the class. They believed that the small activity was more practical than the experiment.

The algae bloom experiment and the food web activity appears to have a positive effect on student understanding of food webs and the effects of population change. We collected data on the Algae Bloom experiment's effect on student understanding of food webs through pre- and post- tests. This data is represented in Figure 4-10. In Potisan, there was a larger increase in the scores of the tests after the experiments had been run. We do not have any evidence that suggests why results varied between schools but the results from Potisan suggested that the students did understand the topics tested better through the experiment.

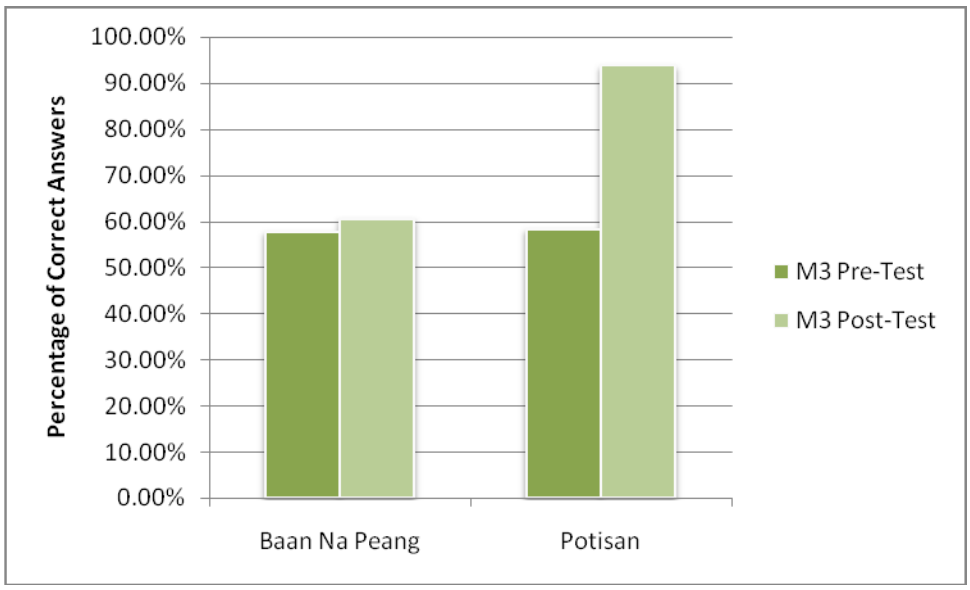

Figure 4-10: Students performance on questions related to food webs and the affect of one change on the entire web

Teacher comments also supported that this experiment had a positive effect on student understanding. Specifically, the teachers believed that students effectively learned the difference between a food web and a food chain through the use of the food web picture activity. The

students reiterated this point in their comments, stating that they didn't understand the food web before participating in the small activity. In addition, the teacher believed that the students retained more information simply because they were paying more attention and more engaged with the material.

The teachers and students gave opinions that this experiment can be linked to students' daily lives. A teacher commented in post interviews that students can draw connections between what they have learned and their own experiences. Specifically, the teacher believes that the students now better understand that if one animal dies, another animal has no food to eat. In addition, the teachers stated that the students now understand the effects of fertilizer run-off. This is very important as most of the student's parents are mainly farmers. The teachers went on to state that this knowledge could relate to the student's farming practices. The students could also use the information to help teach their family so that they become more aware of conserving the environment. Student quotes also supported this. One student stated that "fertilizer runoff can make water turn bad." In addition, this student mentioned telling his or her parents about the subject so they would understand what was learned.

4.2. Observations and lessons learned from running experiments in Sakon Nakhon

Science experiments such as the ones we presented in Sakon Nakhon were a new approach to science education in both schools we visited. We observed a lot of important information and limitations to running experiments in these schools. The following challenges can be addressed in future works.

Teachers benefitted from a longer amount of time reviewing the experiments before providing feedback. The process of completing an experiment and the information that it contained were not easily grasped by teachers due to a lack of time. Several teachers asked for additional time to review the experiments and could not immediately provide feedback during a meeting.

It was also important for us to provide this time so that the teacher would feel fully prepared to teach the experiment. In one instance at Potisan, we had met with one of the teachers, collected information, and had made changes to the experimental design. This teacher told us she did not want to review these changes. This created a situation where the teacher seemed to be more uncomfortable than usual on completing the experiment on her own.

A shortage of teachers allowed less time for teachers to prepare for experiments and created a disorganized atmosphere when it was time to run the experiment. At Potisan there was one teacher for each grade level. Within each grade level there were five different classes. Similarly, at Baan Na Peang there were two teachers who covered all three grade levels. Within those grade

levels there were three classes. In order to prepare for experiments, teachers changed or cancelled classes so that they had time to meet with us. Even though they altered their own schedules, we did not have enough time to sufficiently review the experiment or the active teaching methods in a way which we thought would have been effective.

All phases of experiment implementation took more time and energy by teachers and students than initially expected. The time required to review background material was increased due to the topics not being currently covered in class. Although almost all background had been covered in previous classes, teachers wanted to review the information again. Teachers had multiple reasons for reviewing the information. Some students might not remember the material, whereas others may have not understood it initially. In addition, the students needed to be trained in the use of the lab equipment. In all of the developed experiments except incomplete combustion, teachers split the experiment into two separate classes. One class period was solely for review of the background where as the other class period was used to go through the procedure and complete the experiment.

Students and teachers also took longer than expected to complete the procedure of experiments because of teacher and student unfamiliarity with teaching and learning through hands-on activities. Most teachers were not familiar with doing experiments in their classrooms since we only worked with each teacher once. Some teachers had trouble with explaining the experiment to the whole class and instead individually worked with each group of students. Most students also required more time than expected because many could not follow the procedure on their own.

In addition to time, teachers commented that running experiments in their classrooms took a significantly larger amount of effort than running a passive class. Many teachers commented through interviews that more energy was required to prepare materials and actually carry out an experiment instead of lecturing to a class. This point was explained more in depth from a teacher who ran the salinity experiment. Her explanation was that the experiment took a different type of energy than a lecturing class. In a more passive classroom, the teacher would have to apply energy in disciplining students, while in an active class teachers had to apply energy in preparing and executing the lab protocol. Although the experiments took more energy, the teacher for the incomplete combustion experiment at Potisan said that the effort was worthwhile because students responded well to the experiments.

Teachers have limited classroom time and preferred experiments that took less time. The teachers stated that implementing the adapted experiments in the future would require two class periods or a double period. This is a luxury that the teachers often do not have.

Teachers' and students' unfamiliarity with active teaching methods made them behave irregularly when compared to teachers and students who are already comfortable with the methods. The observational protocol revealed that students often were distracted in class. We

believe that this was because in this region, teachers and students are accustomed to passive teaching methods. While implementing the experiments, students were allowed for the first time to sit in groups, or talk and move around during a lecture. Because of the new freedom, the students often worked with less discipline than in a regular class, and were less focused. Also, since teachers were not comfortable with the teaching methods, they may have been uneasy when reprimanding and questioning students.

Short science activities effectively demonstrated difficult concepts in classrooms and engaged students. In post-experiment interviews teachers and students commented that they liked the science activities. Many students, at Baan Na Peang, commented that they preferred the fun activities to demonstrate science concepts instead of experiments. Additionally, students from Potisan said that they want additional games to explain content in science classes. The teachers that ran the algae bloom experiment commented that students would remember the most from the game on food webs and food chains. They said that they believed this would happen because the games were fun and engaging which will help the students remember.

4.3. Elements and Requirements for Effective Science Experiment Activities in Sakon Nakhon

Through our project experience, we found information that supported and expanded upon information contained in our literature review on effective criteria for experiments in Sakon Nakhon. This section outlines our general findings to make effective experiments in rural areas such as Sakon Nakhon.

Experiments are more likely to be used in classrooms if they fit into the curriculum. Interviews with teachers from the Kusuman Wittayakom School revealed that the only experiments used from a similar project performed last year were those that aligned closely with the national curriculum. During our study, we found information that supports and expands on this statement. From our research, we determined that aligning with the national curriculum goes beyond aligning with the simple broad topics that are covered each year.

First, the teachers stated that schools have some freedom to choose what specific topics to present. For example, students may cover chemical reactions but never specifically cover combustion. The differing curriculum between schools was illustrated when we received mixed responses from teachers on the combustion experiment's relevance.

In addition, teachers from Baan Na Peang and Potisan Wittaya schools reinforced that they felt pressured to cover the entire national curriculum. Therefore experiments must add to or exemplify the curriculum and not diverge from it. Extra time required to review or explain unknown topics hinders teachers. For example, the teachers felt that the student's required significant review of the topic of osmosis partially because it had been covered much earlier in

the year. Experiments need to be run at the time the topic is being covered in class to allow it to reinforce scientific concepts rather than re-teach them.

Substantial teacher consultation is needed in order to make sure the experiments are designed at an appropriate level for their particular students. After comparing student and teacher knowledge to the content of the books of the national curriculum, we gathered evidence that suggests the curriculum is not always understood in the same depth as shown in the text. Often, experiments we selected had been designed at too high of a level. One example is that the inclusion of chemical equations in the combustion experiment, for Mattayom 2, elevated the experiment from one suitable for Mattayom 2 to one suitable for students in Mattayom 5. Reviewing what students did know about topics from teachers or class assessments before designing experiments would allow experiments to be designed closer to the curriculum.

Our work reaffirmed the importance of students connecting with the experiments on a personal level. We received feedback from students stating they liked that they could relate the experiments to their lives. One girl said that she could use the information she learned in her garden at home. In addition, the teachers liked the approach of using local issues, and one had asked for more ideas of connecting academics to real life. The connection to local issues seemed to increase interest and participation in the designed experiments.

Developing experiments in a culturally sensitive fashion may increase the likelihood the experiment will be accepted by the school community. While developing experiments for use in Sakon Nakhon, we attempted to ensure that they did not violate any cultural or religious values common to the area. A specific example is that the experiments should not harm living animals. In one of the original experiments we researched, the effects of agricultural run-off on the food chain of a local pond, we could not select the experiment because small pond animals were going to be harmed. However, intending to harm these small organisms might oppose the Buddhist value of the sanctity of all life. While these tests demonstrated environmental impacts, it may have been very uncomfortable for teachers and students to run these tests. We believe it was quite helpful to the development of experiments to keep these concerns in mind.

4.4. Limitations of Our Findings

While we believe that the findings of our report may be useful to any party pursuing educational development in Sakon Nakhon, it should be noted that this kind of project does not lend itself well to rigorous assessment. This section outlines some of these limitations.

The students and teachers involved in this project are not representative of all those in Sakon Nakhon. In both schools, we implemented the experiment in the highest achieving class level. According to teachers these students are more interested in learning and have higher

abilities. In addition, our experiments were only implemented in two schools in Sakon Nakhon. The data presented in this chapter may not apply to other schools or classroom skill levels.

The specific timing of our research posed significant challenges to teachers and may have limited the success of the experimental activities. Our experiments were not run at the same time as the topics were being gone over in class. In addition, our research took place at one of the busiest times of the year when students and teachers were preparing for exams. The schools also participated in many regional holidays and events during this time period. Different results may be obtained if the project is designed to better fit this busy time period.

Positive reception by teachers and students may have been influenced by their desire to help us succeed. Because we had developed a personal relationship with the teachers, students and teachers wanted us to succeed. In addition, teachers and students wanted the results of the project to reflect well on themselves and their school. This may make our results biased.

Our experiment showed some short-term learning benefits, but we were not able to examine any long term effects. Our project lasted for four weeks and all evaluation methods only examined short term benefits. Specifically, pre- and post-testing was conducted within the same class period, therefore long term knowledge retention was not covered through this evaluation technique. In addition, some teachers only ran one experiment so their opinions on student engagement with respect to experiments are limited.

5. CONCLUSIONS AND RECOMMENDATIONS

In this project, we adapted and implemented science experiments in two schools in Sakon Nakhon. To begin this chapter we summarize the outcomes of our project. Then we provide conclusions developed through our assessment of the adapted science experiments and through our experiences in Sakon Nakhon. Lastly, we provide recommendations about fostering active teaching methods in rural regions such as Sakon Nakhon.

5.1. Project Outcomes

In this project our group adapted three experiments for two schools in the Kusuman district of Sakon Nakhon. For the culmination of our project, we developed dissemination methods to facilitate the adoption of the experiments we adapted, and to encourage excitement in science education in the rural province of Sakon Nakhon.

Summary of Developed Experiments

In order to increase science literacy and increase the use of active teaching methods in the Kusuman district of Sakon Nakhon, we selected, refined, and implemented three laboratory experiments in two schools. The following section outlines these experiments, including any successes and any setbacks.

Mattayom 1 Experiment: Salinity and Plant Growth

This experiment examined the effect of salinity on plant growth through exposing morning glory seedlings to varying concentrations of salinated water. Students examined how this affected the size and health of the seedlings over a period of one week. This experiment was supplemented with a short activity in which the students acted out the mechanism of osmosis. Both the students and teachers believed that this was the element of the experiment that the students would remember the most.

Mattayom 2 Experiment: Incomplete Combustion and Air Pollution

This lab explored how the combustion of different fuels creates differing amounts of air pollution. Students collected the particulate matter created in the combustion of ethanol and motor oil. Then, they were asked to draw conclusions about the effects that combustion of these substances has on air pollution.

Mattayom 3 Experiment: Algae Bloom and Local Ecology

In this experiment, students explored the effects of fertilizer on a population of algae. When the fertilizer was added to a sample of water containing algae, an algae bloom occurred. Students then examined the effect of algae blooms on local food chains. In addition to the experiment, a short activity supplemented the experiment. In this activity, students identified the links of a food chain and a food web. While we encountered difficulties with the experiment, our data suggests that this activity was extremely successful in demonstrating the difference between a food chain and a food web.

Summary of Dissemination Activities

This section discusses the ways in which we attempted to bring our experiments to others schools, and thus possibly have a greater impact on the region.

Teacher's Guide

To disseminate our findings, we compiled the adapted experiments into a Teacher's Guide that enabled these experiments to be used elsewhere in Sakon Nakhon. In addition, we included a variety of information in the Teacher's Guide to help teachers run these experiments in the classroom. The guide contains some of our findings to help promote the use of active teaching methods. The guide also includes a section showcasing the short activities that can be run independently of the adapted experiments. Finally, the guide includes detailed background and instructions on running the adapted experiments, as well as a budget for each experiment. The final guide is shown in Appendix M.

Education Fair

In order to increase excitement about science education and promote the use of science activities in Sakon Nakhon, we collaborated with other researchers performing a similar project to design and run an Education Fair. About twenty-five teachers and one thousand students from different Kusuman District Schools came to see the work we had completed at the Potisan and Baan Na Peang schools. The adapted experiments were showcased in the auditorium and presented by the teachers and students that performed them in class. In addition, we developed fun science stations to keep the visiting students interested and promote science education. The brochure and map for the Education Fair is shown in Appendix N and Appendix O respectively.

5.2. Conclusions

The information we gathered from implementing activities in Sakon Nakhon led us to conclusions concerning how to execute science activities in poor rural regions such as Sakon Nakhon. This section outlines the main conclusions we drew from our work on this project.

Continued use of these activities and experiments within the science curriculum has the potential to improve lower secondary science education in Sakon Nakhon. The experiments we adapted in collaboration with teachers:

Increased student engagement – Our data supports that our experiments had the students more interested in classroom activities.

Promoted student understanding – Our data supports that our experiments could be used to teach scientific concepts.

Excited teachers and students about science education – Both teachers' and students' opinions of science education and the worth of active teaching methods were impacted by our project.

These findings may have many limitations. First, we worked with only two schools in Kusuman. In addition, the teachers and students, on whose opinions we based our results, may have had reasons to want us to succeed. In addition, the unique and new situations our project put the teachers in may have affected the teacher and student outlooks of the project. Despite these limitations, we feel that these types of experiments may be used to successfully achieve these goals if used in the future.

Experiments tend to be easier to incorporate if they align with both the Thai National Curriculum and the topics covered in class. Along with the need for experiments to follow the Thai National Curriculum, experiments can be more effective if they are presented in conjunction with the topic they are expanding upon. When the experiment is presented months later, students and teachers tend to be less comfortable with the material, and thus require more time to review the background of experiments.

Clear and detailed explanations aid teachers and student in completing lab activities. Our experiments often contained instructions that confused the students. The teachers often felt that they had to contribute to the student instructions we provided. When the instructions were improved students were more comfortable with running the experiment without teacher aid.

Short experiments and activities are more likely to be successful in Sakon Nakhon. The shorter the experiment or activity, the more comfortable the teachers stated they were with the

activity. A combined background and experimental technique that extends over one class period causes both the teachers and students to feel uncomfortable. Shorter experiments are also more likely to fall in the skill set of both teachers and students. In addition, teachers often stated that the reason that they haven't implemented such activities in the past is that the experiments take too much class time away from the national curriculum. By reducing the size and complexity of experiments to fit in their entirety one class period, teachers would be more likely to adopt experiments into the classroom.

One element of our project, which demonstrated the success of short activities, was the fifteen-minute classroom activities that demonstrated some of the more difficult scientific background for our experiments. These activities were among the most rewarding and well received elements of our project. Teacher and students both believed that these activities taught the scientific concepts, and made the class more enjoyable.

5.3. Recommendations

Based on the conclusions discussed above, our team has developed a set of recommendations for future educational development in Sakon Nakhon.

We recommend that the Kusuman District Department distributes the Teacher's Guide we prepared to other schools in the Kusuman district. The Teacher's Guide contains information that can help encourage the use of science experiments in other schools throughout Kusuman. By distributing this manual, teachers may be able to incorporate the adapted experiments into their science classes and develop additional experiments with a similar format. If these steps are taken by teachers, they may begin to increase science literacy levels in the district.

While this Teacher's Guide contains a significant amount of information that can assist teachers in adopting active teaching methods, the Teacher's Guide alone may not be sufficient enough to support teachers who have never tried the methods before.

We recommend that Kusuman District use the schools we worked with as models for further professional development in the area. Based upon our experience with five teachers, many teachers in Sakon Nakhon may have insufficient experience with experiments to allow them to be comfortable running an experiment from written instructions alone. Teachers unfamiliar with classroom experiments might find our designs too complicated. In addition, teachers' initial opinion may be that the experiments will not be useful in conveying scientific concepts.

To combat these problems, we suggest using the Potisan Wittaya and Baan Na Peang Schools as peer support centers. Teachers at these schools have the most experience and knowledge with

running the experiments, and thus would be best suited in explaining these methods. In addition, Potisan Wittaya and Baan Na Peang teachers can express their opinions about the experiments, and forewarn teachers of possible difficulties. These facts and opinions would assist teachers in running these experiments in Sakon Nakhon.

Using Potisan Wittaya and Baan Na Peang schools as peer support centers may provide benefits to the area, but this type of professional development could be difficult to implement because teachers have a limited amount of time.

We recommend the Office Princess Maha Chakri Sirindhorn's Projects to encourage the development and dissemination of more 15 minute activities that align with curriculum topics and are readily available to teachers. These shorter activities still promote the same active teaching methods as the adapted science experiments. However, the smaller scale of these activities allows teachers to be more comfortable with experiments, and they interfere less with teachers' schedules. Thus shorter activities could be used as a tool to better transition the teachers to the use of active teaching methods. We recommend that the schools continue to use these activities and the Office of Sakon Nakhon Educational Service should spread them around the region to show some basic scientific concepts. Additionally, we recommend that more short activities be developed and spread through the schools in Sakon Nakhon.

This project adapted three science activities for the Baan Na Peang and Potisan schools. During out limited time at these schools, we observed some short-term positive effects. While the precise long term effects are not yet clear, they do hold value as a small building block towards increasing science literacy through the adoption of active teaching methods in the region. If these experiments are run in conjunction with other projects developing education in the region, the people of Sakon Nakhon may benefit from a higher level of science literacy, and may one day use this knowledge to increase their quality of life.

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APPENDIX A: INTERVIEW WITH LAUREN MATTHEWS (PROFESSOR OF ECOLOGY, WPI)

Conducted in Worcester, MA on 11/25/08

This interview was conducted in person by Matt King. The purpose of this interview was to attempt to collect information on possible lab experiments related to ecology we could do with the students in Bangkok.

After hearing our background research, what do you think are some possible areas in our topics to investigate for experiments?

- Algal blooms
- Salinity levels in Soil
- Food web of ecosystem
- Pesticide/fertilizer investigation
- Compost piles
- Ecology of agricultural fields
- Do you have any additional comments about how those topics could be covered?
- Algal blooms- If they are present- Could be caused by high levels of phosphorous- water full of too many nutrients- causes organisms to die and bacterial to flourish
- Salinity levels in soil-caused by using water that is too high in salt content-poor soil to grow plants in- reduced harvest
- Food web of ecosystem- how pollutants in water affect entire ecosystem-micro-organisms die because of it- not enough food for larger organisms-results in smaller or less fish
- Pesticide/fertilizers affect on small organisms which feed bigger organism
- Compost piles- proper storage- does run off effect pollutant levels?

Do you have any idea's to carry those topics out into experiments?

- Salinity levels- water fast growing plants with water of different levels of salinity
- Food Web-find micro organisms in polluted bodies of water and non polluted-different amount in each
- Pesticide- expose small organisms to pesticides- does it kill them? What is the greater effect on food web
- Compost piles- Are there differences between bodies of water that receive compost run off and bodies of water that don't?
- What should be doing to prepare for these types of experiments?
- Find out what natural water bodies exist in our Sakon Nakhon village.
- Procure nets to sample water bodies
- If possible pilot in Worcester public schools
- Find out what they use, what do they try to take out of the ecological world?

- Find out what local organisms are part of the local food chain
- Do you know of any additional resources which might prove to be useful for us?
- Talk to professor Buckholt- he is the biology lab instructor- his job is to find simple ways to demonstrate complex topics- he has done research in biotechnology
- Contact Carolina Biological supply- they are a biology science education materials company- If we write a nice letter they will probably donate supplies for us

APPENDIX B: INTERVIEW WITH MARTHA CYR (K-12 OUTREACH COORDINATOR, WPI)

Conducted in Worcester, MA on 12/3/08

This interview was done by Matt King in person. The purpose of this interview was to identify evaluation techniques, and to determine ways of teaching teachers.

Relevant background given to Martha Cyr

- Thai people are indirect-cultural tendency to save face
- Attendance is socially compulsory
- Language Barrier
- Time restriction (4 weeks)
- It is a very poor, agriculture region with environmental problems

How should we select which experiments to use?

- Resources for Lab Activities
- Nsdl.org – National Science Digital Library – more academic version of Google
- Dlese.org – Earth Science
- Better use to time to find experiments already written and adapt them than to make our own

Do you recommend a template for experiments?

- Experiments should use template
- Teachengineering.org

Benefits to template:

- Teacher comfort levels may increase with template – basic information in basic format
- Repeatability comfort fact
- True Inquiry can be difficult to do with template
- Teacher Instruction Template
- Learning objectives
- Methodology – student and teacher
- Necessary preparation
- Culminating steps

How can we evaluate the effectiveness of our experiments?

- Engagement
- Observe teachers and students during classes

- Observe what classroom is like
- Look for engagement levels of students
- During activity – are more students engaged?
- Teachers can use these methods in subsequent years
- Quantitative methods of engagement
- Time
- Measure time
- Time spent on our activities
- Time spent on teacher activities (not ours)
- Time spent talking to family about our activities versus English activities
- Transfer of concept to another situation
- Direct students to solutions
- What food chain are you part of
- Where do you fit?
- What would happen if bottom of food chain was affected?
- Scaffolding learning
- Send us e-mail saying whether or not experiments repeated in future

Additional Information

- Make sure the teachers know that they excel at what they do
- We are here to assist, not to be the authority in the classroom

APPENDIX C: INTERVIEW WITH MIKE BUCKHOLT (LAB INSTRUCTOR, DIRECTOR OF BIOLOGY PROJECT LAB, WPI)

Conducted in Worcester, MA on 12/4/08

The purpose of this interview was to identify possible lab experiments and resources related to biotechnology. This interview was conducted in person by Sofia Zamora and Nathan Climer.

Relevant background

- Time restriction (4 weeks)
- It is a very poor, agriculture region with environmental problems
- Supplies are limited
- Must be readily available
- Supplies must be cheap
- Topics given for our experiments to focus on
- Level of education of students
- Teachers may not have a lot of experience in subject areas

After hearing our background research, what do you think are some possible areas in our topics to investigate for experiments?

- Pulling in ground water can start to pull in sea water
- Bring in household products, daphnia, test concentration
- Test tubes of different fertilizers, possibly sprout beforehand
- Salt water tube
- Simulation experiments
- What should be doing to prepare for these types of experiments?
- Four sections
- Pre- and post-
- Statistics
- Application to another section – good way of teaching
- Ask other open questions, design experiments
- How can you chose an experiment
- Unfortunately, experience
- Running experiment beforehand
- Use “tried and true” experiments that have been run before
- Simplicity - internet
- Do you know of any additional resources which might prove to be useful for us?
- Will e-mail group
- Can help design if we have more specific topic

APPENDIX D: INTERVIEW WITH SAKON NAKHON TEACHERS FROM 2008 PROJECT

This section outlines some of the basic finding of Duke and Meg in the informal interview held with Khun Prapatosorn and other teachers in Sakon Nakhon.

General Descriptions of Area

- No local bodies of water , only underground water
- Use Urea 16 fertilizer mainly, used for grass at home, a nitrate
- Use manure minorly, emphasized as better for soil
- Agriculture - rice - field and little bit of water from rain - unnatural wetland - only in wet season
- No fishing
- Buy catfish - grow in pond - show students how to look after fish behind school
- 1 hour science periods
- Schools are 1/2 hour away by car
- Salinated water - water table is too high, salt gets into well
- Acidic water - close to 7, stable

General Descriptions of Schools

- Few materials - a few microscopes
- Students in Kusuman District very poor, not well supported outside of class - have to go home and work, no time for homework
- Students don't learn much/don't understand/don't finish syllabus

Topics studying when during project:

M1 - solubility of acid/base

- separation of matter (solid/liquid/gas)
- filtration
- Already learned plants and photosynthesis, biotechnology

M2 - Matter, states, change of matter

- already learned body, food and drug

M3 - Ecology

- living things, where live
- local ecology

Information About Potisan School

- Better school, more funding
- Well close or in school - pump system, storage, pipes for school
- Grow rice, white sweet corn to eat
- Three labs - physics, biology, chemistry
- Know how to use microscopes
- 1 science teacher per level - also teach other classes
- 5 science classes per level
- Self-study center

Information About Baan Na Peang School:

- Water not clean enough to drink
- Grow rice, tomatoes to eat
- No sinks in science lab, only one room, desks, chemicals mislabeled (can't use), a few microscopes
- 1 science teacher for M1, 1 science teacher shared between M2 and M3 - teach other classes as well
- About 4 science classes per level

Evaluation of Last Year's IQP Group:

- Tragedy of the Commons - only experiment still running
- The rest don't match syllabus
- Failure in communication between teachers and team
- Didn't know students were coming - this year they know
- M1 - food preservation - too high level - M5 or higher (high school)
- Equipment not readily available - not enough teachers, glassware, microscopes, etc
- Low budget, unlike Bangkok school
- Growing plants in soil with different contaminants - didn't follow the expected outcomes - used orange instead of lime juice - plants grew better
- Communications between students/teacher not good - too many teachers in room - students afraid of strange teachers
- Training sessions with teachers too close to class period - one night not enough time to absorb material

APPENDIX E: INTERVIEW QUESTIONS DURING TEACHER EDUCATION MEETINGS

Go over background information – teacher and student

- Splitting experiment – background one day, experiment another day
- Balance between experiment and theory
- Is this a good test of passive vs. active teaching methods?
- Do they mind taking time out of two classes instead of just one?
- Make sure that this is same class
- Do they find it relevant – will want to keep doing this in future, why?
- Goals – what do they need to be shown to use active vs. passive? What makes them feel experiment isn't necessary
- If we take the first 15 minutes of class to run background, what would they do for the rest of class?
- Is the background information clear and understandable?
- How can we improve the background information?
- Is it at an appropriate level for your students?
- Do you need any more information?
- Is there any information that is irrelevant or confusing?

Go over instructions

- Are the instructions clear and understandable?
- How can we improve the instructions?
- Is it too difficult or easy for students to run?
- Are there any other activities that you want us to include in the lab?
- Tell how long algae bloom and salinity is going to take
- Do they think experiment relates to topic? If it proves something?

Go over materials

Go over worksheets

- Are the worksheets at a good level for the students? Are they too easy or too hard?
- Are the questions a good measure of how well the students understood the material? Knowledge retention
- Are the questions phrased well?
- How can we improve the worksheets?
- Are there any questions you think we should add or subtract?

APPENDIX F: POST CLASSROOM IMPLEMENTATION INTERVIEWS

Formative Questions for Teachers

This questions will be asked to teachers after the first day of class to determine how we can improve the experiments. Questions will focus on gathering information on the strong parts and weak parts of the experiment, and specific action which we can take to improve student's education through our experiments.

- Did you have any difficulties while explaining background or instructions of experiment? How can we word the instructions or background better to help ease these difficulties?
- Where do you think the students had trouble following the information?
- Do you think the students understood the material? What did they have trouble understanding?
- How much of the curriculum topic does this experiment cover? Do you think it teaches the topic well enough that you would be able to use this experiment to teach the topic in the future?
- What information do you think the students will remember best? Why?

Summative Assessment for Teachers:

These questions will be asked to determine the success of our project in Sakon Nakhon. The questions focus on the impact of our experiments on both students and teachers, the issues with our evaluation procedure. Some formative information may be gathered in these questions.

- How interested were the students in the activity?
- How do you feel about time and effort than usual to explain the information of the experiment to the students compared to a normal class?
- Do you think our presence impacted the students? What are some good ways they were impacted? What are some bad ways they were impacted?
- Compared to a normal class, do you feel the students absorbed the same amount of information? Less? More?
- Did the students drew connections between the information and their personal experiences?
- Compared to a normal class, do you feel like the students were more or less engaged?
- What percentage of the students was engaged?
- How interested were the students in learning the topic after the experiment was described?

- What factors in the students let you know whether they were engaged or not? What behaviors?
- Do you think that the presence of outsider's in the school have an effect, positive or negative, on the student's engagement?
- To what extent do you think the students will be able to apply or use this information in their lives?

Questions for Students

- This is a mix of formative and summative experiments, designed to gather student's opinion on the experiments. These questions are asked to one student from each group (selected by volunteer) that ran an experiment after one class period.
- What do you like about the experiment so far?
- What do you not like about the experiments so far?
- What about this information is useful? What information do you think you won't use again?
- Do you find this information interesting or boring? Why?
- Did you understand all of the information that the teacher explained to you? What did you not understand?
- Can you tell us an example of a process that includes the process in the experiment?
- Are there any questions on the worksheet that you didn't understand?
- What would you add to the activity if you were able to write it?
- Do you feel more interested in learning about other things related to this topic? Why or why not?

APPENDIX G: ANSWERS TO POST CLASSROOM IMPLEMENTATION INTERVIEWS: SALINITY EXPERIMENT

This interview asked the questions found in Appendix F to the Mattayom 1 (Grade 7) teachers after running the salinity experiment in class. This interview conducted at the school the teacher was from on the dates shown below.

Baan Na Peang: January 27, 2009

Potisan: January 28, 2009

STUDENT INTERVIEW

These questions were the questions we initially asked students. These questions were modified based on the results of this interview.

Do you like the experiments so far?

Baan Na Peang: The students answered in unison "yes." Next, student 1 responded with "I like it" student 2 responded with "I'm happy" and student 4 responded with a hypothesis to the experiment.

Do you find this information useful?

Baan Na Peang: The students answered in unison "yes." Student 1 further stated that she can apply this knowledge to future gardening.

Do you find this information interesting?

Baan Na Peang: - "Yes"-spoken in unison

Did you understand all of the information that the teacher explained to you? What did you not understand?

Baan Na Peang: Student one said that they understand something, but not all. Student 4 said they don't understand reverse osmosis. Student 3 said they understood everything.

Are you interested in continuing the activity?

Baan Na Peang: 3 and 4 liked the experiment. 1 and 2 felt they like experiments and lecture.

Can you tell us what the difference is between diffusion and osmosis?

Baan Na Peang: Students believe osmosis is diffusion through a membrane.

Are there any questions on the worksheet that you don't understand?

Baan Na Peang: The worksheets were fine, the procedure is not very clear.

Would you add anything to the activity if you were able to write it?

Baan Na Peang: Students would prefer fun activities, rather than serious experiments.

Are you interested in learning more?

Baan Na Peang: Yes in unison.

There was only a few conclusions that could be gained from this interview. Because so many questions led students to the answer or was only yes no questions, the protocol was then revised.

TEACHER INTERVIEW

Formative Evaluation

Did you have any difficulties while explaining background or instructions of experiment? How can we word the instructions or background better to help ease these difficulties?

Baan Na Peang: The teacher felt that she was able to cover all of the material mainly because the class was a 2 hour period. However, she thought that when they go back to 1 hour classes, she probably cannot cover all of the material in time. The teacher said that she didn't have enough time to prepare for the class herself but the students have already studied the topic of osmosis so she said that it made it a little easier for them to follow her. She also thought that the topic of osmosis was difficult for the students to understand and imagine. She thought that the hypothesis section was good but the main problem was that the students have no basic background in order to even make a hypothesis. The teacher continued to give an example that at better schools, the students have good background so they would be able to make a hypothesis. The teacher mentioned that she always have to teach everything in a slow step-by-step manner. She thinks that they may need to spend more time on the background. Even though the teacher went through the material by both asking the students to read the background and explaining the material to the students, she felt that the students still found it difficult to understand the material. She felt that every step should be slow and the teacher always has to make a sentence and ask the students to fill in the last word.

Baan Na Peang: The students should be encouraged to read up extra information in their textbook. The students should also be encouraged to read the experimental procedure before they come to class. Also, there should be a set of summary points for the students so that they can understand the main points of the experiments more easily.

BSW: The teacher felt that the main problem was that sometimes she speaks too fast and she assumes that the students knows the content as she has covered a similar topic before. The content of the background information is good but the students usually do not want to read a lot of information so they usually just listen to the information which the teachers explain to them. The teacher believes that we should make the instructions more detailed as the students do not want to read the background. The teacher also mentioned that students from schools in rural areas need a lot of repetition.

Where do you think the students had trouble following the information?

BSW: The teacher thinks that the students understood and could follow most of the information. For example, there was a student in front of the class who was able to give a good answer on why plants grow badly when there is a high salt content. However, the

teacher also thinks that the students are quite slow in learning and retrieving information and because the students are M1 students, they like to play around a lot for example; some students like to make a joke to make the rest of the class laugh.

Do you think the students understood the material? What did they have trouble understanding?

Baan Na Peang: In this experiment, the students did not understand the topic of osmosis.

BSW: The teacher thinks that most of her students understood the content. The teacher mentioned that she has taught the topic before and the students have probably forgotten most of the content but as they have been familiarized to some of the topics before, they could understand the content of the background more easily. The teacher also said that she thought that the students did not understand the topic of reverse osmosis.

The activity (game, illustration) will certainly help the students to understand osmosis. The teacher thinks that the experiment teaches the student to be like a detective through the use of hypothesis, observation and to draw conclusions.

What information do you think the students will remember best? Why?

Baan Na Peang: Diffusion.

BSW: The teacher thinks that the students will understand and remember the fact that "salinity of water will affect the growth of plants" the most. This is because the area is an agricultural area so the students can relate to the growth of plants well

<u>Summative Questions</u>

How do you feel about time and effort than usual to explain the information of the experiment to the students compared to a normal class?

Baan Na Peang: The teacher mentioned that doing experiments requires more time and energy. However, the students always have to interact with the teacher so that they will be able to follow the class. When the students are excited about the experiment, they work on it. Moreover, the teacher also noted that for experiments, she gets tired from preparation of materials. However, in passive learning, the teacher gets tired from trying to control the class (reprimanding the students).

BSW: The teacher thinks that she had to use more time and energy in having to help each individual group of students, whereas in a normal class, the students just sit and listen.

Do you think our presence impacted the students? What are some good ways they were impacted? What are some bad ways they were impacted?

Baan Na Peang: Yes. The two main points were that the students became quieter and they seemed to be more tense when there were observers. They might have questions in their mind about the observers during class.

BSW: The teacher thinks that our presence had a good impact because when there are observers she feels excited. She said that it is normal for a teacher to feel a bit tense when a group of people are observing them. However, the teacher thinks that it is a good thing because it means that she has to prepare well and be ready for class. It is like when any observer comes to see the school, the school must be ready and prepare well.

Compared to a normal class, do you feel the students absorbed the same amount of information? Less? More?

BSW: The teacher thinks that the students absorbed more information because they are more involved.

Did the students draw connections between the information and their personal experiences?

BSW: The students were able to draw connections between the information and their personal experience because it means that they can explain and understand the reason why plants do not grow in saline soil.

Compared to a normal class, do you feel like the students were more or less engaged?

Baan Na Peang: Yes. The teacher said that she was able to control the work that the student does because they have to carefully follow all of the steps to be able to do the experiment. On the other hand, in passive learning, the students usually concentrate for only 10-20 mins.

What percentage of the students was engaged?

Baan Na Peang: Probably 50-60% of the students were engaged during the experiment, while in passive learning (normal lecture classes), it is usually only 30% who are engaged.

BSW: The teacher thinks that probably around 80% of the students were interested in the class activity. She mentioned that the percentage is large because they are the top class for the M1 level.

Probably around 70% of the students were engaged as all the students helped each other do work on the assigned task.

How interested were the students in learning the topic after the experiment was described?

BSW: The students were interested in working on the experiment.

What factors in the students let you know whether they were engaged or not? What behaviors?

Baan Na Peang: The main things that the teachers observe are that the students respond to the teacher's questions. Moreover, it can be observed that the students are engaged when they follow the teacher's instructions. The more engaged students will be the ones which come up when the teachers ask a representative of each group to come up to receive the materials for the experiments. A leader usually emerges from one group.

BSW: The main behaviors that can be observed to see that the students are engaged are that they look like they are focusing on the instructions as they are afraid that they will miss certain steps and one student was also able to give good feedback on the hypothesis questions.

To what extent do you think the students will be able to apply or use this information in their lives?

Baan Na Peang: Yes. They will have extra foundation in farming as they will understand the reason why plants do not grow in saline soil.

APPENDIX H: ANSWERS TO POST CLASSROOM IMPLEMENTATION INTERVIEWS: COMBUSTION

This interview asked the questions found in Appendix F to the Mattayom 2 (Grade 8) teachers after running the combustion experiment in class. This interview conducted at the school the teacher was from on the dates shown below.

Baan Na Peang: February 23, 2009

Potisan: February 3, 2009

STUDENT INTERVIEW

What do you like about the experiment so far?

Boddhi Saen: The students would rate their likeness of the experiment 7/10.

BNP: If the students were to rate their likeness to the experiment, they would give the experiment 10/10. The students said that they like to see the burning process and to see the different results that different fuels give.

What do you not like about the experiments so far?

Boddhi Saen: The students did not like the pollution and the smell that the experiment produces.

BNP: There is nothing the students did not like about the experiment.

What about this information is useful? What information do you think you won't use again?

Boddhi Saen: The students found the experiment useful as they can notice the problem of pollution and its effect to the environment.

BNP: The information they found useful was the fact that motor oil gives harmful pollutants. They said that they never knew it before.

Do you find this information interesting or boring? Why?

Boddhi Saen: The students found the information interesting because they have never known the information before. They also say that they like the fact that they get to understand the topic in a deeper perspective.

BNP: The students said they found the information very interesting and even more information should be added. This maybe information such as information about the fire

triangle, and extra information on how to contain and stop fires, such as the use of different methods such as fire extinguishers to contain a fire. There could also be information to do with health concerns. The students said that they now understand the difference between complete and incomplete combustion. However, the students said that they did not understand the information about the chemical reaction used in the background.

Did you understand all of the information that the teacher explained to you? What did you not understand?

Boddhi Saen: The students understood the information but they were a little confused with the section about chemical reactions.

There are no questions in the worksheet that the students did not understand.

BNP: The students said that they did not understand some of the questions and did not know how to answer them.

What would you add to the activity if you were able to write it?

Boddhi Saen: If the students could add anything to the activity, they would want to try the experiment using other fuels also. The students also want to know more about air pollution and would like to do more experiments on it.

The students said that they like science more after they did the experiment

BNP: The students said that they want more content to the experiment, such as burning other kinds of fuels also. The students said that they are very interested about the topic and they also said that they want to learn more about pollution in general.

TEACHER INTERVIEW

Did you have any difficulties while explaining background or instructions of experiment? How can we word the instructions or background better to help ease these difficulties?

Boddhi Saen: The teacher has already made the changes to the experiment before the actual experiment was run. Whenever the students did not understand anything in the background, they would ask the teacher and the teacher will help explain and clarify the point.

BNP: The only difficulty to do with the experiment is that she thinks that the rope used for burning was too short.

Where do you think the students had trouble following the information?

Boddhi Saen: In the beginning, the students did not understand the instructions, but when one group was able to do the experiment, the other groups would observe how to do it. The students could do the experiment but the main problem was that they don't know how to give explanations in order to explain their answer.

BNP: The students had no problem with following the information.

Do you think the students understood the material? What did they have trouble understanding?

Boddhi Saen: The teacher thinks that the students understood more than 80% of the material. They can understand the reasons why they get certain results. There are about 2-3 students who cannot read and write so they are the only ones which probably did not understand the material at all.

BNP: The students understood most of the material.

How much of the curriculum topic does this experiment cover? Do you think it teaches the topic well enough that you would be able to use this experiment to teach the topic in the future?

Boddhi Saen: The experiment did not cover the curriculum but it can be used for M1 students. However, the teacher also said that the M1 students do not have much experience so they could misbehave. To solve the problem, the teacher thinks that there should either be someone to take care of the students or the teacher should just do a demonstration in front of class.

BNP: She thinks that the topic follows the curriculum.

What information do you think the students will remember best? Why?

Boddhi Saen: The teacher thinks that the students will remember the experiment the most because all the students got to physically do the experiments. The students were also in groups of 4 so all the students got to do the experiment.

BNP: The teacher said that students will be more aware of combustion processes and they will remember the fact that motor oil burns uncleanly.

Summative Assessment

How interested were the students in the activity?

Boddhi Saen: The teacher thinks that 100% of the students were interested in the experiment. They all ask a lot of questions. The teacher said that if she had the time to do experiments for all topics, it would be very helpful.

BNP: The students were very interested in the activity.

How do you feel about time and effort than usual to explain the information of the experiment to the students compared to a normal class?

Boddhi Saen: The teacher said that she gets more tired but it is worthwhile as the students respond very well. The students like doing experiments.

BNP: Compared to the normal class, more time and effort was needed to run the experiment as the teacher has to keep walking around helping each of the groups.

Do you think our presence impacted the students? What are some good ways they were impacted? What are some bad ways they were impacted?

Boddhi Saen: She thinks that the students were not impacted by our presence as they are getting used to it. The students just focus on the experiment. They are more interested in doing the experiment as they are afraid that they will make mistakes if they do not pay attention.

BNP: Our presence did not impact the students because the students are getting used to us.

Compared to a normal class, do you feel the students absorbed the same amount of information? Less? More?

Boddhi Saen: The teacher feels that the students absorbed more information compared to a normal class. In passive learning, the students cannot imagine the effects of combustion. With the use of the experiment, they can now see exactly what makes the environment go bad.

BNP: More, After the experiment was described, the students are very interested to learn about the topic as they were surprised to know that many processes (such as burning

motor oil) that they see around involve incomplete combustion, which is bad to the environment.

Did the students drew connections between the information and their personal experiences?

Boddhi Saen: The teacher thinks that the students can make connections to their personal experiences. For example, when they see black smoke, they will know that it is bad

BNP: The teacher said that before the experiment was done, the students did not understand how motor oil is related to combustion. However, after the experiment, the students now understand that vehicles such as motorbikes, which are the main source of transportation also produce harmful pollutants that harm the environment.

Compared to a normal class, do you feel like the students were more or less engaged?

Boddhi Saen: Compared to a normal class, the students were more engaged.

BNP: Compared to a normal class, the students were more engaged.

What percentage of the students was engaged?

Boddhi Saen: The teacher thinks that 95% of the students were engaged. The students who cannot read or write (2-3 students) are probably the only students who did not understand the material at all.

BNP: Probably more than 90% of the students were engaged.

What factors in the students let you know whether they were engaged or not? What behaviors?

Boddhi Saen: The students were very interested in the topic after the experiment was described. Even the students who used to skip class came to class. They are eager to do the experiment as they always ask questions to the teacher during the experiment.

The main factors which show that the students are engaged are that they ask questions when they do not know how to continue to the next step. They will even ask questions even when they have finished the experiment as they want to check whether they are getting the right results.

BNP: The main behaviors to see that the students are engaged are that they ask a lot of questions to the teachers and they also look like they work very hard as a group as they concentrate very hard on the task.

To what extent do you think the students will be able to apply or use this information in their lives?

Boddhi Saen: The students received a method of thinking: They get analysis skills and realize which fuels are bad. They might also tell their parents to burn less at their farms.

Additional notes: The teacher thinks that the students rushed too much in the test. She thinks that the pre-test and post-test should be homework.

BNP: The students will be able to apply and use the information they have learnt in their lives as they are now able to understand that incomplete combustion processes such as pollution form vehicles are not good.

APPENDIX I: ANSWERS TO POST CLASSROOM IMPLEMENTATION INTERVIEWS: ALGAE BLOOM EXPERIMENT

This interview asked the questions found in Appendix F to the Mattayom 3 (Grade 9) teachers after running the algae bloom experiment in class. This interview conducted at the school the teacher was from on the dates shown below.

Baan Na Peang: January 29, 2009

Potisan: February 2, 2009

STUDENT INTERVIEW

5 students were interviewed after the 2 hour algae bloom experiment.

What do you like about the experiment so far?

Baan Na Peang - One student said that she liked the experiment because she liked trying out the experiment herself. All of the students enjoyed looking at the standard prepared samples as well as the water samples through the microscope.

Boddhi Saen - The students were interested with the activities. On a scale of 1-10, the students would give the experiment 9/10.

What do you not like about the experiments so far?

Baan Na Peang - One student said that the only part that she did not like was that she had to work with fertilizer, which is a "dangerous chemical".

Boddhi Saen- There is nothing the students did not enjoy about the experiments.

What about this information is useful? What information do you think you won't use again?

Baan Na Peang - One of the students found the information about the fact that "fertilizer runoff can make water turn bad" very useful. She said that the information was very useful because she will go back home to tell her parents about the subject so that they would understand it too. The students mentioned that all of the information was important.

Boddhi Saen - The students thought that all of the information was useful. The only activity they thought was not useful was using the lab balance.

Do you find this information interesting or boring? Why?

Baan Na Peang - The students thought that all of the activities were fun. They enjoyed the extra food web and food chain activity (game) a lot. They also said that they enjoyed the experimental procedures a lot and especially mentioned that they enjoy practical work much more.

Boddhi Saen - The students thought that all of the information was interesting as they have never done many experiments in class before.

Did you understand all of the information that the teacher explained to you? What did you not understand?

Baan Na Peang - The students said that they understood most of the information taught. However, most of the students said that they had problems with the use of equipment. Some of the problems that they had were that they found it difficult to measure the fertilizer using the manual balance, they could not see through the microscope clearly and they thought that it was difficult to adjust the focus. The students also mentioned that these problems occurred because this was the first time that they had any experience with the lab equipment.

Boddhi Saen - The students said that before the class they did not understand the concept of food webs but they now understand it much better

What would you add to the activity if you were able to write it?

Baan Na Peang - The students think that in general more games (educational activities) and experiments should be held in their classes. The students also thought that in worksheets there should be fewer questions asked.

Boddhi Saen - The students think that there should be more games to help them understand the content.

TEACHER INTERVIEW

Formative Assessment:

Did you have any difficulties while explaining background or instructions of experiment? How can we word the instructions or background better to help ease these difficulties?

Baan Na Peang: The main difficulty that teacher had was that she did not know how she could link the topic of fertilizer runoff and ecology together. The students understand both of the topics but they do not know how to combine and link them together.

Where do you think the students had trouble following the information?

Bhodi Saan: The teacher said that during class he had to vocally expand the pre-test questions and has to give examples as the students did not seem to understand the questions just through reading the questions. He said that one way to help is to use the wording, which the students understood the most in order to re-write the questions. The teacher also thinks that the questions should be longer to expand and ask the question in a way that is easier for the students to understand.

Baan Na Peang: The information was good and the game helped the students to understand the topic well. The students only had problems with the use of lab equipment such as the microscope or the balance. It took the teacher a long time to teach the students how to use the equipment and the students could not use the equipment properly.

Do you think the students understood the material? What did they have trouble understanding?

Bhodi Saan: The students now know the difference between a food web and a food chain. The information is enough for students to be able to find the difference between these two things.

Baan Na Peang: The students understood the material well as the game helped them reinforce the material.

How much of the curriculum topic does this experiment cover? Do you think it teaches the topic well enough that you would be able to use this experiment to teach the topic in the future?

Bhodi Saan: The experiment covers the topic of food chain and food web very well. The experiment is good for specifically teaching the topic of food chains and food webs. He also said the information is good enough to teach students at all levels. The explanations are easy to understand. The pictures in the background and the food chain and food web game helped the students to learn the background. The teacher thinks that the games helped the students understand the development of a food chain into a food web.

Baan Na Peang: The experiment covers the topic of specifically food chains and food webs very well. The experiment also links the topic about fertilizer in the way that fertilizers make plants grow better.

What information do you think the students will remember best? Why?

Bhodi Saan: The students will probably remember the difference between a food chain and a food web very well. The pictures in the background handout and the game in the class helped the students to picture the process better.

Baan Na Peang: The students will remember the information about the difference between food chains and food webs because the game helped to reinforce the concepts to the students. The students were engaged and had fun so they would probably remember more.

Summative Assessment

How interested were the students in the activity?

Bhodi Saan: The teacher said that the students were very interested in the class (he said that probably more than 90% of the students were interested). They ask questions to the teacher on their own. This shows that they were interested in class. However, in passive learning, they do not answer many questions. In the active class with using the experiment, even the group with boys looks more interested in class. All of the students discuss with each other to get the answers to the pre-test. They might play around with the answers (e.g. a joke about whales and sharks) but it is still on topic.

Baan Na Peang: Compared to a normal class, the students were very excited about the activity, especially the game and being able to use the microscope and seeing the prepared cell samples as they have never seen it before.

How do you feel about time and effort than usual to explain the information of the experiment to the students compared to a normal class?

Bhodi Saan: The teacher thought that he had to spend more time and effort in teaching the experiment. He had to speed up the time as he had to spend a lot of time on explaining the background information. The teacher mentioned that he had to explain both the background and all the steps to the experiment clearly and carefully. The teacher thinks that the class is more tiring as he always has to move around groups answering questions.

Baan Na Peang: More time and effort was needed to run the class as the teacher has to always walk around to help every group and the teacher also had to spend more time to train specific skills to the students so that they can apply it to the experiment.

Do you think our presence impacted the students? What are some good ways they were impacted? What are some bad ways they were impacted?

Bhodi Saan: The teacher feels that the students are more excited when there are observers. The teacher said that he thinks with ob servers, the students have the motivation to perform better. He thought that some negative points were that the students could have felt a little stressed and pressured.

Baan Na Peang: Our presence did not impact the students very much as they were very excited at using instruments such as the microscope and they pay a lot of attention to the experiments.

Compared to a normal class, do you feel the students absorbed the same amount of information? Less? More?

Bhodi Saan: Compared to a normal class, the teacher thinks that the students absorbed more information. If compared to passive learning, he feels that the students learn more through using the experiments.

Baan Na Peang: Compared to a normal class, the teacher felt that the students absorbed more information as they were more engaged in class. Students concentrate a lot because they see new things like games and lab equipment such as the microscope in class.

Did the students drew connections between the information and their personal experiences?

Bhodi Saan: The teacher thinks that the students can draw connections between what they have learnt as they can see how nature works. They mostly answer the questions according to their own experiences. For example, they understand that if one animal dies, the other animal will have no food to eat.

Baan Na Peang: The students could probably draw connections between the information and their personal experience as they will now understand the connections between animals in nature. They will also understand the effect of fertilizer runoff. This is very important as most of the student's parents are mainly farmers. This means that students can relate the information to their own farming practices.

Compared to a normal class, do you feel like the students were more or less engaged?

Bhodi Saan: Compared to a normal class, the teacher feels that the students were more engaged.

Baan Na Peang: Compared to a normal class, the students are more engaged. The students were very interested in the topic as they have not done many science experiments before.

What percentage of the students was engaged?

Bhodi Saan: The teacher thinks that approximately more than 90% of the students were more engaged in the class.

Baan Na Peang: More than 80-85% of the students were engaged.

What factors in the students let you know whether they were engaged or not? What behaviors?

Bhodi Saan: The students asked many questions for example when they know that the student of another group has observed something in the microscope. The students would also ask the teacher to help them find something on the microscope as they want to also be able to observe things. This can be considered as a way of motivating the students as when they find out that their friends are observing things on the microscope, they become more eager to get the observations too.

The main behaviors which show that students are engaged are that they answer the teacher's questions and they also ask questions whenever they have any queries. Another point is that they worked according the all of teacher's instructions and the students seemed to be interested in all of the details. The students make sure that they do each step well and make sure that they do not go out of topic so that they can finish the experiment.

Baan Na Peang: Observerable behaviour to show that students are engaged in learning 1.Students ask a lot of questions, 2. They are eager to see samples in the microscope. They also want to weigh samples or use the microscope by themselves.

To what extent do you think the students will be able to apply or use this information in their lives?

Bhodi Saan: The teacher thinks that it is mainly the students who study after M3 who will get to use most of the information taught. The teacher also thinks that the information is also useful for students who will become farmers as it makes them mare conscious about looking after and taking care of the environment that they are in.

Baan Na Peang: They can understand about nature more but the students who study after M3 will get to use a lot of the information. The students can also use the information to help teach their family so that they become more aware of conserving the environment.

APPENDIX J: PRE- AND POST- TEST QUESTIONS

Mattayom 1 Experiment: Effect of Salinity of Plant Growth

Pre-Test Questions

1. What effect does a high salt concentration in soil have on plants?
2. Reverse osmosis, which causes water to move out of a body, interferes with plant growth. How do you think it will occur during the experiment?

Post-Test Questions

1. What happens to plants when they are exposed to a high salt concentration in soil?
2. If reverse osmosis interferes with plant growth by pulling water out of a plant, how will water flow if a plant is exposed to high concentrations of salt?

Mattayom 2 Experiment: Incomplete Combustion and Air Pollution

Pre-Test Questions

1. Do you think that by inhaling the products of burning a material like motor oil you could be sick?
2. Do you think burning a substance causes noticeable difference in the air?

Post-Test Questions

1. Would you have been worried about your health if you inhale the smoke from motor oil?
2. Do burning fuels cause noticeable difference in the quality of the air we breathe?

Mattayom 3 Experiment: Algae Blooms and Their Effect on Local Ecology

Pre-Test Questions

1. Organize the following animals according to their position in the food chain.

   - Krill and Jellyfish - Mineral
   - Crab and Squid - Killer whales
   - Tuna and Shark

2. Why does one action on the food chain have many different effects throughout the food chain?

Post-Test Questions

1. Organize the following animals according to their position in the food chain

   - Gecko - Grass
   - Cat - Mineral
   - Grasshopper

2. How would lowering the population of one member of a food chain affect the other animals in the food chain?

APPENDIX K: PRE- AND POST- TEST RESULTS

Table J-1: Pre- and Post- Test Results for All Levels

		Baan Na Peang	Potisan
M1	Pre-Test	55.56%	61.54%
	Post-Test	90.28%	82.14%
M2	Pre-Test	78.85%	95.65%
	Post-Test	92.31%	95.65%
M3	Pre-Test	57.81%	58.33%
	Post-Test	60.61%	93.75%

Figure J-1: Student performance on questions related to osmosis and the effects of salinated water on plant growth

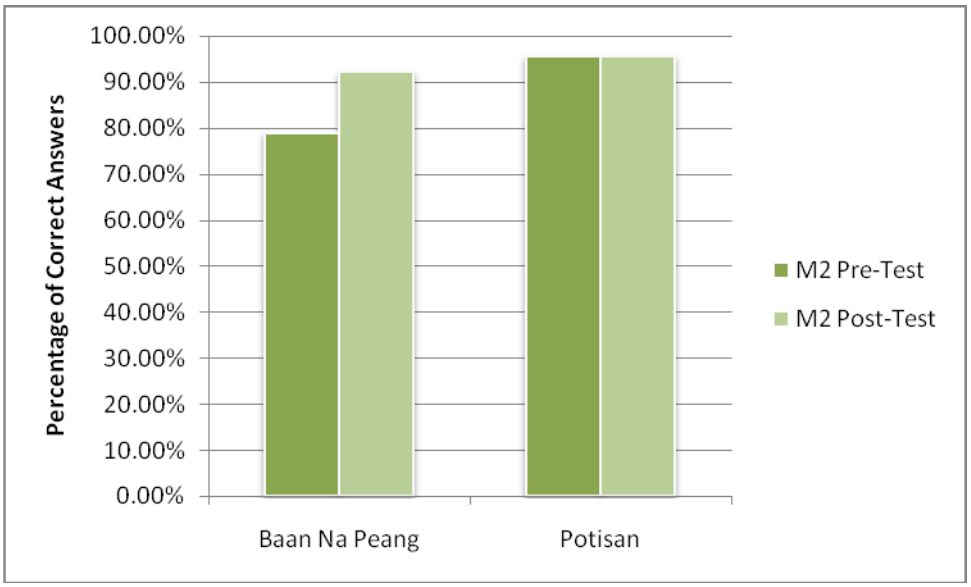


Figure J-2: Students performance on questions related to incomplete combustion and the reactions effect on air pollution

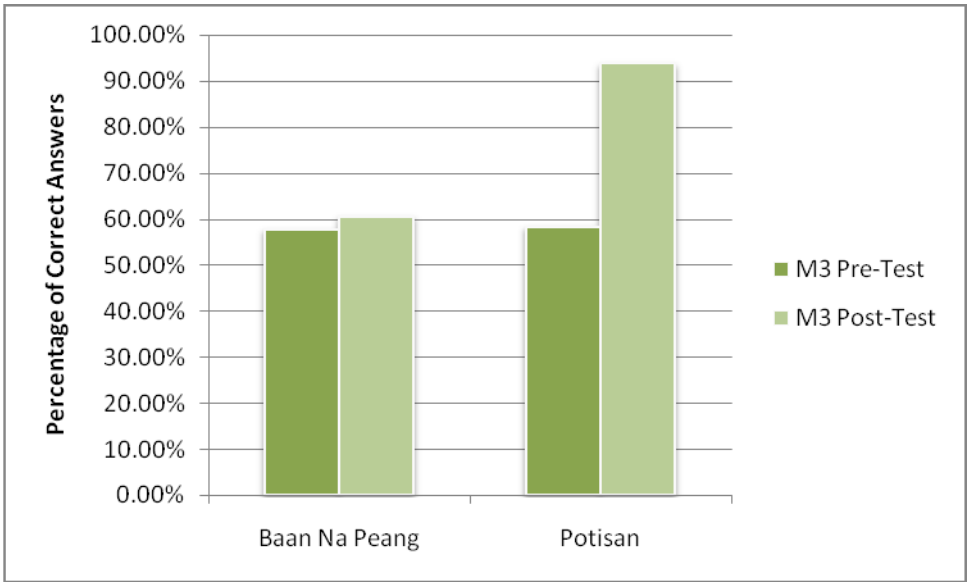


Figure 0-1: Students performance on questions related to food webs and the affect of one change on the entire web

APPENDIX L: OBSERVATION PROTOCOL

Date of observation:

Grade level being evaluated: M1 M2 M3

Classroom environment: Active learning Passive learning

Number of students being evaluated: (/)

Students seated based on: Student choice Class Register Teachers choice

Start time:

End time:

Classroom Representation

*letters and numbers represent the students and relative positions in class

Engaged

How many times does a teacher ask an individual student a question? _____

10 minutes	20 minutes	30 minutes	40 minutes	50 minutes

How many times do students, under their own will, respond to a question or comment? _____

10 minutes	20 minutes	30 minutes	40 minutes	50 minutes

How many times do students, under their own will, ask a question of the teacher during class? _____

10 minutes	20 minutes	30 minutes	40 minutes	50 minutes

How many students stay after class to ask the teacher a question? _____

Not Engaged

How many students are doing work other than the assigned class work? _____

10 minutes	20 minutes	30 minutes	40 minutes	50 minutes

How many times does the teacher have to reprimand students in the class? _____

10 minutes	20 minutes	30 minutes	40 minutes	50 minutes

How many times do students ask for toilet breaks? What is the relative length of the toilet break? _____

10 minutes	20 minutes	30 minutes	40 minutes	50 minutes

How many students are looking out the window or around the class room while the teacher is talking? _____

10 minutes	20 minutes	30 minutes	40 minutes	50 minutes

How many students have conversations in class that do not pertain to the class work? _____

10 minutes	20 minutes	30 minutes	40 minutes	50 minutes

*Notes

Was there a specific student that accounted for a lot of the data? (i.e. misbehaved often, asked many questions, ect.)

Any additional information?

APPENDIX M: TEACHER'S GUIDE (ENGLISH VERSION)

Teacher's Guide

CONTENTS

1. LAB EXPERIMENTS

1.1. How to run experiments

This section outlines how to apply active teaching methods to the experiments.

When to run experiments

According to an educational mindset called *constructivist pedagogy*, students shape what they are learning by what they have already known and experienced. These experiments present information by building on what students have already learned through the National Thai curriculum. Thus, the experiment should be run directly after the topics presented in the background section are covered in class.

Step 1: Teachers Instructions: Preparing for the class

Before the experiment is run, the teacher must make sure that all the required materials are collected and prepared. These preparations are outlined in the **Teacher's Instructions.** This can be done in previous periods or the night before. Preparing all needed material beforehand will make the experiments run smoother and easier in class.

Step 2: Review Background

The Background Section included with each experiment should be a review for the class. By presenting it before the experiment is run, this will give students enough information to make concrete hypothesis. Because the experiments are meant to run parallel with class, the background section is meant to be used as a review, and to expand specific topics addressed in lab. This section can be presented to students using your normal in-class techniques, or can be assigned to be read as homework.

This section also briefly explains how the topics are applied to local problems. This follows an active teaching method called *place-based instruction,* which makes the lesson more pertinent to the students by relating the material to their daily lives and makes students more likely to remember the topics covered. The connection between the topic and student's daily lives should be covered within the background.

Step 3: Review the Student Instructions

The next important step is to review the Student Instructions with the class. By making sure the class is familiar with the class before you run it, it will allow the students to perform more of the experiments on their own.

Each step of the lab should be gone over one by one, and explained to the students. One effective way of showing the class what to do is to demonstrate how to set up the experiment. While this is an effective way to show set up, care should be taken not to reveal the results of the experiment. For example, the Combustion Experiment tests the burning of fuels. The teacher should show how to set up the test for viewing the different fuels, but the fuels should not be lit in front of the class.

Step 4: The Hypothesis Worksheet

At this point, teachers should divide the class into groups. Groups of 4-6 work best for these types of activities. By having students work in these groups, teachers encourage *cooperative learning*, where students of varying levels and knowledge can work together to learn and understand topics.

These groups should be assigned to complete the *hypothesis* section of the lab. This section is an important step in the *scientific method*. Students need to develop a statement in which to test during the experiment. The Hypothesis Worksheet thus asks students to make an educated guess about the results of the experiment.

It will be helpful to tell the students that the answer to hypothesis questions does not have to be right or wrong. This is a best guess, and will be confirmed or refuted by the experiment.

Step 6: The Experiment

In this section, students will run through the **Student Instructions**. Through doing this, students will experience *hands-on* learning.

Students should be allowed to run the experiment on their own as much as possible. The teacher should walk around the class and observe each group, making sure they are on tasks and performing the experiment correctly.

While running the experiments, students should fill out information on the **Observation Worksheet.** This will make a record of what happened in the experiment to be used for the conclusions section.

Step 7: The conclusions

Students are asked to do the **Conclusions Worksheet**. This worksheet can be used to determine the students observation and success in running the lab.

1.2. Equipment Instructions

This sections aims to provide extra information on how to use specialized equipment such as the microscope and the balance. This information is meant to supplement the instructions provided for each of the experiments. It is important to also note that there may be variations among different models of microscopes and also the triple beam balance.

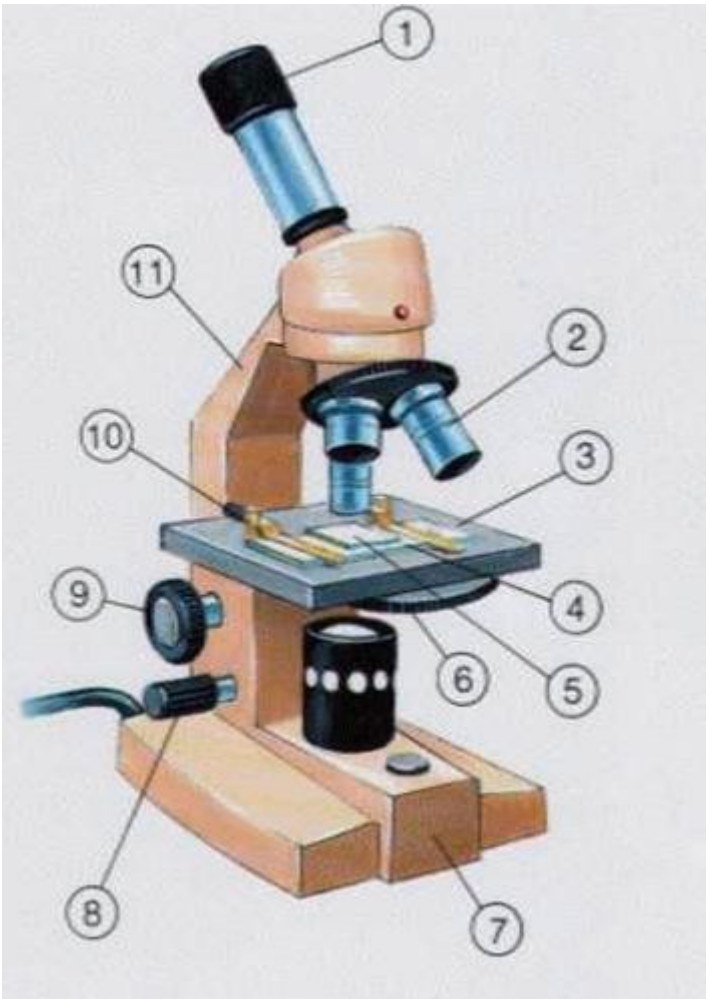
Instructions on how to use a microscope:

1. Set the microscope on a flat and stable surface and plug the power cord into the outlet in order to start the electric light. Switch on the light source.
2. Adjust the diaphragm (Part 6) so that it would allow the largest amount of light to pass through.
3. Rotate the objective lens (Part 2) to lowest magnification (Usually 4x for a standard microscope). This will give 40x magnification. It is important to start with the lowest setting as it would give a wider view of the sample.
4. In the case that the sample is a liquid, prepare the microscope slide by using a pipette to drop the sample onto the center of the slide and placing a cover slip over it. In the case that the sample is a solid, make sure that the sample is flat on the slide before placing a cover slip on it.

Preparation of a slide: A pipette is used to place the sample on the center of the slide and the cover slip is placed over the sample.

5. Place the slide onto the stage (Part 3) using the stage clips (Part 10). Move the slide until the sample is at the center of the lens.
6. Adjust the coarse focus knob (Part 9) until the sample is in focus. Move the slide to center the sample if necessary.

7. Adjust the fine focus knob (Part 8) until the sample is clearly in focus and adjust the diaphragm (Part 6) to get the best lighting. Start with the largest amount of light and gradually lower it so that the sample image has a sharp and clear contrast.
8. Scan around the surrounding areas of the sample to get a general overview of the sample as for at the center of the sample, higher power should be used.
9. Rotate the lens (Part 2) to the 10x objective. This will give 100x magnification. Gradually refocus the image using *only* the fine focus knob. This is very important as using the coarse focus knob could cause damage to the lens. As more light is needed for higher magnifications, adjust the lighting until the image is clear. Repeat the same process when adjusting to the 40x or 400x, magnification.



Parts of a microscope

References

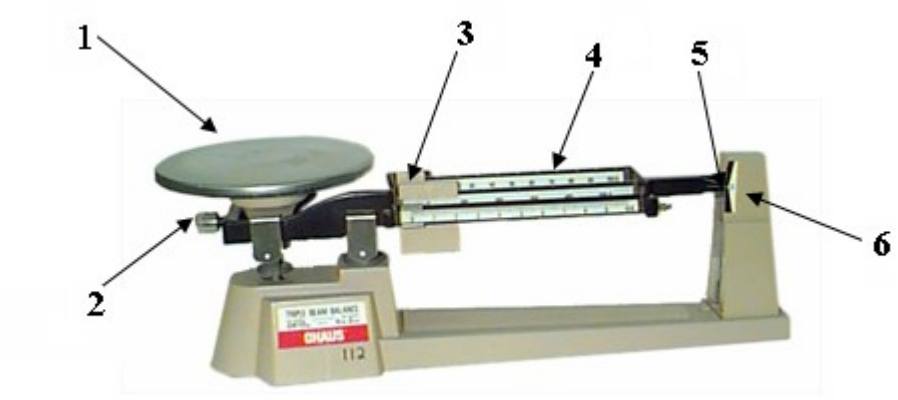
Pictures:

Al-Quds University. Practical Manual for the Biology Experiments Teacher Edition, 02 18, 2009, from: http://www.sep.alquds.edu/biology/scripts/Biology_english/part_1_1.htm

Text:

Home Science Tools. 2009. How To Use a Microscope. 02 18, 2009, from: http://www.hometrainingtools.com/articles/how-to-use-a-microscope-teaching-tip.html

Instructions on how to use a triple beam balance:



A triple beam balance

The triple beam balance can measure samples very precisely. The reading error is only around 0.05 grams. The instructions on how to use a triple beam balance are as follows:

1. Every time the balance is taken out, move the three sliders (Part 3) to the far left of the beams so that the balance reads to zero. When the indicator is not aligned to zero, the balance can be calibrated by turning the set screw on the left under the pan (Part 2).
2. After the balance has been calibrated, place the sample onto the pan (Part 1).
3. Move the slider on the 100 gram beam along to the right until the indicator (Part 5) drops below the center mark on the far right (Part 6), and then move the slider back one slot.
4. Move the slider on the 10 gram beam along to the right until the indicator (Part 5) drops below the center mark on the far right (Part 6) and then move the slider back one slot.
5. Move the slider on the 1 gram beam (smallest beam) until the indicator (Part 5) is aligned to the center of the center mark on the far right (Part 6).
6. In order to get the mass of the object on the pan, add up the numbers from the three beams.

References

Text:

The Department of Physics, Southern Methodist University. 2008, 12 25. Triple Beam Balance. 02 19, 2009, from: http://www.physics.smu.edu/~scalise/apparatus/triplebeam/

Image:

The Department of Physics, Southern Methodist University. Triple Beam Balance. 02 19, 2009, from: http://www.physics.smu.edu/~scalise/apparatus/triplebeam/

1.3. Lab Experiment Activities

1.3.1. The Effect of Salinity on Plant Growth

Teacher Instructions

Background

Diffusion is the process by which particles, whether solid, liquid, or gas, move from an area of high concentration to an area of low concentration to achieve balance. One way to imagine this happening is two rooms separated by a doorway. One of the rooms is filled with girls. The other room is filled with boys. As long as the door remains shut, the girls will stay in their room and the boys will stay in their room. However, once the door is opened, the forces cause the boys to want to move away from the boys, and the girls to want to move away from the girls. They will keep moving making it so that they are evenly distributed. When this happens, the number of boys on one side of the door will be balanced with the number of boys on the other side of the door. This motion can be described as diffusion.

Molecules in nature are a lot like these boys and girls. They usually want to move far away as possible from each other, unless something holds them together. When molecules move from high concentration to low concentration, the process is called diffusion. When you open a bottle of something smelly in a room, the thing that brings the smell all around the room is diffusion.

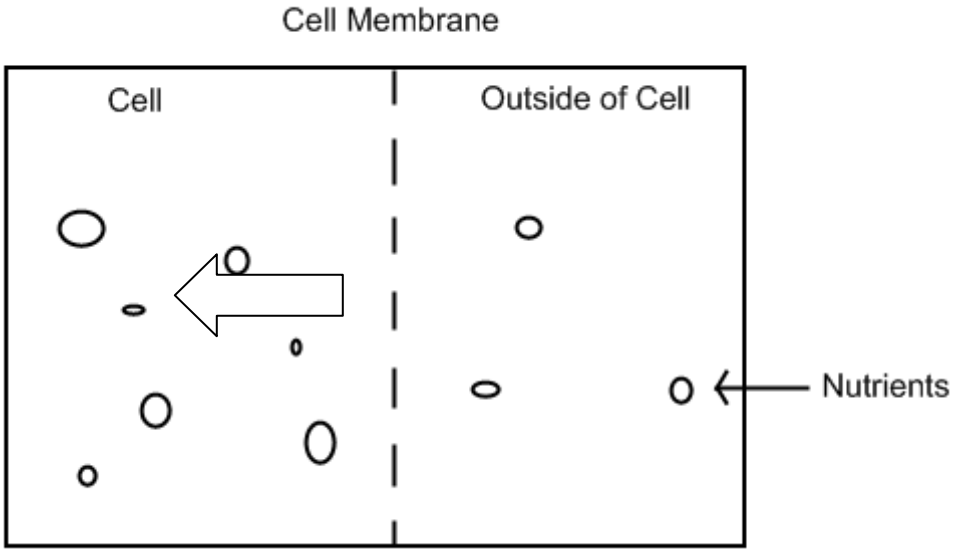
Osmosis is a type of diffusion. Osmosis is the diffusion of water molecules. Although all osmosis processes are diffusion, not all diffusion processes are osmosis. If instead of girls and boys in the separate rooms, there was one room filled with pure water and one room filled with sugar water. Because there are sugar water molecules in the water, taking the place of water molecules, the sugar water can be said to have a lower concentration of water. If door would open, the same thing would happen as when it was girls and boys. Water molecules from the room containing pure water would move into the sugar water room. Sugar molecules from the room containing sugar water would move into the room with the pure water. This would continue until there is the same amount of sugar and water is on both sides of the doorway. This is Osmosis.

If there was chlorine gas on one side of the door, and hydrogen gas on the other side of the door, the same process would happen if the door was opened. The amount of chlorine and hydrogen would balance between the two rooms. However, this is not osmosis. Although it is the same process, this example does not include water. Therefore, it is not osmosis.

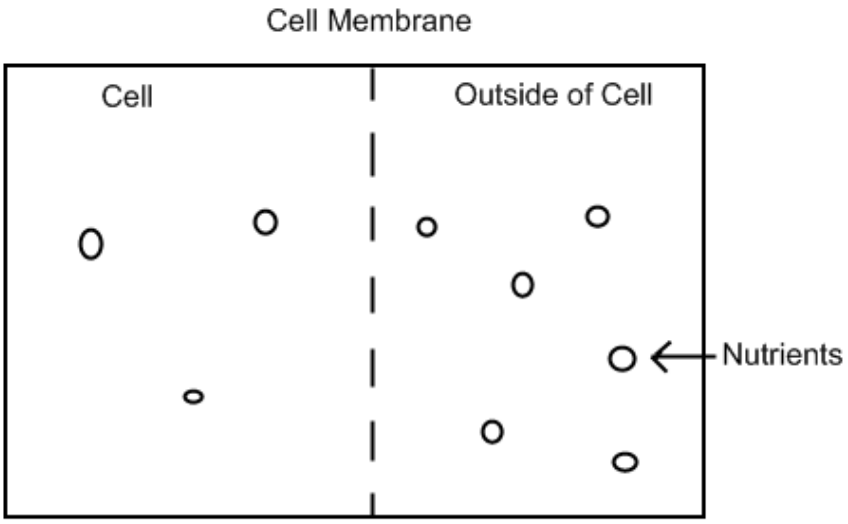
What is salinity? Salinity is the amount of salt dissolved in a given body of water or soil, generally expressed as a concentration in parts per thousand (ppt); all bodies of water have a certain salt concentration. Whereas some bodies of water naturally have a high salinity, such as the ocean and the Dead Sea, most do not. This is because most organisms cannot survive in an environment with a high salt concentration. Normal water has a salt concentration of 0.5 ppt. The Dead Sea in Israel has an average salt concentration of 500 ppt, the greatest known in any body of water. This concentration is so high that nothing can live in the waters, including plants. Many plants have a hard time surviving in soils with high salt concentrations.

Think about when you eat or drink something really salty. Does it make you thirsty? It does make you thirsty because the salt concentration of the water in your body is less than the one in the water of what you ingest, so concentrations have to balance and the food ends up drawing water out of your cells, leaving them dehydrated. This process is called reverse osmosis. Cells are made up mostly of water. The cell membrane around the cells lets water and nutrients pass through. When there is a higher concentration of salt on one side of the membrane, fluid passes out of the cell to bring balance back.

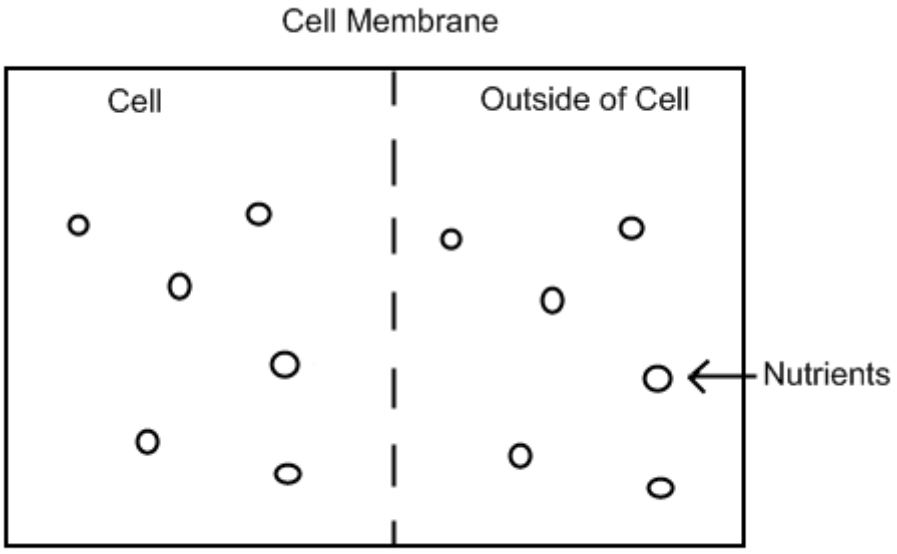
The following diagram shows osmosis. There are more nutrients inside the cell, so water flows into the cell to balance the concentration of nutrients inside the cell with the concentration of nutrients outside the cell.



This process can go in either direction. If there are more nutrients outside of the cell, water will travel out of the cell to give the same concentration of water to nutrients outside of the cell as there is inside the cell. This is shown in the following diagram.



The following diagram shows balance. No osmosis is taking place because there are equal concentrations of nutrients and water both inside and outside the cell.



When salt collects in the soil, it makes it harder for plants to draw water out of the soil through their roots. The more water the plant draws out of the soil, the harder it is to for the plant to draw more water out of the soil. This is because the concentration of salt in the soil is increasing, and the process begins to act in reverse. As the amount of water decreases, the amount of salt is staying the same, leading to an increase in soil salinity. Like a human would become thin and unhealthy when living on scarce or non-nutritious food, so too do plants become when unable to draw enough water out of the soil.

This is relevant to Sakon Nakhon because the groundwater in Sakon Nakhon is becoming increasingly salty. Since people in Sakon Nakhon use groundwater as their main water source to water crops, the soil which is used for farming is being exposed to salinated water. This is a problem because the salt in the water becomes stuck in the soil and builds up. Any plants that are grown in this soil will not grow as well as they would were they to be planted in soil that is not salty.

A scientific experiment works through reasoning and gradually going to conclusions. It is a method that is used to work out if a particular variable is the main factor leading to a conclusion. For example, if there are two variables (X and Y), an experiment will help to determine whether X is the course of Y to occur. Looking in a wider perspective scientific experiments are used to provide a better understanding of natural phenomena. It is probably the most commonly used method in scientific research.

The three main variable used in the scientific method are known as the independent variable, the dependent variable and the control variable.

The **independent variable** is the variable that researchers use to work out whether something is the "cause" of a phenomena. In this experiment, the independent variable is the amount of salt used.

The **dependent variable** is the variable that is used to work out whether the reasoning actually leads to the conclusion. In this experiment, the dependent variable is the growth of the plants.

The **control variable** is the variable which researchers can derive methods to control it. In this experiment, the control variable is the amount of water used.

The Experiment

Educational Goals

- To provide an experiment that shows the effect of biotechnology on local agriculture
- To stimulate students interest in biotechnology outside regular classroom procedures
- To teach students how to make predictions
- To teach students how to cooperatively work in groups
- To actively engage students in the subject of biotechnology

Introduction

In this experiment, the student will investigate the effect of salinity on plant growth. They will first complete the hypothesis exercises with their team. The student will then plant their seeds in cups, place them in an area that receives sunlight, and add clean water to them every day. After germination, the student will water each plant with water that contains a different amount of salt and daily record observations as to the growth or sickness of the plant. At the end of a week following germination, the student will complete the individual worksheets which they will receive from the teacher.

Relevance

Students will be able to see the topic of biotechnology in action. This experiment will engage them in the subject matter because it relates to their daily lives. Students who do this experiment will be able to understand that there are positive effects to biotechnology.

Materials Required Per Class

1. A large source of soil
2. About 1 Liter of bottled or purified water per group of 4 students
3. About 1 Liter of local water (from well or pump) per group of 4 students
4. About 1 Liter of mildly salinated water per group of 4 students
5. About 1 Liter of very salinated water per group of 4 students
6. 4 large buckets to store soils and water in
7. 4 plastic or Styrofoam drinking cups for every group of 4 students
8. A roll of masking tape
9. Dry Measuring Cups

10. 4 seeds of a fast sprouting crop for every group of 4 students
11. Area in class room or school that is exposed to sunlight (window)
12. 1 plastic or Styrofoam cup for watering per group of 4 students

Materials Required Per Group of Students

1. 4 plastic or Styrofoam drinking cups
2. Masking Tape
3. Dry Measuring Cups (at teacher station)
4. 4 seeds (of a fast sprouting crop)
5. 1 Liter Bottled of purified Water
6. 1 Liter Local Water
7. 1 Liter of mildly salinated water
8. 1 Liter of very salinated water
9. 1 cup of soil
10. Area that is exposed to sunlight
11. 1 plastic or Styrofoam cup for watering

Procedure for Teacher

<u>Preparation for first day</u>

1. Fill a large bucket with soil.
2. Cut approximately 1 foot of masking tape off of the roll for each group and place it at each groups station
3. Place set of measuring cups at the front of the class room next to buckets
4. Fill one large bucket with local groundwater (from tap or well)
5. Fill one large bucket with clean water (bottled or purified)
6. Prepare the mildly salinated water solution. Per group of 4 students, mix 17.5 mL (38 grams) of salt with 1 L of water. For the entire class, multiply the amount of salt and amount of water by the number of groups.

7. Prepare the very salinated water solution. Per group of 4 students, mix 35 mL (76 grams) of salt with 1 L of water. For the entire class, multiply the amount of salt and amount of water by the number of groups.
8. If running water is not available, place one large bucket full of water at the front of the classroom
9. Place 5 plastic or Styrofoam cups at each groups station
10. Place 12 seeds at each groups station
11. Either Make one copy of worksheet 1 for each group and place at each groups station, or write questions from worksheet 1 on the blackboard or whiteboard for students to write in their notebooks and answer.
12. Find an area that is exposed to sunlight where all the plants can be stored

<u>Preparation for Every Day until the Seeds Have Sprouted</u>

1. Have clean water available every morning for the students to water their plants.
2. Have a cup for each group to transport water in every morning.
3. When the plants are approximately 2.5 cm tall, it is time to move to the next set of instructions

<u>Preparation for After Seeds Sprout – Continue for Two Weeks</u>

1. Have clean water available every other morning for the students to water their plants
2. Have local water available every other morning for students to water their plants
3. Have mildly salinated water available other every morning for students to water their plants
4. Have very salinated water available every other morning for students to water their plants
5. Place buckets of water at front of class
6. Have a cup for each group to transport water in every morning.
7. Either make one copy of worksheet 2 for every group and hand out to each group, or write the instructions on the blackboard or whiteboard for the students to write into their notebooks and answer. Complete Observations three times a week.

Preparation for end of 1 week after sprouting

1. Either make one copy of worksheet 3 for every student or write questions onto the black or whiteboard for students to write into their notebooks and answer.

Optional Instructions - Measuring Salt Concentration of Local Water

In order to determine the concentration of salt in local groundwater, it is possible to take a sample of groundwater and boil off all of the water. In this way, it can be determined how salty the groundwater is compared to the pure water used in the experiment and the salt water solutions used in the experiment.

1. Clean and dry a pot to boil water in.
2. Weigh the pot – write down the weight of the pot
3. Measure out 250 mL of local water and put in the pot
4. Boil the water until all water is gone
5. Weigh the pot again. Subtract the 1st measurement of the weight of the pot from the weight measured in this step.
6. Calculate concentration by dividing grams of salt by liters of water

Expected Answer to Student Worksheets

Worksheet 1

Hypothesis

1. What sample do you think will show the most growth after the end of the experiment? List the samples ("A" "B" "C" "D") in order from most growth to least growth.

   A, B, C, D

2. Are there any samples that you think won't grow by the end of the experiment?

   Sample D will die

   Sample C will become sick and/or die

3. Draw pictures of what you think sample A will look like at the end of the experiment:

   (Pictures of plants)

4. Draw pictures of what you think sample B will look like at the end of the experiment:

   (Pictures of plants)

5. Draw pictures of what you think sample C will look like at the end of the experiment:

   (Pictures of plants)

6. Draw pictures of what you think sample D will look like at the end of the experiment:

   (Pictures of plants)

7. In question 1 of this worksheet you listed a sample as the one that will show the most growth over 3 weeks. Why do you think this plant will show the most growth?

I chose sample A, because this is the sample that doesn't have any salt added to the water. This sample will grow the best because the salt in the other solutions of water will draw the water out of the cells in the plants and cause them to die.

Worksheet 3

Individual Conclusions

1. Which plants grew the best? Why? What type of water were they getting?

   I chose sample A, because this is the sample that doesn't have any salt added to the water. This sample will grow the best because the salt in the other solutions of water will draw the water out of the cells in the plants and cause them to die.

2. What happened to the plants that were receiving other concentrations of salt water?

   The plants that were receiving the very salty and mildly salty concentrations of salt water died. The sample receiving very salinated water died faster than the plan receiving mildly salinated water.

3. Did any of the plants die?

   Yes – Samples C and D

4. If you were to grow a garden, what type of water would you want to use to water your plants?

   I would use clean water to water my plants, to prevent them from dying.

5. What happens to the soil after it has been watered with salinated water? Do you think anything will grow in the soil?

   After the soil has been water with salinated water, it becomes salty as well. Nothing will grow in the soil for a long time after this happens.

Student Instructions

Background

Diffusion is the process by which particles, whether solid, liquid, or gas, move from an area of high concentration to an area of low concentration to achieve balance. Imagine two rooms separated by a doorway. One of the rooms is filled with girls. The other room is filled with boys. As long as the door remains shut, the girls will stay in their room and the boys will stay in their room. However, once the door is opened, girls and boys will begin to move in and out of each room until there are the same amount of girls and boys in each room. In moving between rooms so that the amount of girls on each side of the doorway is the same, they are diffusing between rooms.

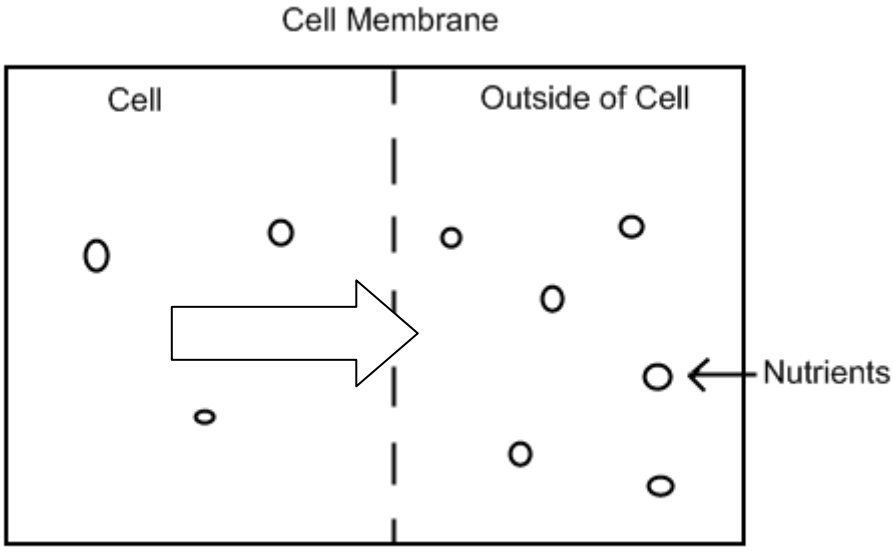
Osmosis is the diffusion of water molecules. Although all osmosis processes are diffusion, not all diffusion processes are osmosis. If instead of girls and boys in the separate rooms, there was one room filled with pure water and one room filled with sugar water, and the door would open, the same thing would happen as when it was girls and boys. Water molecules from the room containing pure water would move into the sugar water room. Sugar molecules from the room containing sugar water would move into the room with the pure water. This would continue until there is the same amount of sugar and water is on both sides of the doorway. This is Osmosis.

If there was chlorine gas on one side of the door, and hydrogen gas on the other side of the door, the same process would happen if the door was opened. The amount of chlorine and hydrogen would balance between the two rooms. However, this is not osmosis. Although it is the same process, this example does not include water. Therefore, it is not osmosis.

What is salinity? Salinity is the amount of salt dissolved in a given body of water or soil, generally expressed as a concentration in parts per thousand (ppt); all bodies of water have a certain salt concentration. Whereas some bodies of water naturally have a high salinity, such as the ocean and the Dead Sea, most do not. This is because most organisms cannot survive in an environment with a high salt concentration. Normal water has a salt concentration of 0.5 ppt meanwhile the Dead Sea in Israel has an average salt concentration of 500 ppt, the greatest known in any body of water. This concentration is so high that nothing can live in the waters, including plants. Many plants have a hard time surviving in soils with high salt concentrations.

Think about when you eat or drink something really salty. Does it make you thirsty? It does make you thirsty because the salt concentration of the water in your body is less than the one in the water of what you ingest, so concentrations have to balance and the food ends up drawing water out of your cells, leaving them dehydrated. This process is called osmosis. Cells are made up mostly of water. The cell membrane around the cells lets water and nutrients pass through.

When there is a higher concentration of salt on one side of the membrane, fluid passes out of the cell to bring balance back.



When salt collects in the soil, it makes it harder for plants to draw water out of the soil through their roots. The more water the plant draws out of the soil, the harder it is to for the plant to draw more water out of the soil. This is because the concentration of salt in the soil is increasing. As the amount of water decreases, the amount of salt is staying the same, leading to an increase in soil salinity. Like a human would become thin and unhealthy when living on scarce or non-nutritious food, so too do plants become when unable to draw enough water out of the soil.

This is relevant to Sakon Nakhon because the groundwater in Sakon Nakhon is becoming increasingly salty. Since people in Sakon Nakhon use groundwater as their main water source to water crops, the soil which is used for farming is being exposed to salinated water. This is a problem because the salt in the water becomes stuck in the soil and builds up. Any plants that are grown in this soil will not grow as well as they would were they to be planted in soil that is not salty.

The Experiment

Introduction

In this experiment, you will investigate the effect of salinity on plant growth. You will first complete the hypothesis exercises with your team. You will then plant your seeds in cups, place them in an area that receives sunlight, and add clean water to them every day. After germination, you will water each plant with water give each plant water that contains a different amount of salt and daily record observations as to the growth or sickness of the plant. At the end of a week following germination, you will complete the individual worksheets which you will receive from the teacher.

Relevance

The quality and salinity of the water used to irrigate crops with has a large impact on the productivity and health of the crops themselves. Using salinated water to irrigate crops leads to salination of soils. This can hinder plant growth, or even cause the plants to die. You will investigate the effects that different concentrations of salt in water have on plant growth.

Materials Required Per Group of Students

1. 4 plastic or Styrofoam drinking cups
2. Masking Tape
3. Dry Measuring Cups (at teacher station)
4. 4 seeds (of a fast sprouting crop)
5. 1 Liter Bottled of purified Water
6. 1 Liter Local Water
7. 1 Liter of mildly salinated water
8. 1 Liter of very salinated water
9. 1 cup of soil
10. Area that is exposed to sunlight
11. 1 plastic or Styrofoam cup for watering

Procedure for Students

<u>First Class</u>

1. Read the Background, Intro and Relevance sections of this activity

2. Complete Worksheet 1 with your team
3. Gather the Materials Needed
4. Poke 3 small holes in the bottom of each cup, excluding the water cup
5. Label the cups with your group number
6. Label cups “A” “B” “C” “D”
7. Add one cup of soil to “A” “B” “C” and “D”
8. Add 1 seed to “A” “B” “C” and “D” about 1 inch deep
9. Ensure all seeds are covered by the soil
10. Fill the cup for watering 1/3 full of water and pour the water on “A”
11. Fill the cup for watering 1/3 full of water and pour the water on “B”
12. Fill the cup for watering 1/3 full of water and pour the water on “C”
13. Fill the cup for watering 1/3 full of water and pour the water on “D”
14. Place all 4 cups in an area that is exposed to sunlight

<u>Every Morning before sprouting</u>

1. Fill the cup for watering 1/3 full of water and pour the water on “A”
2. Fill the cup for watering 1/3 full of water and pour the water on “B”
3. Fill the cup for watering 1/3 full of water and pour the water on “C”
4. Fill the cup for watering 1/3 full of water and pour the water on “D”

<u>Every morning after sprouting</u>

1. Fill the cup for watering 1/3 full of bottled water and pour the water on “A”
2. Fill the cup for watering 1/3 full of local water and pour the water on “B”
3. Fill the cup for watering 1/3 full of mildly salinated water and pour the water on “C”
4. Fill the cup for watering 1/3 full of very salinated water and pour the water on “D”
5. Record observations on Worksheet 2

<u>At the end of 1 week after sprouting</u>

1. Complete Worksheet 3 individually

Student Worksheets

Worksheet 1

Hypothesis

1. What sample do you think will show the most growth after the end of the week? List the samples ("A" "B" "C" "D") in order from most growth to least growth.

2. Are there any samples that you think won't grow by the end of the week?

3. Draw pictures of what you think sample A will look like at the end of 1 week:

4. Draw pictures of what you think sample B will look like at the end of 1 week:

5. Draw pictures of what you think sample C will look like at the end of 1 week:

6. Draw pictures of what you think sample D will look like at the end of 1 week:

7. In question 1 of this worksheet you listed a sample as the one that will show the most growth over 3 weeks. Why do you think this plant will show the most growth?

Worksheet 2

Observations

Draw a picture of sample A

Measure the height of sample A:

Date of observation:

Draw a picture of sample B

Measure the height of sample B

Date of observation:

Draw a picture of sample C

Measure the height of sample C

Date of observation:

Draw a picture of sample D

Measure the height of sample D

Date of observation:

Worksheet 3

Individual Conclusions

1. Which plants grew the best? Why? What type of water were they getting?

2. What happened to the plants that were receiving other concentrations of salt water?

3. Did any of the plants die?

4. If you were to grow a garden, what type of water would you want to use to water your plants?

5. What happens to the soil after it has been watered with salinated water? Do you think anything will grow in the soil?

Pre – Test

1. What effect does a high salt concentration in soil have on plants?

2. Reverse osmosis, which causes water to move out of a body, interferes with plant growth. How do you think it will occur during the experiment?

Post – Test

1. What happens to plants when they are exposed to a high salt concentration in soil?

2. If reverse osmosis interferes with plant growth by pulling water out of a plant, how will water flow if a plant is exposed to high concentrations of salt?

Budget

Material	Groups per class	Quantity required per group (4 students)	Student per class	Cost per item	Cost per class
Soil	10	N/A	40	35	350
Bottled Water	10	1 Liter	40	20	200
Empty Bottles	10	3	40	N/A	N/A
Salt	10	1	40	40	400
Plastic Drinking cups	10	5	40	5	250
Masking tape	10	N/A	40	35	350
Dry measuring cups	10	N/A	40	50	500
Package of Seeds	10	N/A	40	40	400
Total Cost of lab:					2,450

1.3.2. Incomplete Combustion and Air Pollution

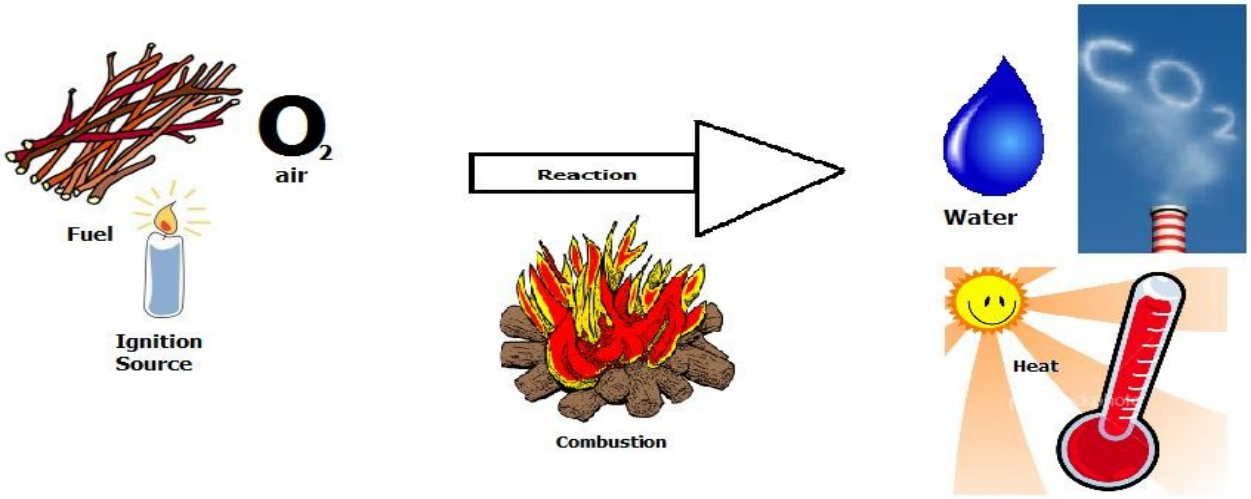
Teacher Instructions

Background

Combustion is what happens when an object or material burns. For example, this material could be a bunch of wood being burned for a campfire. All of the components of the wood burn, leaving only one behind. The component left behind is the element carbon. This carbon can be left behind either on the ground, in the form of ash or soot, or in the air, in the form of dirty smoke. This dirty smoke, which pollutes the air, can be produced by both manmade and natural materials. The smoke, which is often called air pollution, is made up on small pieces of pollen and dirt called *particulate matter*. Normally air has a natural amount of particulates getting into the air. One way this can happen is dust getting stirred into the air on a windy day in the dry season. When there is too much dust or dirt in the air, our bodies cannot filter the dust out, and we get sick.

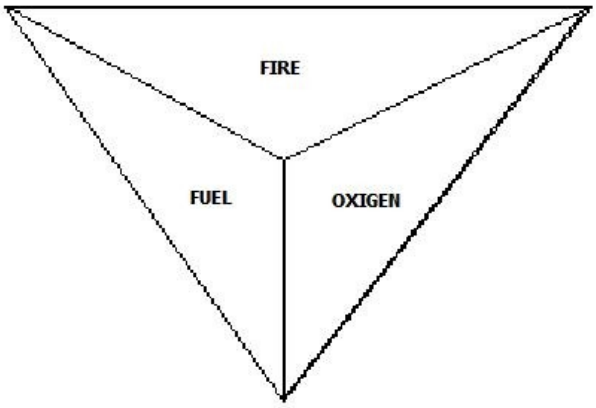
When you burn, or combust, things, it produces heat, a transparent gas known as carbon dioxide, and water, which can be in the form of water vapor. This transformation occurs through a chemical reaction. A chemical reaction is when you combine two substances to get an entirely new substance. This is different from a physical change. A physical change is when you mix two materials together to form a mixture. An example of this is when you mix ground coffee and sugar. If you were to taste this dusty mix, you can easily taste the coffee and the sugar as different flavors. This occurs because the coffee and the sugar are still the same substances they were before.

In order for combustion to occur, several different ingredients are necessary. Think of when you try to start a fire. You cannot start a fire without anything to burn. This is called fuel. Fuel, such as wood or cloth, is necessary to create fire. Air is also necessary for starting fires. Fire consumes air – it needs the oxygen in order to sustain itself. Think of when you are frying something and the oil catches on fire. Have you ever smothered a fire by placing a lid over the flame? The fire goes out almost immediately, because it runs out of oxygen and dies. You also need something to start the fire with, such as a lighter or a match. This is called the *ignition source.*



All materials are composed of different amounts of basic ingredients, named elements. One of these elements is carbon. Carbon requires a lot of oxygen to be burned, especially when combined with other elements. Therefore, fuel that is made of up of mostly carbon will burn more completely than fuel that has more impurities. Combustion can occur in two different ways. In one way, known as *complete combustion*, the fuel and the oxygen are completely consumed by the reaction. Since everything that is reacted (fuel and oxygen) is transformed into heat, carbon dioxide, and water, it does not form anything else. This includes soot or ash. The other way is known as *incomplete combustion.* This occurs when there is not enough oxygen to burn up all the fuel. Because there is fuel left over, it remains after the reaction is complete as soot or ash.

When fire goes out of control it can be very dangerous. Fire can quickly burn tables, books, and houses, and can trap people inside rooms and suffocate them. It is very important to prevent it from spreading. Fire needs two things to keep on burning: oxygen and fuel.



As it can be seen in the safety triangle, if you keep fire from receiving one of them it will stop burning. If you drop water on the fuel source, it stops being a fuel so it cannot keep on burning. The same will happen if you cover the fire so it cannot receive air anymore. If the fire in your experiment begins to spread outside the candle, cover it with the glass jar or water it.

The Experiment

Educational Goals for Teacher

- To allow students to see what a combustion reaction is
- To show that chemical reactions can have negative environmental effects
- Identify what air pollution is
- To show that some types of fuel burn cleaner than others

Introduction

In this experiment your team will investigate the combustion of three different types of fuels: Methanol, Vegetable Oil and Motor Oil. All of these reactions produce different amounts of ash depending on their properties. Your team will investigate what happens when these fuels are combusted and you will consider the side effects of combustion.

Teacher Relevance

Students who do this experiment will be working with a combustion reaction. They will be able to relate the material that they read in an academic book to what actually happens in life. They will see a chemical reaction in person. The students will learn that some reactions can have a negative environmental effect.

Teacher Materials Required

1. Methanol
2. A bottle of motor oil
3. A bottle of Vegetable Cooking Oil
4. A roll of cotton rope, 5 mm thick
5. Large glass jars (2 per group of students)
6. Small glass jars (2 per group of students)
7. Large paper clips (2 per group of students)
8. 4 Wood Pieces
9. Lab pipette or straw (2 per group of students)
10. Glass of water
11. Pair of scissors (1 per group of students)

Teacher Procedure

1. Place containers of methanol, vegetable oil and motor oil on front table
2. Cut each group a 5 cm piece of cotton rope and place at group stations
3. Place 2 paper clips, 2 small glass jars, 2 large glass jars, 2 pipettes or straws and 1 pair of scissors at each group station

When groups have their station setup

1. Ensure students stay away from cotton rope that is lit
2. One member has to make sure the cotton rope is soaked in water after being burnt

Expected Answer to Student Worksheets

Worksheet 1 – Expected Student Answers

Hypothesis

1. Do you think the combustion of the motor oil will be a complete or incomplete reaction?

   Complete (circled) Incomplete

2. Do you think the combustion of the vegetable oil will be a complete or incomplete reaction?

   Complete Incomplete (circled)

3. Do you think the combustion of the methanol will be a complete or incomplete reaction?

   Complete Incomplete (circled)

4. Which ones would you think have the most impurities?

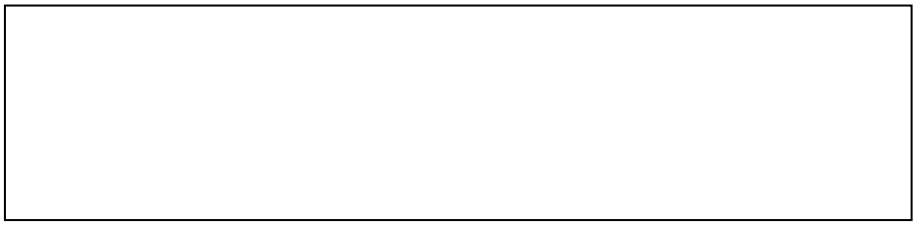
   Motor oil

5. Knowing that incomplete combustion causes the formation of particulate matter, what do you think the glass jars will look like? Draw pictures of what you think the jars will look like at the end of the experiment:

-
  - Methanol jar

Vegetable Oil jar

Motor Oil jar



Worksheet 3 – Expected Student Answers

Individual Conclusions

1. Was your hypothesis about what the jars would look like correct? Explain the similarities or differences.

2. Which material burned cleaner? From this observation, do all materials cause the same amount of pollution?

   Methanol burned cleaner than vegetable oil and vegetable oil burned cleaner than motor oil. They cause different amount of pollution.

3. Why is combustion where there is a lot of pollution harmful to the environment?

   Because it produces Carbon Dioxide, which is a greenhouse gas.

4. Can you think of any ways to reduce the amount of pollution that goes into the environment?

   Burned less or use a clean fuel to burn object.

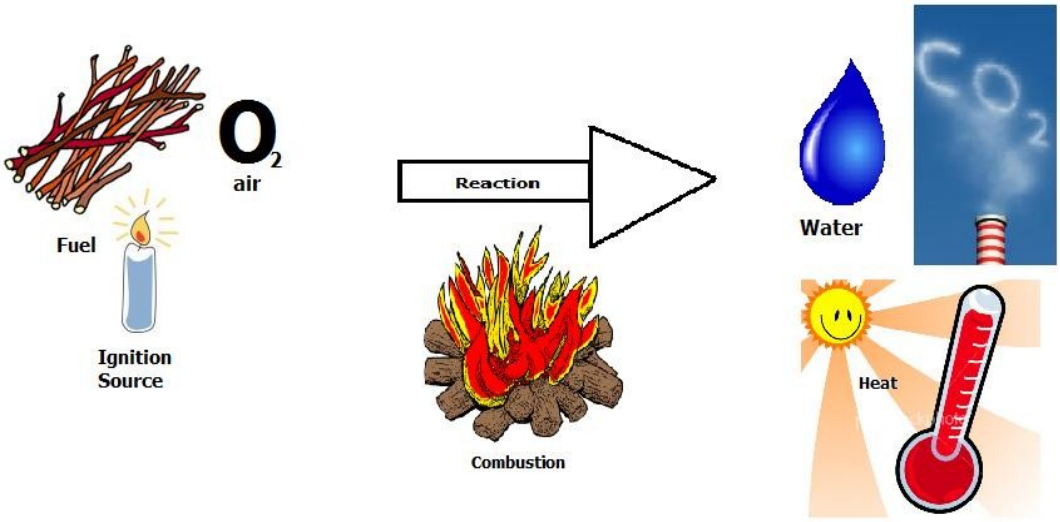
Student Instructions

Background

Combustion is what happens when an object or material burns. For example, this material could be a bunch of wood being burned for a campfire. All of the components of the wood burn, leaving only one behind. The component left behind is the element carbon. This carbon can be left behind either on the ground, in the form of ash or soot, or in the air, in the form of dirty smoke. This dirty smoke, which pollutes the air, can be produced by both manmade and natural materials. The smoke, which is often called air pollution, is made up on small pieces of pollen and dirt called *particulate matter*. Normally air has a natural amount of particulates getting into the air. One way this can happen is dust getting stirred into the air on a windy day in the dry season. When there is too much dust or dirt in the air, our bodies cannot filter the dust out, and we get sick.

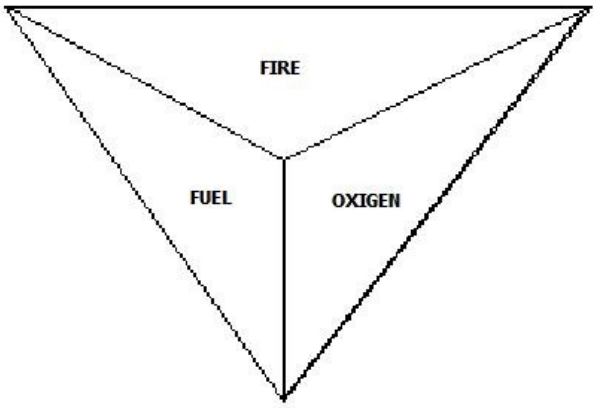
When you burn, or combust, things, it produces heat, a transparent gas known as carbon dioxide, and water, which can be in the form of water vapor. This transformation occurs through a chemical reaction. A chemical reaction is when you combine two substances to get an entirely new substance. This is different from a physical change. A physical change is when you mix two materials together to form a mixture. An example of this is when you mix ground coffee and sugar. If you were to taste this dusty mix, you can easily taste the coffee and the sugar as different flavors. This occurs because the coffee and the sugar are still the same substances they were before.

In order for combustion to occur, several different ingredients are necessary. Think of when you try to start a fire. You cannot start a fire without anything to burn. This is called fuel. Fuel, such as wood or cloth, is necessary to create fire. Air is also necessary for starting fires. Fire consumes air – it needs the oxygen in order to sustain itself. Think of when you are frying something and the oil catches on fire. Have you ever smothered a fire by placing a lid over the flame? The fire goes out almost immediately, because it runs out of oxygen and dies. You also need something to start the fire with, such as a lighter or a match. This is called the *ignition source.*



All materials are composed of different amounts of basic ingredients, named elements. One of these elements is carbon. Carbon requires a lot of oxygen to be burned, especially when combined with other elements. Therefore, fuel that is made of up of mostly carbon will burn more completely than fuel that has more impurities. Combustion can occur in two different ways. In one way, known as *complete combustion*, the fuel and the oxygen are completely consumed by the reaction. Since everything that is reacted (fuel and oxygen) is transformed into heat, carbon dioxide, and water, it does not form anything else. This includes soot or ash. The other way is known as *incomplete combustion.* This occurs when there is not enough oxygen to burn up all the fuel. Because there is fuel left over, it remains after the reaction is complete as soot or ash.

When fire goes out of control it can be very dangerous. Fire can quickly burn tables, books, and houses, and can trap people inside rooms and suffocate them. It is very important to prevent it from spreading. Fire needs two things to keep on burning: oxygen and fuel.



As it can be seen in the safety triangle, if you keep fire from receiving one of them it will stop burning. If you drop water on the fuel source, it stops being a fuel so it cannot keep on burning. The same will happen if you cover the fire so it cannot receive air anymore. If the fire in your experiment begins to spread outside the candle, cover it with the glass jar or water it.

The Experiment

Student Relevance

Combustion happens any place material is burned. Combustion happens at a factory in a city and inside the engine of a farm tractor. There are many possible solutions to regulate the amount of ash released into the atmosphere. Applying them in order to keep air quality high is important because an excess of ash in the air can cause respiratory diseases like asthma or lung cancer.

Student Materials Required

1. 6 cm long piece of cotton rope
2. 2 large paper clips
3. 2 large glass jars
4. 2 small glass jars
5. 4 Wood Pieces
6. 3 Pipettes or straws
7. 1 cup of water
8. Methanol
9. Vegetable Oil
10. Motor Oil
11. Scissors
12. Candle

Student Procedure

<u>Part 1</u>

1. Place the two wood pieces in a stable location, parallel to each other separated by two and a half centimeter.
2. Bend the paper clip so that it looks like this: 
3. Cut 6 cm length of the thick cotton rope
4. Weave the paper clip in and out of the outer most layer of the 6 cm long piece clothesline so it looks like this: 
5. Bend the bottom piece of the paper clip so it can stand on its own
6. Fill one small jar with a sample of methanol from the front of the classroom

7. Using the pipette put 20 drops of methanol on the clothes line that is attached to the paper clip
8. Place the clip in between the wood pieces and put the glass jar facing downwards over the wood pieces
9. When finished setting up ask the teacher to light the clothes line with a candle
10. Let the clothesline burn until the flame disappears and place the smoking remains of the paper clip in a cup of water
11. Complete portions of worksheet 2 concerning methanol
12. Repeat step 1-10 by using vegetable oil instead of methanol
13. Complete portions of worksheet 2 concerning vegetable oil
14. Repeat step 1-10 by using motor oil instead of methanol
15. Complete worksheet 2

<u>Part 2</u>

1. When experiment is finished complete worksheet 3 individually

Worksheet 1

Hypothesis

1. Do you think the combustion of the motor oil will be a complete or incomplete reaction?

   Complete Incomplete

2. Do you think the combustion of the vegetable oil will be a complete or incomplete reaction?

   Complete Incomplete

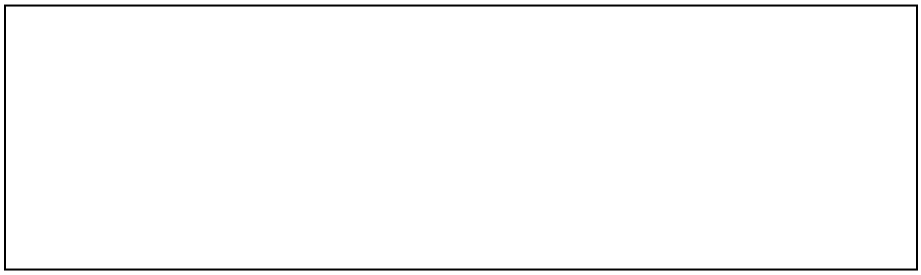
3. Do you think the combustion of the methanol will be a complete or incomplete reaction?

   Complete Incomplete

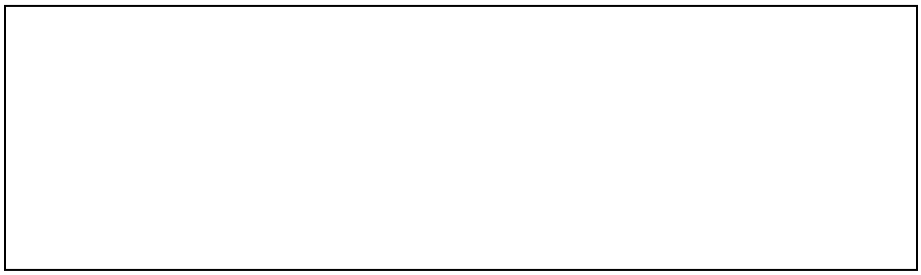
4. Which ones would you think have the most impurities?

5. Knowing that incomplete combustion causes the formation of particulate matter, what do you think the glass jars will look like? Draw pictures of what you think the jars will look like at the end of the experiment:

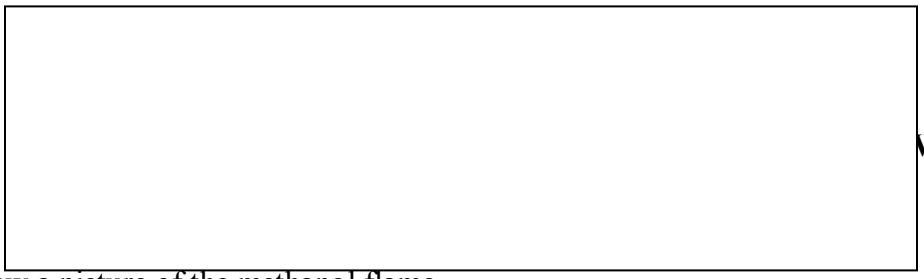
Methanol jar



Vegetable jar



Motor Oil jar



Worksheet 2

Draw a picture of the methanol flame

Draw a picture of the methanol jar

Draw a picture of the vegetable oil flame

Draw a picture of the vegetable oil jar

Draw a picture of the motor oil flame

Draw a picture of the motor oil jar

Worksheet 3

Individual Conclusions

1. Was your hypothesis about what the jars would look like correct? Explain the similarities or differences.

2. Which material burned cleaner? From this observation, do all materials cause the same amount of pollution?

3. Why is combustion where there is a lot of pollution harmful to the environment?

4. Can you think of any ways to reduce the amount of pollution that goes into the environment?

Pre-Test Questions

3. Do you think that by inhaling the products of burning a material like motor oil you could be sick?

4. Do you think burning a substance causes noticeable difference in the air?

Post-Test Questions

3. Would you have been worried about your health if you inhale the smoke from motor oil?

4. Do burning fuels cause noticeable difference in the quality of the air we breathe?

Budget

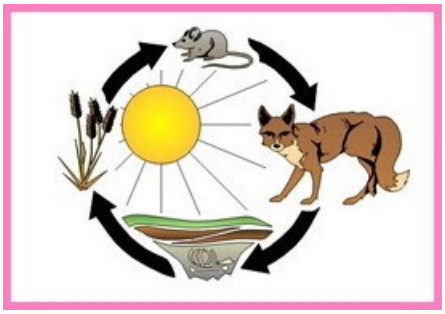
Material	Groups per class	Quantity required per group (4 students)	Students per class	Cost per item	Cost per class
Box of Paper clips	10	N/A	35	20	20
Clothes line	10	1/2 metre	35	25	875
Drinking Glasses	10	2	35	10	200
Plastic Drinking Cups	10	3	35	5	150
1 mL pipette	10	N/A	35	40	40
Pair of scissors	10	1	35	40	400
Bottle of motor oil	10	N/A	35	60	60
Candle	10	1	35	2	20
Bottle of vegetable oil	10	N/A	35	25	25
Bottle of methanol	10	N/A	35	55	55
Pieces of wood	10	2	35	7.50	150
Total Cost of lab:					2,120

1.3.3. Algae Bloom and Local Ecology

Teacher Instructions

Teacher Background

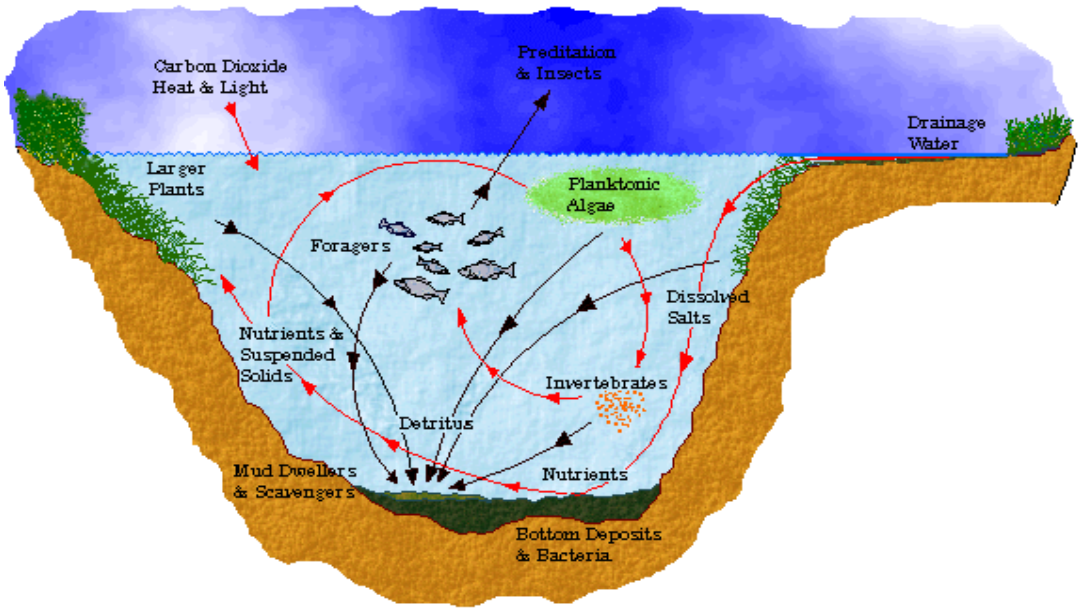
What is a food chain? A food chain is process showing the relationship between organisms in a community where each member is eaten in turn by another member. The relationship starts from the producer going to the primary consumer and then to the secondary consumer. This relationship is known as a food chain.



What is a food web? Food webs are a graphical representation of the way organisms interact in an ecosystem. In these diagrams arrows typically show how a bigger organism consumes a smaller one. Food webs work as chains, if one of the links in the web gets disturbed, it cuts the whole chain. As you can see in the diagram, all organisms are interconnected and rely on each other as food sources. The most basic species in a food chain, the basal species, is the one that doesn't feed from other organisms. The following species forming the chain are called intermediate species. Finally the organism with no predator above it is, which ends the chain, is named the top predator. Humans are the top predator in most food webs. For example, in your local pond, from which we fish for lunch, we, humans are the top predator of its food chain.

When the food chain becomes unbalanced, it occurs due to an overabundance or scarcity of an organism in the food web and the entire chain is affected. One example of a basal species is algae. Algae are plant organisms that live in water, and mainly consume minerals dissolved in the water. They are eaten by different intermediate organisms. When the algae grows too much, and becomes overabundant, it unbalances the ecosystem. This is called an **algae bloom**.

Algae blooms often occur due to an overabundance of food, such as fertilizers that come in run-off from farms. These blooms are very harmful to the local ecology of a pond. Although at first, the population of organisms in the pond which feed on the algae grow very fast, eventually the algae grows too big and cuts off sunlight and resources in the water. The algae in the pond die, forming large amounts of dead plant material. When the dead material begins to decompose, it draws too much oxygen out of the water. Starved of oxygen, the fish and other organisms in the pond, which depend on oxygen to survive, die as well.



Example Food Web

What is agricultural runoff? Agricultural runoff is any form of chemical used in agriculture that gets into ponds. This should be prevented because the pond won't be able to support as many fish as it could if the chemicals didn't affect some species in the food web. Chemicals that may be used in local agricultural practice could be:

Herbicides- A chemical that kills plants or inhibits their growth; intended for weed control.

Pesticides- A chemical used to kill pests, especially insects

Fertilizers- Organic or inorganic plant foods which may be either liquid or granular used to amend the soil in order to improve the quality or quantity of plant growth.

How do you store fertilizers to prevent agricultural runoff? A drainage system should be built to collect any runoff water. Chemicals which may escape during tank rinsing, spills, seepage from the storage, and heavy runoff from firefighting or floods must be controlled. Otherwise, they may contaminate surface or groundwater supplies. Dikes, collecting pools, and washing slabs with sumps would provide a proper drainage system. All the collected runoff water can be applied to a labeled site, provided that the concentration of pesticide does not exceed the labeled rate.

How do you use Microscopes in this experiment? Microscopes can be used in this experiment to show a difference between the amounts of organisms in water with an algae bloom as opposed to water without. Water with an algae bloom, before the algae bloom decomposes, will have a

much higher number of organisms. After the algae bloom decomposes, there will be a much lower number of organisms.

The Experiment

Educational Goals for Teacher

- To provide an experiment that shows the food chain of a local pond
- To provide an experiment that shows the effect of run-off on water plants
- To stimulate students interest in local ecology outside regular classroom procedures
- To teach students how to make predictions
- To teach students how to cooperatively work in groups
- To actively engage students in the subject of local ecology

Introduction

In this experiment you will investigate the food chain of local ponds. You will observe a natural food chain in a local pond. Then your group you will investigate further into the side effects of agricultural runoff on algae, a basal species, and the intermediate microorganisms that feed on the algae. This will be done through the growth of algae using water collected from local ponds through exposing the water to a sample of agricultural runoff. The algae will grow very thickly. Though the experiment will not go for long enough to watch the algae die and cause the organisms in the water to suffocate, you will see the effect that fertilizer has on the growth and death of plants and organisms in a local pond. Microscopes can be used to observe the number of organisms in the water, both before and after the algae bloom has occurred.

Teacher Relevance

Students will see that agricultural chemicals which get into the water supply will cause plants to grow too fast and too much, leading to a population of organisms to expand rapidly and later starve. Students will see that this occurs with other plants, such as duckweed, and not just algae. Students will relate this to good and bad agricultural practices.

Teacher Materials Required

1. A large source of pond water (fish pond)
2. About 2 Liters of pond water per group of students
3. 2 small buckets
4. Empty bottles for gathering samples – 2 per group

5. A roll of masking tape
6. Fertilizer
7. Microscope – 1 per group if possible
8. Microscope Slides – 2 per group
9. 1 mL plastic pipette – 2 per group
10. Dry Measuring Cups
11. Area in class room or school that is exposed to sunlight (window)

Procedure

Preparation for first day

1. Cut approximately 1 foot of masking tape off of the roll for each group and place it at each groups station
2. Place set of measuring cups at the front of the class room next to buckets
3. Place 2 small buckets at each groups station
4. Make one copy of worksheet 1 for each group and place at each groups station
5. Make one copy of worksheet 2 for each student and place at each groups station
6. Find an area that is exposed to sunlight where all the plants can be stored
7. Prepare liquid agricultural run-off by mixing X fertilizer with X water.

Preparation for every day

1. Have a cup for each group to transport water in every morning.
2. Make one copy of worksheet 3

Preparation for end of the week

1. Make one copy of worksheets 3 and 4 for every student
2. Conduct discussion with students on the effects of algae blooms
    2.4 Go over results – more organisms than when first started
    2.5 Explain how this number will continue to increase until the algae dies, after which all of the organisms will die.

2.6 Explain why the organisms die

2.7 Explain the importance of preventing agricultural run-off

Expected Answer to Student Worksheets

Worksheet 1 – Expected Student Answers

Hypothesis

1. What do you think will happen to the water and organisms when exposed to agricultural runoff?

   Plants and algae grow faster and cover the surface of the local pond.

2. Will the color change?

   Yes, it will turn green.

3. Will the number of organisms change?

   Yes, there will be more organisms.

4. Will the amount of plants change?

   Yes, there will be more plants.

Worksheet 4 – Expected Student Answers

Conclusions

Individual Student Worksheet

1. Did the plants and organisms respond to the agricultural run off as you expected?

_____
_____
_____
_____

2. Are organisms affected by agricultural run off? How are they affected?

   (Possible Answer) Yes, the number of organisms increased in the beginning. However, once the algae covered the surface the organisms died.

3. How can this affect the organisms at the top of the food chain?

   The top predator will have no food to consume

4. Is this an issue that affects you? Are you at the top of the food chain?

   Yes it does affect us because we are at the top of the food chain (top predator).

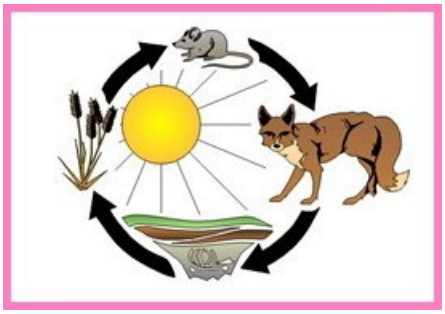
5. How can agricultural run-off be prevented?

   Limiting the addition of fertilizer to soil during rainy periods and/or being aware of where you put fertilizer in relation to bodies of water.

Student Instructions

Student Background

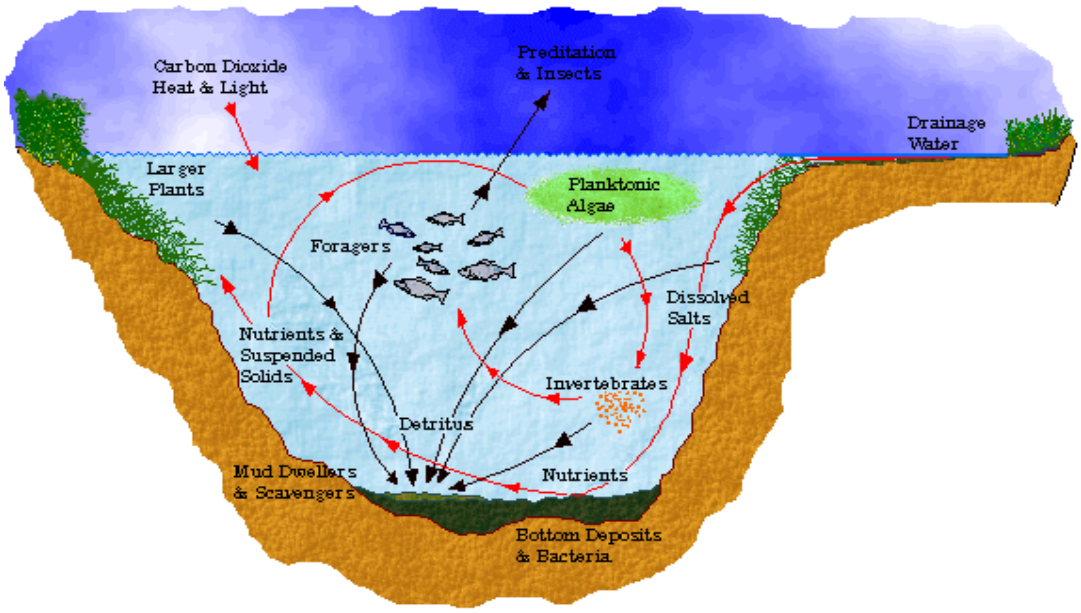
What is a food chain? A food chain is process showing the relationship between organisms in a community where each member is eaten in turn by another member. The relationship starts from the producer going to the primary consumer and then to the secondary consumer. This relationship is known as a food chain.



What is a food web? Food webs are a graphical representation of the way organisms interact in an ecosystem. In these diagrams arrows typically show how a bigger organism consumes a smaller one. Food webs work as chains, if one of the links in the web gets disturbed, it cuts the whole chain. As you can see in the diagram, all organisms are interconnected and rely on each other as food sources. The most basic species in a food chain, the basal species, is the one that doesn't feed from other organisms. The following species forming the chain are called intermediate species. Finally the organism with no predator above it is, which ends the chain, is named the top predator. Humans are the top predator in most food webs. For example, in your local pond, from which we fish for lunch, we, humans are the top predator of its food chain.

When the food chain becomes unbalanced, it occurs due to an overabundance or scarcity of an organism in the food web and the entire chain is affected. One example of a basal species is algae. Algae are plant organisms that live in water, and mainly consume minerals dissolved in the water. They are eaten by different intermediate organisms. When the algae grows too much, and becomes overabundant, it unbalances the ecosystem. This is called an **algae bloom**.

Algae blooms often occur due to an overabundance of food, such as fertilizers that come in run-off from farms. These blooms are very harmful to the local ecology of a pond. Although at first, the population of organisms in the pond which feed on the algae grow very fast, eventually the algae grows too big and cuts off sunlight and resources in the water. The algae in the pond die, forming large amounts of dead plant material. When the dead material begins to decompose, it draws too much oxygen out of the water. Starved of oxygen, the fish and other organisms in the pond, which depend on oxygen to survive, die as well.



Example Food Web

The Experiment

Student Relevance

Your impact on even the smallest species of a food chain has larger impacts on the abundance of even the top predators. Your experiment will show the impact on a food chain because of improper storage and containment of agricultural runoff. One of the larger species in a pond system is fish.

Student Materials Required

1. About 2 Liters of pond water
2 Small buckets
3. Masking tape
4. Fertilizer
5. Microscope
6. 2 Microscope Slides
7. 1 mL plastic pipette – 2 per group
8. Area in class room or school that is exposed to sunlight (window)

Procedure

1. Review Background, Intro and Relevance
2. Complete Worksheet 1 with your group
3. When teacher is ready go to a local pond
4. Using the sample jars, take two samples near vegetation in the pond
5. Use the magnifying glass to observe the organisms in the water
6. Observe the intermediate sized species in the pond
7. Bring organisms back to class room or other observation area
8. Using microscope observe the microorganisms (basal species)
9. Using magnifying glass observe the intermediate species
10. Begin Worksheet 2 with your group
11. Measure five grams of fertilizer with the mass balance and add it to one sample of water to create fertilizer run-off.
12. Place buckets in the sun
13. Complete worksheet 2.

Everyday

1. Complete worksheet 3.
2. Observe water with magnifying glass
3. Observe water with microscope

End of the week

1. Observe water with magnifying glass and microscope
2. Complete worksheet 3
3. Complete worksheet 4 with your group

Work Sheets for Students

Worksheet 1

Hypothesis

5. What do you think will happen to the water and organisms when exposed to agricultural runoff?

_____
_____
_____
_____

6. Will the color change?

_____
_____
_____
_____

7. Will the number of organisms change?

_____
_____
_____
_____

8. Will the amount of plants change?

_____
_____
_____
_____

Worksheet 2

Observation

Daily Observations – Date (Day 1)

1. What types of organisms did you find in the pond? Where do they fit in the food chain?

_____
_____
_____
_____

2. Draw pictures of the plants and organisms you found in the pond

3. What color was the water? Clarity?

_____
_____
_____
_____

4. Are there any plants or algae growing in the water?

_____
_____
_____
_____

Worksheet 3

Daily Observations – Date (Day 2 – 5)

1. What types of organisms did you find in the pond? Where do they fit in the food chain?

_____
_____
_____
_____

2. Draw pictures of the plants and organisms you see in the water

3. What color was the water? Clarity?

_____
_____
_____
_____

4. Are there any plants or algae growing in the water?

_____
_____
_____
_____

Worksheet 4

Conclusions

Individual Student Worksheet

6. Did the plants and organisms respond to the agricultural run off as you expected?

_____
_____
_____
_____

7. Are organisms affected by agricultural run off? How are they affected?

_____
_____
_____
_____

8. How can this affect the organisms at the top of the food chain?

_____
_____
_____
_____

9. Is this an issue that affects you? Are you at the top of the food chain?

_____
_____
_____
_____

10. How can agricultural run-off be prevented?

_____
_____
_____
_____
_____
_____

Pre Test

1. Organize the following animals according to their position in the food chain.

- Krill and Jellyfish
- Mineral
- Crab and Squid
- Killer whales
- Tuna and Shark

2. Why does one action on the food chain have many different effects throughout the food chain?

Post Test

1. Organize the following animals according to their position in the food chain

- Gecko
- Grass
- Cat
- Mineral
- Grasshopper

2. How would lowering the population of one member of a food chain affect the other animals in the food chain?

Budget

Material	Quantity per group	Cost per item	Number of groups	Cost per class
Small Bucket	2	25	8	400
Empty Bottles	2	N/A	8	N/A
Microscope Slide	2	75	8	1,200
Masking Tape	N/A	35	8	35
1 mL Plastic Pipette	2	10	8	160
Fertilizer	N/A	100	8	100
Dry Measuring Cup	1	50	8	400
Total Cost per of lab:				2,295

2. FUN ACTIVITIES

2.1. Osmosis Game

This fun activity will help to explain the concept of osmosis and reverse osmosis to the students. By assuming that boys are water molecules and girls are salt particles, the students will move around to represent the process of osmosis.

Procedure:

1. Separate the class room into 2 zones, representing the outside and the inside the cell.
2. In the case where boys are fewer than girls, allocate an equal number of boys and girls inside the cell and more girls than boys outside of the cell.
3. Explain that there is a higher concentration of salt outside of the cell (fewer water molecules outside of the cell compared to inside of the cell). Therefore, boys inside the cell need to move out of the cell in order to make the number equal.
4. Once there is equal number of boys outside and inside the cell, nothing moves as everything is balanced.
5. On the other hand, if there are more water molecules outside the cell, boys need to move into the cell. This will in turn show the process of reverse osmosis.

2.2. Food Web Game

The food web game will allow the students to understand the concept of food webs and food chains. Also, it will allow students to distinguish the difference between them.

Materials required:

1. Pictures of plants
2. Pictures of animals
3. Arrow signs
4. Tape

Procedure:

1. Put all of the pictures (plants, animals) and arrows on the board.
2. Explain the rules that students need to put their hands up in order to answer.
3. Ask the students to make a food chain by arranging the order from producer to top predator through using arrows.

Once the students have made several food chains, further ask students if any of the animals can eat across the food chains. Drawing arrows across the food chain will form a food web.

3. Brief description on how to design an experiment

Information on many scientific experiments, which are applicable to the middle school level, can be found from many sources such as textbooks and websites from the internet. These sources can be used as an initial guide to the implementation of science experiments to the classroom.

An important part in the development of science experiments especially if they are being used for teaching purposes is that the experiments should be tested out and modifications should be made to supplement the curriculum requirements. Also, some experiments may take a long time and this may not be suitable for a class time that is around an hour.

Another important aspect is the availability of equipment. When information on an experiment is gathered, the teacher should consider the availability of materials and also the budget in buying the equipment. In order to make the laboratory sustainable, the budget must be affordable to the schools. For example, if the experiments were written in a foreign country, some materials may not be readily available in Thailand. In a case like this, the teacher would have to try to find supplementary materials, which can be found in Thailand. Also, some experiments may need expensive equipment such as microscopes, which some schools may not be able to afford.

In order to implement applicable science experiments to the classroom, the main factors that have to be considered are the level that the students are at, alignment to the national curriculum and also the time constraints

4. MORE EXPERIMENTS

Other science topics that can be shown through experimentation

This section intends to provide a list of other science experiments, which can also be used as experiments in class. Most importantly, the experiments listed are related to the student's local environment. These experiments are taken from the following source:

Giorgio Carboni, Fun Science Gallery. 2001. Science Experiments on Environmental Education and Biology. 02 21, 2009, from: http://www.funsci.com/fun3_en/exper1/exper1.htm

Water Table – The Effects of Soil and Groundwater Contamination

In this experiment, students will learn that groundwater, which for the Kusuman region is the main source of water, can be contaminated easily by substances such as pesticides and fertilizers. Students build a model of a well out of local resources and experiment with the contamination of that well using food coloring or dyes and water.

Effects of Fertilizer on Plant Growth

The experiment will show students the effect of biotechnology on local agriculture as through the experiment, the students will be able to determine the best fertilizer for plants. Students will determine this by growing plants using different types of local fertilizers. As the area is agricultural based, learning about the use of fertilizers to enhance plant growth will be very useful.

The Chemistry of Photosynthesis

The experiment was designed to show students the effect of chemical reactions to their local environment. It will show that if plants lack any of the conditions required for photosynthesis, they will not grow. Students will see this through watching the health of plants which are refused water, sunlight, or oxygen, and comparing this with plants that have all the requirements of photosynthesis. Most importantly, students can learn about chemical reactions through looking at an example that they can clearly see in nature.

List of other topics that can be used as experiments in class

- *Soil composition:* The main components of soil will be separated and the properties will be evaluated. Through the experiment, the students will understand more about soil, which is very important for agriculturally based area.

- *Soil moisture and permeability:* The permeability of different soil components such as sand, clay and mixed ground will be looked at. The students will learn that certain soils are better in keeping water than others. This would help students understand how soil effects irrigation.

- *Soil erosion:* Soil erosion is a big problem in agriculture. The model in the experiment will show the students how erosion occurs.

- *Soil profile:* The experiment will allow students to understand that soil has many different layers. This will give them an understanding of what happens as the roots of a plant go down into the soil.

- *Hydroponic systems:* This experiment or demonstration will show the students how to grow plants without using soil. This will enhance the student's knowledge in new methods in agriculture.

- *Soil ecosystem:* Students will understand the role certain organisms such as earthworms and centipedes, which live in the soil.

- *Culture of protests:* Students will understand how microorganisms such as algae and protozoa, which can be found in local pond water, breed.

- *Production of oxygen by photosynthesis*: Students will visually see that oxygen is one of the important products produced by plants.

- *Respiration in plants and animals:* The opposite process to photosynthesis will be shown. Respiration is an important energy-releasing process for humans and other organisms.

- *Lung model:* The experiment will show students how the human lung works. This will make it easier for students to understand an important aspect on the topic of how the human body works.

- *Extraction of the chlorophyll:* Different pigments from chlorophyll will be extracted. Students will learn different extraction techniques. The topic will be useful as chlorophyll takes an important role in the process of photosynthesis

- *Paper chromatography:* Students will learn about separation techniques, which are important for the purification of substances.

APPENDIX N: BROCHURE FOR EDUCATION FAIR

Fun Science!

MENTOS + DIET COKE- Use mentos to create a fountain of coke! Discover how this chemical reaction works

NEWTONIAN PHYSICS MACHINE – Witness how the infinite bouncing of basket balls demonstrate Newton ' s Third Law of Motion

INVISIBLE INK—Send secret messages to your friends by making your own invisible ink using baking soda and water

CORNSTARCH GOOP – Transform common kitchen materials into malleable dough with the solely heat and movement of your hands!

SINK OR FLOAT— Whether different objects sink or float depends on their density. Come test it out!

VINEGAR AND BAKING SODA BALLOONS - Inflate balloons with the gas generated by the acid base and rapid decomposition reactions

PAPER AIRPLANES: Whose plane is the best? Discover the aerodynamics of planes

EGG IN A BOTTLE: See how a pressure differential is capable of pulling an egg into a bottle!

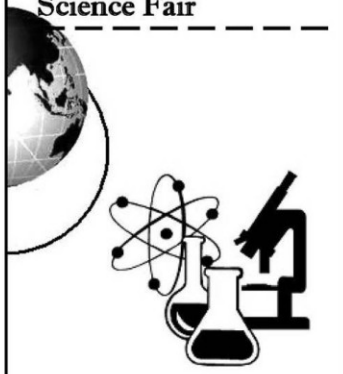
BUILD A MOLECULE: Create your own edible structures.

HERBIUM – Could you recognize the different plant species in your school? Find all their interesting facts

Who are we?

This year a group of 12 students, divided into two teams, came to Kusuman to work with teachers at four different schools. The students comefrom two universities: Jakrapan Moon, Boontida Uapipanakul, Veerada Thammmasunthorn and Leu-Shyue Chen are students in their last year at Chulalongkorn University, majoring in Industrial Chemistry. Rose Colangelo, Carol Okumura, Sean Patrick, Elias Whitten-Kassner Nathan Climer, Matt King, Sofia Zamora and Kelsey Miranda are students at Worcester Polytechnic Institute. Rose and Sean are majoring in electrical and computer engineering, Nathan is majoring in biomedical engineering, Matt and Kelsey are majoring in chemical engineering, Sofia is majoring in civil and environmental engineering and Carol and Elias are majoring in mechanical engineering.

Kusuman Educational Science Fair



Presented by:

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

WPI

Chulalongkorn Univer-

Classroom Science Experiments

We are proudly a collaboration of students from Chulalongkorn University and Worcester Polytechnic Institute. Through our sponsor, the Office of H.R.H. Princess Maha Chakri Sirindhorn 's Projects, we have worked in Sakon Nakhon to develop, refine, and test replicable science experiments in four schools in the Kusuman District. The purpose of our work here was to work with teachers to help them to run engaging, educational science lab activities that can be used as a supplement to the Thai curriculum.

Effect of Salinity on Plant Growth

The soil in Sakon Nakhon is becoming increasingly salinited with time. This change can effect plant growth. In this lab, students demonstrate how osmosis, caused by high salinity in the plant's water, causes differing plant growth.

Combustion and Air Pollution

As fuels burn, they result in waste products. In this lab, students explore how combustion of different fuels creates different amounts of air pollution.

Ecological Effects of an Algae Bloom

This lab was designed to show students how agricultural run off can effect local ecosystems. By adding fertilizer to water, students can see the increased growth of algae, and are taught to understand how this can effect the local food web.

The Biotechnology Board Game

Game designed to teach students about biotechnology and agriculture through simulation of a real life farm owner. By making the appropriate decisions, students will learn the difference between organic and genetically modified crops, as well as the importance of investment.

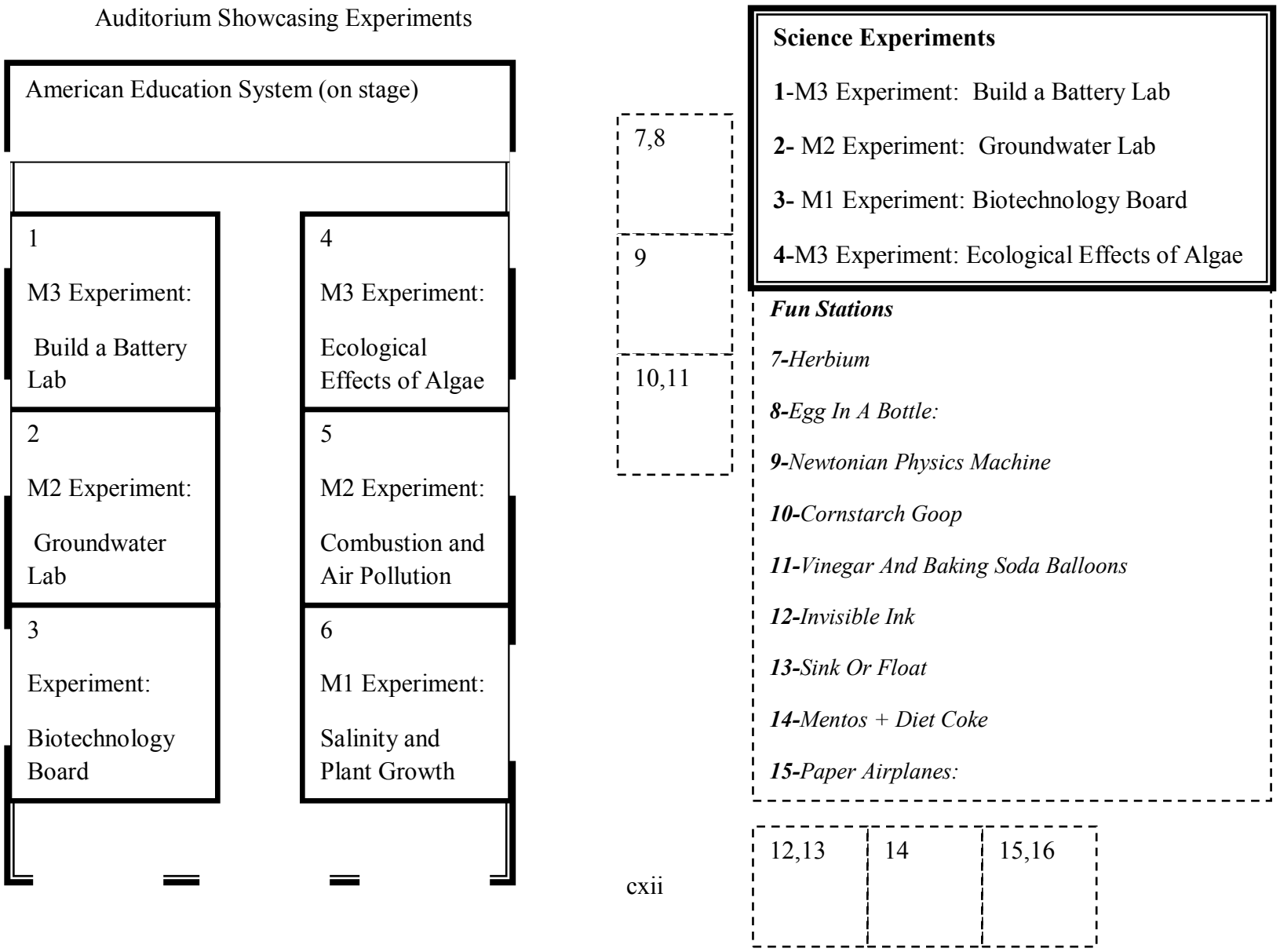
Groundwater Lab

Consists of four parts: permeability, groundwater flow model, pH testing, and measuring the pH of local water. Students construct and gather materials that are locally available.

Build-a-Battery Lab

Consists of students constructing a battery out of limes and metals such as copper and zinc. Students learn about electronic circuits and electric safety.

APPENDIX O: LAYOUT OF EDUCATION FAIR



APPENDIX P: RECOMMENDATIONS FOR THE OFFICE OF H.R.H. PRINCESS MAHA CHAKRI SIRINDHORN'S PROJECTS

This section outlines additional specific recommendations for the Office of H.R.H. Princess Maha Chakri Sirindhorn's projects for future work in the area of Sakon Nakhon

We recommend that any other teams that are sent to work with schools in Sakon Nakhon include some native speaking Thai students. Having two native Thai speakers on our team helped us to communicate with the teachers, especially when only one of the teachers spoke English. This helped us to work better with the teachers and prevent misunderstandings.

We recommend that teachers in the Kusuman District get training in different active teaching methods. Teachers might find it very helpful to have a firm background in different kinds of active teaching methods before trying to run them in their classes. This could begin with a workshop in active teaching methods for teachers.

We recommend that future projects are when teachers have more time. The teachers we worked with were often very busy with classes. They may have only one free period per day. The teachers often changed or canceled classes to work with us. Because of this, the student's learning was interrupted. It may be helpful if teachers had more time available for working with the project team.

We recommend that teams match the experiments they design to the topics being covered in class at the time the team is in the schools. We were able to use the National Thai Curriculum to make our experiments fit the curriculum. However, the topics weren't being taught in class at the time when we went to Sakon Nakhon. Also, different topics were currently being covered in each school. Future project teams should design experiments that match the topics being covered in the classrooms of their specific schools.

We recommend that teams only work with one school if they have a short period of time (four weeks). We did not have a lot of time to spend working with each teacher, especially since we only spent two days per week working in each school. We also did not have as much time for cultural exchange with the schools. Project teams may have a better impact if they focus on only one school.

We recommend that the Teacher's Guide be spread throughout the Kusuman District. The Teacher's Guide has useful information that could help teachers in the Kusuman District use science experiments in their classrooms. Especially the version of the Teacher's Guide that is written in Thai can be very useful to teachers. However, although the Teacher's Guide may be able to help teachers run experiments, it may not be enough by itself.

We recommend that Baan Na Peang and Potisan teachers help other teachers to learn how to use experiments in their classrooms. We learned that many teachers in Sakon Nakhon may have trouble becoming comfortable with running experiments if they learn only from Teacher's Guides. Teachers may find the experiments to be too complicated, or may not believe that their students will learn from experiments. We suggest that teachers from Baan Na Peang and Potisan help other teachers by explaining how to run experiments. They can also share their opinions on the experiments, including what worked really well and what they had trouble with. This could be very helpful, but may be difficult because the teachers at all of the schools do not have very much time.

We recommend that future projects focus more on designing small, fifteen minute activities than on longer experiments. These experiments follow the curriculum, and help teach topics that are difficult for students to understand. The activities use active teaching methods, and don't take up a lot of time. Teachers who are not comfortable running a long experiment might be more comfortable with these short activities because they do not need as much preparation. We believe that these small, fifteen-minute activities are one of the most important findings from our work in Sakon Nakhon.

APPENDIX Q: CULTURAL LEARNING ESSAYS

The WPI-Bangkok Project Center provides students with a special opportunity to advance their intercultural awareness and competence. During the preparation period and on-site, students learn about general categories of cultural difference, specific aspects of Thai culture, and how to distinguish cultural stereotypes from appropriate generalizations. The essays in this Appendix use the Describe-Interpret-Evaluate (D-I-E) process for debriefing and analyzing cultural encounters in constructive ways. Recommended by intercultural learning and study abroad experts, this model guides learners to separate observable facts from interpretation, and to delay judgment until multiple perspectives of the same events or behaviors have been identified and considered. By doing so they are more likely to be empathic and less likely to make incorrect interpretations and negative judgments that will limit their effectiveness when working internationally or domestically with people of different origins. Using this process can also help people manage the stress and frustration often felt in cross-cultural situations.

TABLE OF CONTENTS

EXAMINING THE THAI TOUCH

A Cultural Essay by Nathan Climer

In this essay, I will explore a series of situations when relaxing with Thai students that both confused and startled me.

Describe

When I was relaxing with Thai students at Chula, I noticed that students often were physically affectionate with each. Students would also occasionally playfully rub each other on the head. Another thing I noticed Thai girls walking down the side walk holding hands. While in Sakon Nakhon and observing students, I noticed groups of girls using each other as arm rests. The students would even occasionally do things like hit a friend on the rear, or pinch each other on the sides. Teachers that I became friends with in the province also would often walk up and place a hand on my back, or hold my arm. I have noticed friends having conversations where their face is only three inches away from another. Many of these interactions were between both same and opposing genders. Whenever I either asked, or was part of a conversation talking about these people, I learned that the people involved were very close friends. Here in Sakon Nakhon, men who are in a relaxing state have put their arms around my shoulder, and led me along by holding my hand or arm.

In contrast, the only kissing I have seen while in Thailand is amongst foreigners. I have rarely seen a boy and a girl walking slowly and holding hands, or sitting very close with their heads on each other's shoulder. I have not noticed a Thai person hugging another. In business settings, the gap in physical contact is most apparent. No one in the Palace of the Princess, or in the District Education Office in Kusuman, touched each other that I noticed at all.

Interpret

My initial reaction to seeing the Thai students being so physically close is to think that the students are dating, or at least flirting with each other. I was also startling because these interactions seemed very different and almost out of place from what I normally saw in Bangkok. This made me think that the students' culture may be slowly changing away from that of the adults. I also thought that possibly more of the students were dating than the rest of the people Bangkok.

This explanation made little sense to me. Previous instruction in Thai culture had led me to believe that Thai people were often wary of physical contact. In business settings, I can fully see this being the case. A wai is used instead of a handshake for example. In open social situations, people also rarely touch one another. This often made me feel like it was difficult to have open relationships in Thailand.

After reflecting on it, and staying with Thai students and teachers in Sakon Nakhon, I developed a different interpretation of these interactions. I believe that in a relaxed environment, close Thai friends are often very physically affectionate, even more physically affectionate than your typical American. Strict codes of conduct, such as not touching the head, have little or no meaning amongst close friends. This belief has been reinforced through my interaction with Duke and Meg. In addition, I asked a Thai acquaintance by the name Anne about this action. Anne stated that it was true: Americans often enjoy their space among friends more. She went on the point out how common it is for girls to hold hands, which she believed would be scandalous in the states.

Our group constantly engages in physical contact that we heard Thai people believe is offensive. When we realize what we've done, we usually immediately apologize. Duke and Meg are quick to respond that it actually is not rude to do such things. We are friends, they say. The closer friends are, the more physically affectionate they typically can be. However, in a strict, business setting, Thai people often refrain from any physical contact.

Evaluate

I know I felt very embarrassed the first few times I thought the Thai students were dating. In addition, I felt slightly awkward around what I thought were couples. As I slowly developed a new viewpoint, I was slightly shocked that what I was seeing was not what I was taught. When I finally accepted a final viewpoint, the feelings of awkwardness and confusing gave way to more understanding: I no longer feel strange around close Thais.

Learning this different and unexpected bit of how people interact in other cultures has been an interesting and expanding viewpoint. I have learned that a person can be offensive and awkward in other cultures in ways that are not actions. By interpreting situations incorrectly, I caused embarrassment for both myself and others around me.

If I was part of the host culture, I would probably feel offended that the Farang assumed that I was dating my best friend. In addition, as I am not very physical person, I probably appear distant to some Thai people. However, in a business setting I probably seem very professional.

A BUDDHIST FUNERAL

A Cultural Essay by Matthew King

In January of 2009, I attended a Buddhist Monk's funeral in Sakon Nakhon, Thailand. Thailand is a country situated in South East Asia and most people follow the Buddhist religion. Three American students and I arrived at the funeral just before the prayer service started around 8 p.m. We were instructed on how to pay our respects by our Thai house keeper and Thai academic project partners. Although the occasion was solemn many people spoke even through the prayers. There were over one-thousand people in attendance at the funeral. After the prayers were over the entire temple turned into a carnival like atmosphere. There were vendors selling food, movies on projector screens, and bands playing on a stage. The villagers made us dance in front of the stage, in the center of a circle of them. Many of the villagers had been drinking alcohol. This funeral seemed to be a lot different than other funerals I have experienced in United States. Generally the funerals I have attended have been sad occasions and only friends and family have attended. Additionally, the ones I have attended took place early in the morning and did not include drinking alcohol. After a short while, the director of a school we were working for said it was best if we were to go back to the school. At that time I was confused to why we should leave but we abided by his request and began to walk back to our house.

Informed interpretation of this cultural situation can lead to some credible explanations of what actually may have happened. First of all the funeral may have seemed different to me because of the difference in beliefs that many Thai people have from many Americans. Buddhists typically believe that there is another life after you pass away. If the person who passes away has lived a religiously appropriate life then in the next life their status will increase. This may have led to a celebration of the Monks life because many monks are regarded very highly, and live following the teachings of Buddha. Many people in America do not have beliefs of reincarnation and death may seem like a sad time to them. Additionally, there may also have been many different interpretations of why the host asked us to leave. First of all from a strictly religious perspective, alcohol is forbidden in Buddhism because it is considered an immoral worldly pleasure (Promta, 2008). The director may have felt embarrassed by the villagers and may have wanted to prevent us from associating the villagers indulging in alcohol with Buddhism. Another possible explanation is that the director may have been unhappy with us. He may have felt that we were out of line for associating ourselves with those villagers who chose to drink at the funeral. He may have chosen not to explain to us that he was upset because many Thai people choose to save face and be indirect even when feeling upset (Klausner, 1993). Finally, as I had observed throughout my experience in Thailand, a host is always trying to please his or her guests. The Thai people that we interacted with in Sakon Nakhon were always trying to make sure we were happy, comfortable, and taken care of. For some reason, the director may have thought that we

should not be at the funeral any longer. He may have asked us to leave in order to look out for our best interest.

After the situation was explained to me, by our Thai academic project partners, I felt a sigh of relief. At first I was worried that we had done something to offend the director. Our partners explained that the director was looking out for our best interest because he was worried that drunken people may turn violent. If I was a member of the host culture I too would have felt very responsible for anything that happened to my guests. I also would have tried to prevent any possibility of an incident that might have caused any sort of harm to my guests. Looking back and considering all perspectives, I feel more content about atmosphere of the funeral than I did in the period of time immediately after being asked to leave. At first the experience seemed to be different because it did not feel correct to be at a funeral and be in a joyous mood. Throughout my experience in Thailand, I have found that different cultures may have different traditions but it is best to try to interpret them before jumping to conclusions.

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Klausner, William J (1993). *Reflections on Thai Culture.* Bangkok, Thailand: The Siam Society.

Promta, Somparn (2008). *An Essay Concerning Buddhist Ethics.* Bangkok, Thailand: Chulalongkorn University Press.

NIGHT MARKET MUSICIAN

A Cultural Learning Essay by Kelsey Miranda

Bangkok is a cramped, colorful city that sprawls like a giant dirty octopus over southern Thailand. Plants sprout out of rooftops, and stray dogs lay panting in the sidewalk. Even at night, Bangkok is full of people and noise. In the night markets, street vendors and street shops sell food that varies widely in smell, shape, and probability of causing illness. Going to the night markets is as much a feast for your eyes as it is for your stomach. Vendors and restaurants set up trolleys, tables, and benches in the road without a care for the cars, motorcycles, and tuk-tuks that try to pass through without hitting any of the pedestrians that clog the streets.

Living in Bangkok, the night markets are one of the first places I wandered to eat. In a large group that mostly consisted of farang from WPI, we wandered through the streets, picking a street restaurant at random and laughing over our inability to read the menu. While we headed home afterward, full and content after a delicious meal of tom yum soup, we heard music. I looked around, trying to pinpoint the singer, and almost didn't believe my eyes when I found her.

It was an old woman, bent and wrinkled. She walked unsteadily along the street, eyes closed as she sang with the voice of a much younger woman. A young man walked behind and a little to the side of her, hands on her upper arms just above her elbows. He guided her through the street, occasionally steering her out of the way of passersby, whether pedestrian or vehicular. He had a very solemn look on his face, as though he was worried or preoccupied with something.

At first I didn't believe it was her. I looked back at her several times, noticing her mouth was open even as I continued to look for a young woman. Perhaps, I thought, it was someone approximately my age, or a little older. Perhaps it isn't a person at all, but someone playing a radio. When I finally realized that it was the woman singing, I was a little confused. Why was she singing in the middle of the road? Who was the young man, and where was he taking her? Were the other people in the street, most of them Thai, surprised by this, or was it a common sight?

One interpretation would be that, in the crowded streets, a young grandson or nephew was helping his elderly relative to negotiate the pitted streets and traffic. With the hierarchy of age and status, someone such as an elderly grandmother would be treated with the utmost care. This interpretation, however, does not shed any light on why the woman was singing.

I consulted with three Thai friends to gain more insight into what could have been going on in this situation. In all three cases, they believed that the woman was a blind beggar, singing for

coins. Often times, beggars will walk through the streets with a bag around their neck for people to put coins into. I didn't get a close enough look at the woman to see whether or not she was wearing a coin-collecting necklace, but I have been surprised and somewhat horrified at the number of old woman and very young children on the sides of roads and sky train paths, playing with cups or wâying low with their foreheads practically touching the ground. The man leading her could be her guide.

Although all three of my friends agreed that she was a blind beggar, they each viewed her disability and livelihood differently. Duke, my Thai teammate, explained that Thai people give coins to beggars because it is a good thing to do. They honestly want to help them to improve their quality of life. In giving to the poor, they are doing a small part to help those who are less advantaged than they are. Another friend, Ann, expanded on the previous view by saying that in giving to beggars, some Thai believe they are improving their karma by giving someone else a better chance at a new or better life.

This belief can also effect the actions of the beggar. Some beggars feel that they must give something in return for the payment, instead of receiving the money for free. This can be done by singing, as in the scene I witnessed. Another way this is done by the selling of small, inexpensive items, such as mints, for a small amount of baht. Ann stated that some beggars will refuse payment that is greater than that which the mints are worth – for example, if someone tries to give them twenty baht for a packet of mints instead of ten. She said that this could be partly due to the before mentioned karma, as they are able to honestly earn their supper, and partly due to the wish not to be the object of pity.

My third Thai friend, Lee, told of a reaction. He said that some Thai people view beggars such as the one seen with suspicion, and do not give them coins. This is because beggars, similar to pickpockets, sometimes are not begging because they have no other livelihood, but because it is profitable. Lee stated that the average beggar can make much more per day than a Thai person working in a normal job. In addition to this, they often do not work alone, but form work gangs to fleece certain street corners and BTS stations.

Viewed through the lens of my own culture and experiences, I would be inclined to believe that this woman was part of a scam. This happens all over the world. In Worcester and Boston, people hold signs along the sides of roads, asking for money. Many people, myself included, refuse to give money in the likelihood that it will be spent on drugs or alcohol. In Paris, street children roam in packs, selling sob stories about mothers stuck in Africa or South America.

When I examined the situation using what I know of Thai culture and the experiences of my Thai friends, I came to see that it is very possible that the woman was simply trying to earn a living using one of the only skills left to her – her voice. This would both allow others to increase their

karma by helping an elderly woman improve her quality of life, as well as allowing the woman to keep her dignity and somewhat prevent being looked upon with only pity.

COMMUNICATING CROSS-CULTURALLY

A Cultural Learning Essay by Sofia Zamora

For our project, we needed to evaluate the behavior of students during the implementation of our refined experiments. We decided to evaluate the students through a behavioral observation protocol. This protocol required a thorough understanding of the interaction between the teacher and the students, thus the observer had to understand Thai. Since Duke and Meg are the only two members of our team able to speak fluent Thai, they were the members best suited to run the protocol. As a group, we agreed that during the in-class implementation, Duke and Meg would be the observers, and one of the remaining members would attend the activity to assist both them and the teacher. We explained the protocol and its purpose to all teachers, especially emphasizing our need to observe the experiment under "normal" circumstances. These circumstances involved having a single teacher run the activity without assistance or a foreign presence. Before initiating an experiment, we would usually repeat the request that, while running the experiment, the teacher require little or no help from us. Abiding by our procedures, we reinforced this during the implementation of the Combustion experiment at Potisan, which I assisted. However, while the teacher was running the activity, she expected and requested that Duke and Meg constantly aid her with minute tasks, such as setting up materials, and handing out materials and instructional sheets, which should have gone to the non-observer. They repeatedly hinted that they needed to follow the protocol, and that I could help her. However, she only asked me to help her twice. Meanwhile, Duke and Meg had to interrupt their observations several times to assist her. We were aware that the novelty presented by this project for both the teachers and us made both parties hesitant to voice their personal opinions. Nonetheless, we expected and encouraged the teachers to express their main concerns and needs before the implementation of the experiments, so that we could collaboratively address them. A few of the teachers did not state their concerns or needs. These teachers often lacked confidence during the activities, creating circumstances like the one just described.

There are two main reasons why the teacher might have behaved this way. One reason is the possibility of miscommunication problems. Communication between the teachers and non-Thai team members of our group was difficult due to language barriers and noticeable cultural differences. My knowledge of the Thai language allowed me to politely greet others and engage in simple everyday conversation. I couldn't express or understand ideas that required more than the objects surrounding us or topics we had recently discussed. In addition, the Thai-English dictionaries we brought with us had a different phonetic system than the one we originally learned, so I pronounced the words wrong, making it difficult for the teachers to understand me. There were also noticeable cultural differences that interfered with our communication. One of the most common of these contrasts was the playful character of Isaan people versus our group expectancy of having a serious and professional work environment. Another contrast was in

differing expectations regarding independence and work habits. In the work environments I have participated in, people are expected to be independent and full of initiative, and to assume full responsibility of a task. The teachers of the region seemed to be more comfortable adapting and following specific instructions while sharing responsibilities. These factors might have led the teacher to view the mutually agreed requests more as suggestions than as directions for the implementation.

Another possible reason behind this situation is the inherent discomfort that professionals feel in following the guidance of those who are not educational professionals. We are younger than the teachers and don't have any expertise in the field of education. I believe that most professionals around the world might not be comfortable following the guidance of younger individuals who lack proper training and knowledge of the specific field of expertise. Even when implementing new methods unknown to them, professionals tend to rely on their knowledge and experience to ease the process. Therefore, the teacher could also have felt that because of her experience in education, it would be more helpful for her students to run the activity with Duke's and Meg's assistance than either herself alone or the assistance of someone that could not clearly understand her concerns nor explain information to the students.

A more area-specific reason could be found in one of the main traits of Thai culture: Thai people aid and obey their seniors; they feel bound to be serviceable to them. I first became conscious of this trait after we discussed as a team the behavior displayed by the teacher. We established that in this project, the teachers were our seniors, not only because they are older than us, but also because they are professionals in the field of education, a field we were only beginning to learn about. It is common practice in Thai classrooms for a teacher to ask a student to aid her with side tasks, like booking rooms, communicating with other teachers and students, and posting information. It would not be uncommon for a Thai person to feel more comfortable requesting duties to another Thai person, when the case is such that it is culturally required, than to people from other nationalities where this serviceable behavior towards seniors is not expected. Accordingly, it might have happened that the teacher assumed that the Thai members of our team would want to assist despite the special circumstances of the activity. In addition, she could have felt uncomfortable making these requests to me, when she could have felt that this implicated me going out of my way to help her. She could also have wanted to be attentive to one of the foreign visitors, and as a host, make me feel comfortable and well served.

When we were implementing the experiment, I did not fully analyze the reasons behind the teacher's behavior. I viewed it superficially, assuming that the problem was that she could not take us seriously because we were young and inexperienced in the field of education. I felt confused, and after noticing that Duke and Meg would collaborate with her in everything they were asked, even at the expense of our data collection, I felt slightly frustrated. My reaction was negative, and it reflected on the manner in which the three of us worked together during the activity. After analyzing these possible reasons behind the teacher's behavior, I think her

reaction, and the constant support Duke and Meg offered despite our pre-established procedure, were normal polite reactions from a Thai perspective. Most of their cultural characteristics oriented her and Duke and Meg to develop the experiment in this manner. Now that I see the other perspective I know I could have been more helpful by not putting so much pressure on Duke and Meg. Effective cross-cultural communication requires more than only understanding the language and some basic traditions. It is important to be aware of both parties' expectancies and be able to compromise the extent of the advancement of a stage within a project in order to foster mutual collaboration.

APPENDIX R: TEAMWORK ASSESSMENT

Throughout the course of our two month project, our team worked together to build the best and most efficient team possible. This section reviews the roles each individual took in the project. In addition, we review the things we have learned from the project, both as group and as individuals, about teamwork. We assessed our strengths and weaknesses as team members, as well as our efforts to address weaknesses improve ourselves, and by extension, the team as a whole.

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CONTRIBUTIONS

In addition to the writing contributions noted on the Authorship page of our IQP, each group member played a different role in helping our team to complete our IQP. Without the contributions of each of our members, we would not have developed a project of the same quality. In addition our team feels as though everyone contributed equally to our project. Although every single contribution could not be noted, below we have tried to summarize each individual's role.

Nathan Climer was always ensuring that we were well organized and addressed any computer or technical challenge that arose. He provided our team with several strategies to keep organized. He was the original one to recommend the meeting minutes that proved successful in keeping us organized. These minutes included topics such as: what we did, what we needed to do, and any significant changes to our project work. In addition he established a checklist of all tasks we needed to get accomplished before the completion of our time in Sakon Nakhon. He ensured we were always organized by keeping our files neat on Share point. He dealt with any technical challenge that arouse through share point. Addition Nathan can be credited for formatting and designing the layout of our paper in Microsoft word. His knowledge of these programs helped the team perform to the best of our capability.

Matthew King contributed through utilizing his strengths in editing and communication for the teams benefit. Matthew was one of two main editors that ensured any submission was free of grammatical and spelling errors. He used his ability as a communicator to write correspondence for the team when necessary and ensured that our team's message was clear, appropriate, and respectful. He exhibited this through his interactions and emails with the sponsor, teachers, and liaison. Additionally his communication skills were used to design several of our presentations and design talking points for each individual. Lastly, he helped organize meetings with teachers when necessary.

Kelsey Miranda was an extremely reliable teammate who would step up to any task as well as serving as one of the main editors. She ensured that submission of project material was free of grammatical and spelling errors. Kelsey volunteered often for tasks such as cultural exchange, teacher meetings, and project writing. She was critical in establishing most of the cultural exchange activities. She developed plans that the team could use to complete these actitvities. The team could rely on Kelsey to get any type of task done and know that it would be completed at the highest level possible. She excelled in all areas of the project and this helped to ensure that the team developed a cohesive final product.

Jakrapan Moon was one of two Thai students whose effort towards the project, through analysis and teacher interaction, aided our group significantly towards achieving our goals. In initial meetings Jakrapan relayed important information to the teachers through his knowledge of the

Thai language and culture. He also completed observation of the classrooms and post-experiment interviews. The diligent effort he showed in these tasks allowed our group to help teachers implement experiments in their classrooms. From the information that he helped to gather, he compiled and analyzed the data we gathered through our evaluation methods. This analysis was used to develop our findings, conclusions and recommendations.

Boontida Uapipatanakul offered dedication to our team through efforts as our Thai communicator and analyzer. Her likable personality allowed her to interact with teachers and helped coordinate our experiments, interactions with teachers, and communications. She was able to always keep us up to date with information regarding the teachers we were working with and was able to relay information to them as well. In addition she collected data through the observational protocol, pre- and post-tests, and finally student and teacher interviews. After collecting this information she helped to analyze it. Additionally, she not only authored the Teacher's Guide as noted in the authorship page but also translated the entire guide into Thai. Her efforts helped the team achieve our goals.

Sofia Zamora served our team by developing the flow of our writing in many chapters and being a creative influence throughout our project work. Sofia used her ability to write in a flowing manner to ensure our writing made sense to the reader. She developed the initial writing for many chapters of our report before it was passed on to other writers and editors. Additionally, any time a problem needed to be solved with our project she used her creative influence to come up with innovative ways to solve the problems. She assisted our team in thinking outside the box and considering all options before selecting a single option. Sofia's contributions ensure that our project and writing were well developed and thought out.

Each of these team members contributions were great assets. Although we mention specific roles each team member played it should be noted that every team member assisted in each of these roles. There was never a single person who completed a task without help from other teammates. Therefore we believe that each member of our team contributed equally towards the completion of our IQP.

TEAMWORK ASSESSMENT

Our team developed a strategy to allow us to face and address internal conflicts, and to help us work more effectively and professionally together. We believe that this strategy effectively opened lines of communication between different members in the group, even when parties were experiencing tensions. This strategy was the use of a Formative Teamwork Assessment.

In this assessment, we first reflected individually on the strengths and weaknesses of the team as a whole, ourselves, and our teammates. This reflection was documented in specific worksheets, which gave us a guideline for giving each other constructive criticism. We enforced that in these criticisms, we would not just tell people in what areas they could improve, but specific actions they could take to improve their work. This personal reflection was shared with the group, and members took time to review other people's comments.

After individually reviewing each other comments, we came together to discuss ways in which we could improve as a team. We examined each team member and comment, brainstorming more ways on which we could improve our effectiveness as individuals, and as a team as a whole. Again, the focus of these meetings was on developing specific actions that a person or the group could take to improve our work.

Through focus on developing achievable actions, we developed specific strategies to improve our team efficiency. One of the major findings during the second week of our project in Sakon Nakhon was that we all were trying to enforce our own working style on the group. Matt and Sofia preferred to get work done at their own pace. In addition, Matt stated that working in a distracting environment slowed his work. In contrast, Nathan, Kelsey, and Meg wanted to have clear deadlines and task lists to keep everyone focused.

After discussing the stresses placed on the group, we came up with a set of ways we could improve our work and the work of individual members. Matt stated that he could work with headphones to increase his reliability. Nathan, Kelsey, and Meg said they would set more personal deadlines and tasks instead of enforcing small deadlines on the entire group in order to make a less stressful work environment.

In addition to the Formative Assessment, our team developed a strategy to effectively communicate about updates and challenges of the project. We held 15-30 minute meetings twice a day to discuss different parts of the project. Team members would each be given a turn to review what they had accomplished since the last meeting, and any major findings or discussions that affected our project. This was especially effective in communicating the results of our interviews with all members of the group.

After this initial discussion, the group discussed the direction the project was headed. Members determined what needed to be worked on, and who was doing what. This part of the meeting

facilitated communication about the specific challenges of our project and how to address each one.

Above internal communication, we kept lines of communication open with others to address challenges of the project. Occasionally, different stakeholders had different goals for parts of the project. One example was when the Office of H.R.H. Princess Maha Chakri Sirindhorn's Projects and the Kusuman Education District Office Area 1 had a miscommunication on the scope of the Science Education Fair. We tried to keep lines of communication open with both parties, and communicated with our advisors to try and resolve this conflict.

Another example our use of communication to solve problems happened early on in our project. Khun Prapatsorn had met with the teachers in Sakon Nakhon to discuss our experiments and determine the best topics for pursuit. One of the better received topics was the Effect of Agricultural Run Off on Local Ecology. We later determined that this experiment was culturally unacceptable because it intentionally killed small microorganisms and insects. When this discovery was made, we open lines of communication with Ajarn Siripastr, our liaison for the Office, and our advisors to determine the best course of action. Our final determination was to view a similar but different topic: how this same agricultural runoff can stimulate algae blooms.

SELF ASSESSMENT: NATHAN CLIMER

The IQP was an expansive project, consisting of four months of intensive work with the same 6 people. One of the biggest challenges associated with this type of project is being able to work as a member of a team. This unique experience has taught me a lot on how to work better with others.

On major area that is important to working effectively in a team is reliability. I believe that team members would say that I was reliable in my role as an organizer. I was persistent in my role, making sure that the team was always ready for their tasks and that work was spread evenly throughout the group. In addition, I believe the group would say that I made myself available to help out with any issues related to SharePoint or computer software.

I am usually not defensive when partners or advisors target an issue that relates to me. While I was usually open for discussion in these types of conflict, I occasionally was unable to understand the context of the point being made to me. When this happened, I tended to become very frustrated. After considering other's comments over a period of time, I could better rationalize and work with the constructive criticism I was given.

Despite these challenges, I did make significant improvements based on the comments of others. One particularly effective communication I had was with Sofia at the beginning of our work in Sakon Nakhon. During one teamwork assessment, Sofia helped me to identify particular aspects of what I could improve upon to be a better teammate.

The first major feature Sofia helped me understand was that I responded negatively to many of her ideas. When presented a new idea, she felt that I immediately began to tear it apart. This initial response led to a feeling of disrespect. Through our discussion, we revealed that I could improve my professionalism through making an effort to accept an idea before I was critical. We determined that if I could change my initial discussion by focusing on an idea's merits. After discussing these merits, a better conversation can be had about the limitations of an idea. After incorporating this, I believe I showed much more respect to other's new ideas.

This discussion also revealed that I initially had difficulty soliciting feedback from team members. Early on in the project, I was making broad changes to the methodology section. I initially made these changes without the input of all team members. Through open discussion and the use of our Formative Team Assessments, I learned that some team members felt that I was not respecting their opinion because of this.

I thus adjusted my behavior to attempt to keep all parties involved with the majority of my decisions and work. I initially took this too far. A later discussion revealed that I was considered by two team members to interfere with work. This was because I asked for opinions on things that were too small to warrant group work. This both distracted people from their work, and

disrupted their thought process. Based on this finding, I only involved group members at major decisions and turning points in the project. The team members later stated that by doing this I had much improved my overall efficiency without interfering with work.

While the Formative Assessments were a good vehicle for this communication, I also gave encouragement to others when they were working. One person I tried to help was Kelsey. When we began, Kelsey was very shy and did not often defend her opinions as much as she wanted to. In addition, she did not always share her ideas. I continually encouraged her to speak her mind, and I believe I helped her grow with confidence in this area.

SELF ASSESSMENT: MATT KING

The ability to work with a team and many different types of people is one attribute I consider especially important for a professional in the work place. I believe that my teamwork skills have improved after working for the past eight weeks, on an Interdisciplinary Qualifying Project (IQP), with a group of team members who varied in personality, work style, and culture. Although this improvement is significant, I recognize that there is always room for improvement. In the following paragraphs I will reflect on my abilities to work within this team.

Reliability is a key aspect of working with other people. I believe that if my IQP team members were asked they would say that I was always reliable when it came to completing work. I delivered tasks on time including implementing our project and writing as well as editing our report. Often I would be charged with editing many sections of our project and would have deadlines to meet after others had finished initial writing. I would stay up until late hours of the night to ensure that my work was completed on time. Although my work was always delivered on time, I did experience some difficulty when it came to writing in a distracting environment. My group worked through this issue by ensuring that I was not distracted when it came to writing and allowed me to work on writing in the evening hours.

Another key aspect of working in a team is being able to accept constructive criticism and then taking steps in order to improve areas of weakness. This is an area that I have struggled with in the past. When others offer me constructive criticism, I do need a while to absorb it. I often try to explain what I really meant to say or do rather than immediately accepting how I may have been perceived. Through this project I have worked hard at this aspect. Throughout the IQP, when people have offered me constructive criticism, I have tried to work on thinking about what they are saying to me rather than formulating a response. In many team work assessment meetings I worked towards listening to what my teammates said and accepting it rather than replying immediately. I think that overall this has helped me improve and allowed my teammates to understand that I am accepting of constructive criticism. This is an aspect of teamwork that the IQP has helped me develop further and I will continue my efforts in the future.

Throughout our team work process, our team members gave each other advice on how to improve. It was important for each of us to review this advice in order to improve our own abilities. One of the areas that I have recognized that I needed to improve on was how I express my ideas. I am generally a confident person and have strong opinions. At points during the project, this came across to my teammates as being too strongly opinionated. Understanding this I tried to take steps to improve my weakness in this area. I made sure that anytime I felt very strongly about something I would explain in depth and detail what I thought was the best course of action. In situations where I felt as though other team members solutions to problems were as strong as mine I tried to defer to them. In this way, I helped other team members see that although I do have strong opinions I am accepting of others as well. In addition to sharing my

own ideas and opinions, I tried to encourage other teammates to give their own opinions. There were some members of our team that were sometimes hesitant to offer their own ideas. Since these people are inherently quiet, I would often ask them how they felt about certain aspects of our project. I tried to ask them in private where they might feel more comfortable giving their own opinions. Through this method, I tried to ensure that everyone in our team had a say in what was done.

When working with my teammates I tried to help them improve as much through this project as possible. When I wrote team work assessments I wouldn't only write what I felt as though they could improve on but actually included advice on ways to improve. I always kept my suggestions professional and constructive. I used this project as an opportunity to help others improve as much as possible. The IQP experience has been a great opportunity for all members of my team to improve as individuals and team members.

SELF ASSESSMENT: KELSEY MIRANDA

During the past four and a half months, I have worked intensely with a unique and talented set of individuals. One important thing to learn when working full time with a set group of individuals is how to recognize and address tensions and challenges as a group. This experience has been very rewarding and very educational, and has helped my team members and I to develop many skills, including teamwork, which would have been difficult to develop during a traditional class setting.

In our formative teamwork assessment, partners have repeatedly said that I am always reliable and put forth my best effort. I have shown this by both completing my own work well, and by picking up odd jobs to make sure everything gets done. This was especially true in Sakon Nakhon, when we had a million and one things to balance, between meeting with teachers and implementing our experiments, and running cultural exchange activities with the schools. It was occasionally suggested that I put forth too much effort, especially by Sofia, who would tell me to take a break or stop work for the evening instead of taking on more tasks.

I remained open to discussion on what I could better in the team and accepted constructive criticism. A more minute form of this was during the first week in Sakon Nakhon. During this time, I was very distracted at the Potisan and Baan Na Peang schools during the work day, especially when the primary school students would cluster around our conference room to stare and giggle. When it was brought up that I was very distracted, I accepted the feedback and worked to be more diligent. This also evident when it was brought up that I did not speak enough at meetings. To help counteract this in meetings just with team members, I worked at trying to give feedback more in meetings and contribute more opinions to the objects being discussed. One final way I accepted constructive criticism was on improving my presentation skills. Although the improvement in this area was not quite as prompt, as it required a lot of practice which I gained through the weekly meetings with advisors, I was able to go from memorizing a script and reciting it to the ceiling, to speaking without notes or script while making eye contact with the audience. Perhaps even more rewarding for me is the decrease in fear related to presentations. I still really don't like them, but I'm not terrified of them anymore.

I also tried to view my teamwork from the point of view of other members on the team. Although I had strengths that I contributed to the team, I also had several weaknesses as well that I addressed and modified. The most inconsequential of these was timeliness, especially regarding getting up on time for morning meeting. I could see how this was frustrating to my team members, especially for Nathan and Matt, who succeeded in being punctual for these meetings. To address this, I woke up fifteen minutes earlier every day. The other way this was evident was in the third week of our work in Sakon Nakhon, when tension arose between Matt and myself. Looking at this situation, I could see that it was not the individual blame of either of us, but was a combination of living situation and stress. In order for this problem to be solved,

the solution could not be one-sided, but needed to involve an increase in tolerance and patience from both parties. In this situation, I both accepted constructive criticism and worked to be more open-minded and view Matt's actions through his eyes. This allowed me to be more open-minded when observing his actions and speech. I also, on the occasions when I did become irritated, remained mindful of my tone of voice so as to prevent my irritation from upsetting the balance and peace of the team and my working relationship with Matt.

I regularly tried to give constructive feedback to group members, in order to share my feelings and opinions, and elicit those of others. At first, this was very difficult for me. Especially in completing the formative teamwork assessment, I was hesitant to too harshly criticize others. I was sometimes told that I was too flexible, meaning that although I would give opinions, if someone expressed the opposite opinion I was more likely to agree than to continue to express my point of view. However, I worked hard to uphold my opinions more, and to be able to give honest, helpful constructive criticism to my team members.

SELF ASSESSMENT: JAKRAPAN MOON (DUKE)

I feel that I am reliable in most things but sometimes I have not been punctual for the morning meetings. One of the ways that the group helped to improve my punctuality in Sakon Nakhon was to make sure that I got up at a certain time by helping to wake me up. I believe that my partners think that I always deliver my best effort. This is because I always got my tasks done and I also always gave feedback on the things that I thought went well or didn't go so well.

I believe that when partners or advisors target an issue that relates to me, I have not been defensive. Usually, when I am given comments, I always discuss the issue and ask the person how they think that I could improve. For example, when I am given comments by my partners that I should explain the pictures on the slides more or make sure that I do not keep repeating the same point, I would ask them to give me first of all their feedback and then I will ask them to give me techniques that could help me improve upon the particular point without being defensive with what I have done.

During teamwork assessment each week, I usually directly point out my weaknesses. For example, I directly said to my teammates that I have always been indecisive and all members helped me find ways to improve upon it. I listened to their comments and during further meetings, I kept the feedback I have received in mind and tried to improve my decisiveness. Another one of my weaknesses is my participation during group meetings. During the first weeks, I hardly made any contribution to group meetings at all as I found it difficult to follow my team members. However, when I discussed with my team members, everybody helped me follow the meeting better by making sure that only 1 person speaks at a time.

During the start of the project, I found it very uncomfortable to give any feedback or make any comments about my team members. However, after many weeks of doing team assessments, I felt more comfortable. I began to for example tell my teammates such as that I felt that they have been too quiet in group meetings and I suggested that in every meeting, every group member should have a certain time that they should speak.

SELF ASSESSMENT: BOONTIDA UAPIPATANAKUL (MEG)

The Interactive Social & Science Project could not have been completed if I were working on my own. Teamwork is very important. Each team member comes from a different background. Therefore, some adjustments were needed. Moreover, evaluating the team as a whole and individual is helpful in order to keep each of us aware of individual team member's weaknesses, as well as how we could improve. In the following paragraphs, I describe the problems that I faced and how I improved to address these problems in order to produce the best project and team outcomes.

Firstly, when there are many tasks to be completed in a team, reliability is vital. This is because a lack of reliability can cause the delay in submitting work. I believe that my partners would say that I am reliable, because I always complete my tasks on time. Even though I had less time, since I had to attend a few hours of class per week, I managed to complete and hand in my tasks on time by working extra hours. I believe that achieving the team's objectives is important, as well as helping to improve society. I did not only do what I was asked, but put extra effort in searching the precise information that might be useful by doing a survey before the project actually began, and having informal conversations with the students outside class periods. However, by doing extra activities, it distracted me from the project. The team helped me to focus on work by having meeting minutes that would remind me of certain tasks that need to be done in certain period.

Secondly, when working as a team it is important to listen to each other, be open, and try to resolve problems rather than defending oneself. When partners or advisors targeted an issue that related to me, I was not defensive, and was always open to discussion. For instance, when I was in Sakon Nakhon, I had a difficult situation where I could not serve both the team and the teachers' needs. The teachers expected me to help them run the class, where the team expected me to be an observer and not distract the class. I discussed with the team and resolved the problem promptly. We as a team agreed upon and came up with the solution that one of three observers should help the teachers if it was necessary and two main observers should concentrate on what is going on in the class and give the most precise data. Therefore, I believe that I succeeded in accepting constructive criticism, but sometimes I was too flexible. My teammates sometimes commented that I could defend some of my opinions more.

Every week we did both a teamwork assessment on both the individual and the team as a whole. In this period, each team member gave advice on how each individual could improve on their weaknesses and what strength they should keep up. I identified one of my strongest areas to be the area of organization as I was able to coordinate well with all the teachers and the people who were involved in the project. I had discipline and patience, as in many cases the teachers asked for favours. Some of these favours had no relation to class, but I still had the patience to pursue them. I realized that one of my weaknesses is my participation in group meetings, because

personally I tend to listen more and I tended to not be very direct. Towards the end of the project, I improved in this area a lot, as I was able to express my opinions when appropriate. I could not have improved in this area without the help from my teammates.

Furthermore, I usually expressed my feelings and proposed actions to the whole group. For example, I felt that at one point in time, we had been disorganized. I then directly expressed my feelings, and said that we could improve by coming up with a detailed checklist of tasks we had to complete. I believe that this helped to improve the team's overall organization, and made sure we completed all tasks.

Lastly, I strongly believe everyone in our team learned a lot from this project. This can be beneficial to our future when we interact and work with other people. This project gave me a valuable experience and opportunity to improve myself and learn things that cannot be taught in class.

SELF ASSESSMENT: SOFIA ZAMORA

One of the aspects this project helped me improve the most was in personal discipline and organization. Because of the high-school I attended and the work practices I had developed I was not used to follow guidelines meticulously and to abide by tight deadlines. At the beginning of the project, I even had a hard time understanding what was being asked in guidance e-mails and the manual. My teammates had to explain to me what we were being requested more than a couple of times. Even though, I put a lot of effort into the project since its initiation; I wasn't canalizing it in the right direction. I would describe my initial participation in the project as not very reliable. For example during the first weeks of PQP, I presented the Sakon Nakhon section two days after the agreed group deadline. This didn't give enough time to my teammates to review it. Through the project my team stressed to me how important it was for us to abide by the guidelines and our agreed deadlines. Once on the field I realized it was important not only because other people relied on my work to further develop theirs but because this would allow me to receive better feedback and be able to provide feedback on more aspects of the project. One of the most noticeable times I felt the improvement on my work methods was when I wrote the first draft of the methodology. I carefully followed the guidelines in the manual and I passed it to Nathan as planned. This not only facilitated for him to understand my ideas but gave both of us enough time to discuss aspects of it in which we disagreed. I stopped spending lots of hours and effort struggling with organization and I began canalizing my effort towards covering more topics and areas. By the end of the project, I was delivering according to the agreed schedule and my contributions became reliable.

Our project required a lot of adaption in a short period of time while continuously advancing it. This caused the sessions during our first week in Kusuman to be tense. Since we were shaping the foundation of the project we all wanted to shape it in our own way. Matt, Nathan and I would often engage in discussions about how to begin implementation. They told me I was hard to communicate with me because I was defensive about my ideas and instead of paying attention while listening I would be thinking about ways to highlight my points of view. I addressed this by analyzing my participation during meetings and keeping myself from thinking on other things while listening. The first time I tried this I was so self-conscious that I barely spoke during the meeting. I slowly increased my participation again, and as my team recognized I became open to other's ideas while being able to portray mine in a nice manner.

During the project my team also helped me to identify a communication weakness, which improvement has become one of my goals. As one of the most cheerful and expressive members of my team, I loved to propose many ideas and immediate solutions to last minute problems. However, I could not easily convey my thoughts and my teammates had a hard time understanding the reasons behind my proposals. Due to my foreign background, I didn't have previous experience conducting highly interactive professional meetings in English. During the first weeks of field work, I would sometimes feel frustrated because I felt my ideas were not

being taken into account. After discussing it in two meetings we arrived at the common agreement that I should spend time organizing my ideas before expressing them and that my teammates should be more patient with me and ask me to explain my idea again when they didn't understand it. This was an effective solution because my team started to understand more of my ideas, many of which we implemented, and I relaxed more during sessions.

During our sessions I would also regularly and politely express my opinions about how I felt we were addressing a stage of the project and about the way we were interacting among each other. In one occasion Nathan was reviewing one of the experimental sections Kelsey and I had written together. He needed feedback about the changes he was proposing and only requested Kelsey's help. I had been feeling that he mainly interacted with Kelsey and Matt, excluding a little bit the rest of the team. In that moment I expressed to him that not only I wanted to also provide feedback but that I had noticed he had this tendency. He addressed the problem and began requesting for most of our teams opinions.

Living and working with the same group of people can be very challenging. However, this situation allowed us to be able to take better advantage of each member's strengths and to better address each member's weaknesses. This project showed me that a well organized group can be very effective.